OBJECTIVE QUALITY ASSESSMENT METHOD OF STEREO IMAGES

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ABSTRACT

Several metrics have been proposed in literature to assess the quality of 2D images, but the metrics devoted to quality assessment of stereoscopic images are very scarce. Therefore, in this paper, an objective assessment method is proposed to predict the quality level of stereoscopic images. This method assesses stereo images from the perspective of image quality and stereo sense. Experiments demonstrate that the objective assessment method the paper presented gets similar results with the general subjective assessment method. And the method is simple, rapid, convenient and practical.

Index Terms— Stereo image, Quality, Stereo sense, assessment

1. INTRODUCTION

3D imaging has received significant attention in both research and application development, since they can provide a strong sensation of depth to viewers just like in real world [1]. In recent years, enthusiastic research efforts have been recently revealed in [2]. From John Logie Baird who introduced the first version of stereo TV, many approaches have been developed [3]: stereoscopic vision with glasses, auto stereoscopic displays, holographic systems. In parallel, methods for 3D scene representation [4] and data content broadcasting [5] have been widely studied. On the other hand, image quality will reflect the performance of these systems or algorithms directly. Therefore, research on quality assessment is an important work for 3D imaging applications. But quality assessment of stereo images is still a very difficult and arduous task.

Quality assessment of stereo images is achievable either through subjective tests or through objective assessment [6]. The best way to assess image and video quality would surely be to run subjective tests according to standardized protocols, which are defined in order to obtain correct, universal, and reliable quality evaluations. However, the use of subjective tests is a time consuming approach. Furthermore, the analysis of the obtained results is not straightforward. Therefore, the definition of objective assessment reliably predicting the perceived quality of images would be a great improvement in the quality assessment field.

2D picture quality assessment methods are not adequate to measure 3D image quality since depth reproduction, the most important factor in a 3D system, and typical stereoscopic distortions (for instance crosstalk) are not incorporated [6]. Up to now, only a few objective assessment methods of stereo images have been put forward [7], which used depth map to assessing stereo sense. But depth map will bring the two issues: First, computing depth maps for images is a highly computationally intensive and time consuming process. Second, it is not easy to accurately compute depth map, because of occlusion, camera noise, and so on. Third, it is hard to decide what degree of depth is good, and more is better or less is better.

We present in this work a rapid method which does not use depth map to objectively measure stereo image quality. This paper is arranged as follows: Section II makes a brief introduction of absolute disparity image to stereo sense; in section III, we propose objective quality assessment for stereo images; Section IV presents the experiments we conducted and analyzes the results of these experiments; Section V summarizes the conclusion.

2. THE INFLUENCE OF THE ABSOLUTE DISPARITY IMAGE TO STEREO SENSE

It is totally different when we view a 2D image and a stereo image. Viewing a 2D image, two eyes can only see a same image。While as for a stereo image, two eyes see two images with the standard disparity. Fig.1 presents a stereo image with standard disparity (From the website of China Tianjin 3D Company Ltd, with the original size of 280×744). In the perspective of a single eye, stereo image dose not make a distinction from the 2D image, what that eye view is a same image. But with the combinative effect of two eyes, stereo image distinguishes significantly from 2D image. When two eyes viewing stereo image, human brain can generate stereo sense from the standard disparity information, which is the distinction of the stereo image.

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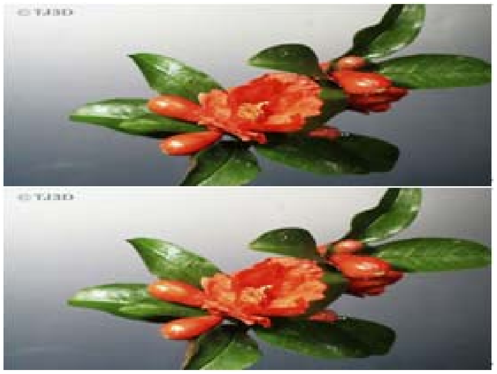

Fig.1 Stereo image

Fig.2 is the absolute disparity image of Fig.1. Define the left and right image of Fig.1 as L and R, Fig.2 as D (As the data of the image cannot be negative, we just take absolute value), then:

$$D = \left| R\text{-}L \right| \tag{1}$$

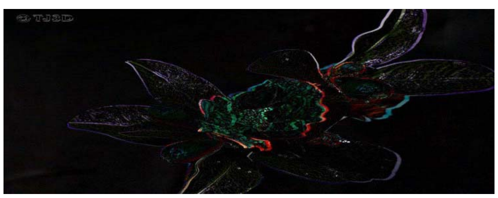

Fig.2 Absolute disparity image of Fig.1

The absolute disparity image is the different information that two eyes view from the stereo image. From Fig.1 we can see the image data of the two adjacent viewpoints is highly related at the same time. If the absolute disparity image is an image with the value of 0(all black), that is to say, the two images are completely the same and no eyes disparity exists, the image pair like this cannot make physical stereo sense according to the principle of human eye physical features (And so is the fact: eyes cannot sense stereo sense when viewing two identical image). Therefore, the more similar between the absolute disparity image of the original and the coded stereo image, the better the two eyes disparity quality shows, and the better the stereo sense presents.

The following experiment makes further study of the relation among the quality of stereo sense and the absolute disparity image.

Fig.3 is generated by adding constant noise to Fig.1 (change the value of R,G,B into 255), and the position of the noise is where the value of D is relatively large(the two-eye disparity is obvious). 25 volunteers view the stereo image with stereo glasses and report that the quality of the viewpoint pair is awful, hardly any stereo sense viewed, deep information cannot be recognized and the feeling of the stereo sense is disgusting.

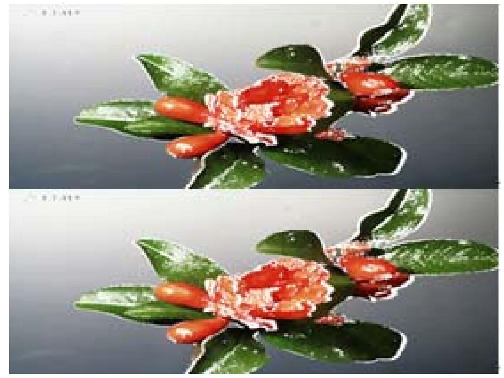

Fig.3 Add noise to where the value D is relatively large.

Fig.4 is also generated by adding constant noise like Fig.3, but we choose the position where the value of D is close to 0(where nearly no disparity exists). The 25 volunteers report that the quality of the stereo image is relatively bad, no degradation of the stereo sense sensed, deep information can be recognized and the feeling of stereo sense comfortable、natural and accordance with the visual experience.

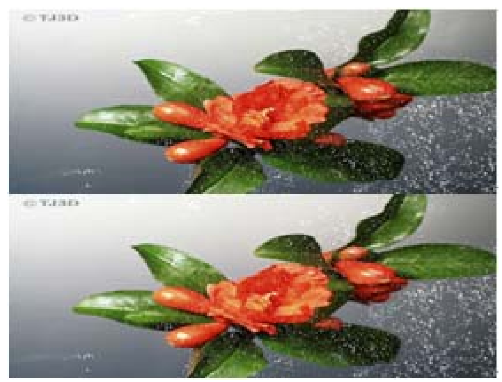

Fig.4 Add noise to where the D value is close to 0

We add the same constant noise to the stereo image, but the influence to the stereo sense is distinct. When adding constant noise to where the value of D is large, the stereo sense lose immediately, while adding to where the value of D is approximately 0, the stereo sense cannot be impaired. The experiments indicate that the influence of the stereo image to the human eye stereo vision mainly concentrates on where the value of the absolute disparity image is large, and in the position where the value of D is small, constant noise can only affect the quality of the image, not the stereo sense.

3. OBJECTIVE QUALITY ASSESSMENT OF STEREO IMAGE

In this paper, we assess the stereo image quality from two aspects: the objective assessment of image quality and the objective assessment of the stereo sense between the viewpoint pair. Therefore, in this paper the indicator of stereo image objective assessment has two parts, one is image quality, and the other is stereo sense.

3.1. Image quality assessment (IQA)

We follow the method of PSNR when deal with objective quality assessment of an image. And we define the value of IQA as the arithmetic mean of the left and right image assessed by PSNR.

$$IQA = (PSNR_L + PSNR_R)/2 \tag{2}$$

3.1. Stereo sense assessment (SSA)

On the basis of the experimentation above, we concentrate on the assessment of the absolute disparity image. Our objective assessment of the stereo sense follows the method of PSNR. Then we present the model of objective quality assessment of stereo image as follows:

Firstly, we get the absolute disparity image X_1 and X_2 from the original and processed image (Equation 3, 4). Then we get:

$$X_1 = |R_o - L_o| \tag{3}$$

$$X_2 = |R_P - L_P| \tag{4}$$

Secondly, we remove the slight noise and signal with low magnitude from the absolute disparity image of the original image (X_1) so as to decrease the interference. Since the existence of the psychological stereo vision, disparity with low magnitude may be suppressed or enhanced. Because of this, low magnitude signal cannot serve as the assessment. Then we can compute the disparity distribution condition (Fig.5) of the original image.

Fig.5 the disparity distribution condition

Thirdly, we combine X_1, $X_2$and the disparity distribution condition of the original image, compute $PSNR_M$ in the position of the two-eye disparity as SSA, the function is as follows:

$$SSA = PSNR_M = 10\log_{10}\frac{(2^n - 1)^2}{MSE_M} \tag{5}$$

$$MES_M = \frac{\sum_M [X_1(x,y) - X_2(x,y)]^2}{\text{Number of M}} \tag{6}$$

Suppose M is the sum of points witch is white in Fig.5

4. EXPERIMENTAL RESULTS

4.1. Stereo images database

The experiments are conducted on the standard PC, and the synthesis results are shown on the 3D FreeEyE (4210) display with the resolution of 1380×768(made in Tianjin 3D company, China), and the Philips display with the resolution of 1024×768. The viewers are requested to ware the computer 3D imaging glasses, if the images are shown on the Philips display.

Many testing processes on subjective quality assessment have been defined as ITU-R BT.500-11. One common process is Double Stimulus Continuous Quality Scale (DSCQS) [8]. we follow this method in this experiment.

The stereo images used in this experiment are from the stereo image database of school of electronic and information engineering, Tianjin University, China. The subjective stereo sense assessment of the database is based on the following five aspects: the image depth, the comfortable degree of the stereo sense, the existence of the stereo sense, the natural degree of the stereo sense and whether accordance with the visual experience.

4.2. Experimental results

This experiment adopts double-viewpoint stereo images with a total number of 300 pairs, including 30 pairs of original stereo images and 270 pairs of processed stereo images (burr, JPEG, J2K, and so on) for comparison. The image sizes are from 320 x 240 to 1024 x 768

We have computed the values of IQA, SSA and ESSIM (enhanced SSIM introduced in [7]) of the 270 processed stereo images, and the scatter spots of these three metrics and DMOS are as follows:

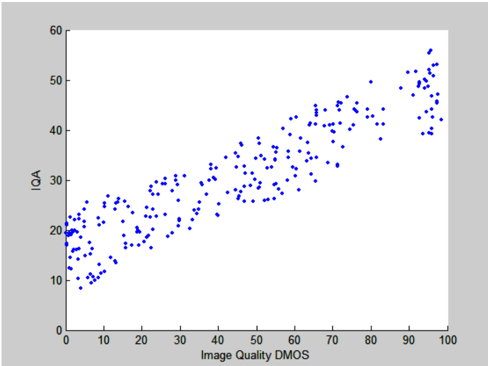

Fig.6 The scatter points of IQA

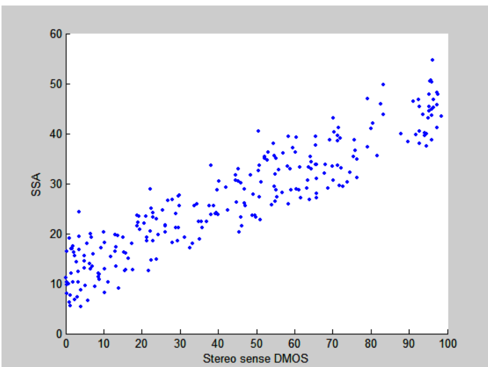

Fig.7 The scatter points of SSA

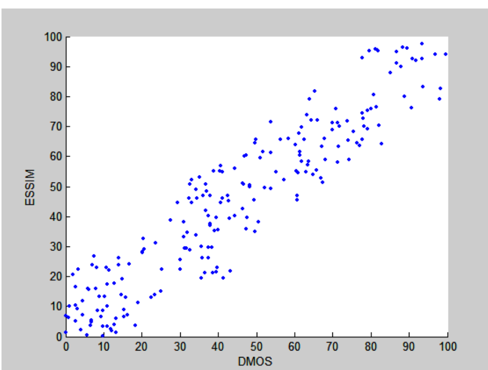

Fig.8 The scatter points of ESSIM

From Fig.6-8, we can notice that IQA and SSA well correlate with the subjective experiments, and the stereo image quality assessment method in the paper is as efficient as ESSIM. However, there is a significant difference between the two methods. In fact method in the paper is at least 20 times faster than ESSIM, because computing depth maps is a time-consuming process.

From the experiments, we can conclude that IQA is suitable for the assessment of the image quality and SSA is suitable for the stereo sense quality, then the combination of the two metrics can be defined as the objective quality assessment model of this paper.

5. CONCLUSION

In this paper, we propose an objective quality assessment method for stereo image originally. This method assesses stereo images from the perspective of image quality and stereo sense. Experiments verify that the objective assessment method of this paper achieves relatively good consistence with the general subjective assessment method, and the method is simple, rapid, convenient and practical

6. ACKNOWLEDGMENT

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