Study of Surgery Stereo Image Compression

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1 Introduction

Surgery System is applied not only in term of the Medical usage but also Education. Nowadays, this system can be sent to other places in real-time. In order to, maintain the resolution on both images, the system needs to increase the amount information for double. In this case, the transmission speed will drop. Therefore, the Study of Surgery Stereo Image Compression becomes necessary.

2 Research and Proposed Methods

Stereo Image is the pair of images, which are taken from the different perspective views. There are two types of stereo image: Parallel type and Toe-in type.

- The Parallel type is the pair of images, which are taken by aligning two cameras in parallel or use only one camera and shift the camera in parallel direction.

- Toe-in type is the pair of images, which are taken by rotating two cameras for making an angle. And these two cameras need to point at the same object(s).

In this research, we have focused on surgery stereo images, which are taken in Toe-in type. In term of compression, we have focused on both lossless and lossy compression. Therefore, we'd to divide our proposed method into two methods: Disparity method, which based on lossless compression and Color:Gray method, which based on lossy compression.

2.1 Disparity Method

This method is based on lossless compression. The goal is to transform the Toe-in Stereo Image back to Parallel Stereo Image by using the Block Matching and Optical Flow's Vector Calculation. And after we could transform the image In Parallel type, the camera(s) is aligned in parallel direction, which means the differences on both images are relied on shift value. And that seems easier to find the disparity value than Toe-in type. Because of the angle between camera and objects make the direction of Optical Flow's vectors become unpredictable, which means the calculation also difficult.

2.2 Color:Gray Method

This method is based on lossless compression. This method of requiring only one color image, which means when we view the stereo pair, we just need only one color image and one gray image. In this case, we can reduce the size of stereo image. By the way, when we use the gray image instead of color image, we need to concern about these two important factors: Human Depth Perception and Human Color Perception.

- Human Depth Perception is the human's visual ability to perceive the world in three dimensions (3D) and the distance of an object [1]

- Human Color Perception is the human's visual ability to perceive the presence of light sensitive cells in the eyes called rod and cone. But the research has shown that the rods do not seem to be involved in the perception of color in human beings. There are three types of cones in retina. Each type of cone detects either red, green, or blue. All other colors humans see are mixtures of these three colors. And the amount of color humans see also depends on the strength, concentration, and position of the light source. [2]

In the research, as we are working on Surgery Stereo Image, therefore, we have considered that this method might work not only the Natural Stereo Image but also the Surgery Image.

3 Experiment and Result

3.1 Disparity Method

In this method, we have used the Toe-in type of stereo image along with the Block Matching Algorithm. However, it is difficult to find the shift value due to the problem of angle in Toe-in stereo image. In the experiment, we have simulated the 3D environment of Toe-in Stereo Image by using OpenGL and Optical Flow's Vector by using OpenCV [3, 4] as shown in figures below:
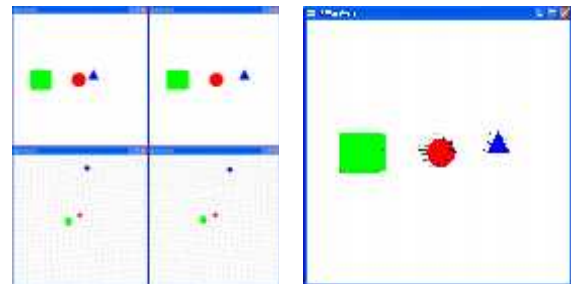

Fig. 1. Simulation of Stereo Image: Toe-in (Left), Stereo Image with Optical Flow's Vector (Right)

According to the Optical Flow's figure above, there are many lines of vectors, diagonal and horizontal. As we can see that the vectors are mostly found at the corner of the objects because the optical flow is difficult to apply on texture of an object. Normally, in optical flow, the more vectors come closer to the center, the more shortened vectors will become, which mean there is no movement at the center of an object. Therefore, when we calculate the length of the vector, we need to select the vector that sticks to the corner like the blue circle's positions that shown in figure 1.

After that, we also applied the Optical Flow to the Surgery Stereo Image as shown in a figure below:
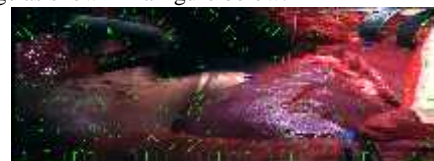

Fig. 2. Surgery Stereo Image (Toe-in) with Optical Flow's Vector

In Surgery Stereo Image, it differs from the Simulated Stereo Image because it contains textures with brightness, which

becomes the important factors when we want to calculate the shift value from the vector. According to vectors in figure 2, which are spread in and out from the objects unlike in the simulation one. However, we need to focus on the vector at the corner of the objects. After that, we might understand the vector's directions and transform it back to parallel type for the purpose of compression.

3.2 Color:Gray Method

The method of Color:Gray is based on one of the research paper [5]. And we have applied this method to our research and set up the experiment. In the experiment, we have used the questionnaire as the evaluation method.

Fig. 3. Color:Gray Method's Experiment

Questionnaire's Details:
- The evaluation of Human Depth Perception for ten levels (level 1 means the subject cannot feel any depth from the stereo image and level 10 means the subject can feel the depth from the stereo image clearly).
- The evaluation of Human Color Perception for ten levels (level 1 means the subject see only grayscale from the stereo image level 10 means the subject can see the color from the stereo image as clear as the original stereo image).

Experiment's Details:
- We have prepared the 4 sets of stereo images: 3 sets of Surgery Stereo Image and 1 set of Natural Stereo Image. And in each set we also have divided the stereo image pairs into 4 pairs: "Left:Color Right:Color pair", "Left:Color Right:Gray pair", "Left:Gray Right:Color pair", and "Left:Gray Right:Gray pair".
- In the experiment, we have used the shutter glasses as a stereo image viewer.
- During the experiment, after the subject saw the stereo pairs in each set, he/she will be asked to answer some couple questions like "Did you feel any depth in the image?" for the evaluation of Human Depth Perception and "Did you see the color in the image clearly? " for the evaluation of Human Color Perception. The answers will be evaluated by score from 1 to 10.

3.2.2 Experiment's Results

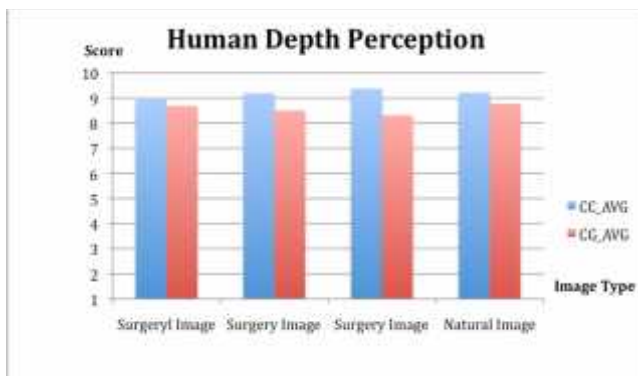- Test Subjects: 16 persons (Male: 13 persons, Female 3 persons)
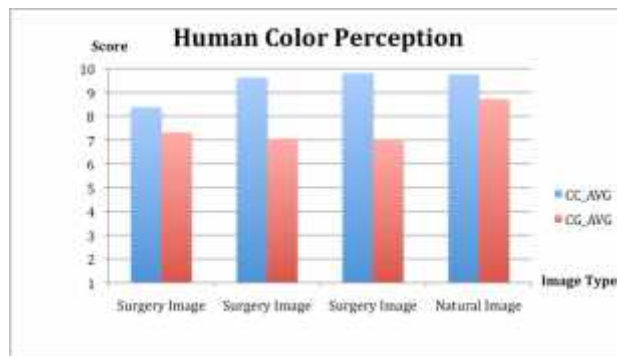

Fig. 4. Human Depth Perception's Result

Fig. 5. Human Color Perception's Result

According to Human Depth Perception graph, when we have compared the Color:Color pair(Original) to Color:Gray pair, and we have found that the results are not so different, especially, between Surgery Stereo Image and Natural Stereo Image.

In Human Color Perception graph, we also have compared the Color:Color pair(Original) to Color:Gray pair, and we have found that the subject can see the color clearer in the Color:Color pair. And the Natural Image's results seem to be better than the Surgery Stereo Image.

4 Conclusion

In this research, we have considered both lossless compression and lossy compression. Therefore, in this research we have two proposed methods, which are Disparity Method and Color:Gray Method.

- Disparity Image method uses the block matching algorithm with Optical Flow's Vector to find the shift value. In the experiment, we have simulated the 3D environment with some objects and camera's viewpoints. And we also have tested on the original stereo image. Unfortunately, due to the angle problem, this method is still not yet completed.

- Color:Gray method uses the grayscale image to reduce the information of stereo image. According to the experiment, I found that Color:Gray pair might be able to use for compression in term of color perception.

In the future, we have planned to continue the Disparity Image method by calculating the vector values and directions to transform the Toe-in stereo image back to parallel stereo image. And for Color:Gray method, as our research is based on the Surgery Image, and we have found that the components of RGB in Surgery Image, red channel seems to be the most effective color such as the color of blood or the color of human's internal organs. Therefore, we have planned to use its characteristics to improve the gray image for the experiment to make it as close as possible to the original Color:Color pair. Lastly, the results must be evaluated by doctors.

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