A study on autostereoscopic 3D display crosstalk measurement and quantification

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ABSTRACT

The 3D light field display allows both eyes to perceive different images, giving a three-dimensional effect. However, when an unintentional image is perceived by the eye, one feels dizzy or sees a distortion of the three-dimensional effect, and this phenomenon is called crosstalk. How to evaluate and quantify crosstalk is very important in the development of 3D displays. In this study, a method to define and reasonably quantify the 3D display crosstalk phenomenon was proposed.

1 Introduction

The development of 3D display technology has been actively conducted for several decades, and 3D TV has been commercialized mainly with glasses-type 3D technology. Glasses-type 3D technology was not popular in the market for a long time due to the fact that additional glasses were required to view the video. Therefore, the current display industry is actively developing glasses-free 3D display technology that can view 3D images without wearing glasses. Glasses-type 3D technology can almost completely control the image seen by both eyes through the glasses in front of the eyes. However, since the autostereoscopic 3D technology requires control so that both eyes can recognize images from different views using a lens or barrier attached to the display, relatively severe crosstalk may occur. When the crosstalk phenomenon becomes severe, the viewer may feel dizzy or the image quality such as a three-dimensional effect may be distorted and perceived as compared to the original image. In this study, 3D crosstalk is defined by dividing it into two categories from the views perceived by viewers, and a rational evaluation method and quantification method are presented.

2 Crosstalk definitions and causes

The principle of three-dimensional effect when a viewer watches a glasses-free 3D display is shown in Fig. 1(a). By sending a different image at each view, the two eyes perceive a different image, so that the viewer can feel the three-dimensional effect of the image. However, if the intended image and the unintentional image are mixed and recognized at a specific point in time, As shown in Fig. 1(b), a crosstalk phenomenon occurs.

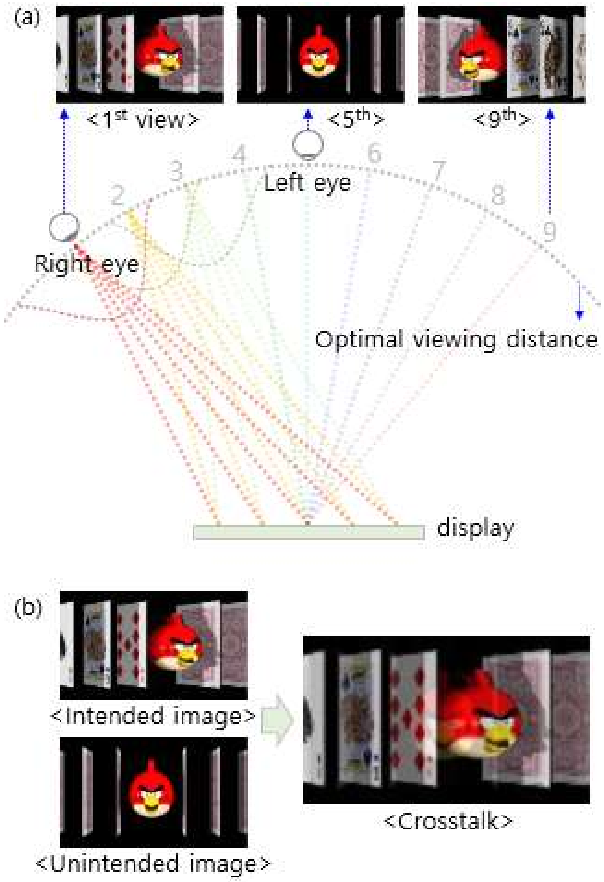

Fig. 1 (a) glasses-free 3D principle (b) crosstalk

The causes of crosstalk that are recognized by mixing other images in addition to the intended image at the time can be broadly divided into two as shown in Fig. 2(a). First, glasses-free 3D technology uses a lens or a barrier to gather images of the corresponding view at one point, but if the images are not accurately gathered, images from adjacent views may be mixed and recognized at one view. This phenomenon is named as “local crosstalk” in this paper, and by this, it is mainly not seen clearly compared to the original image, and viewers feel dizzy when watching for a long time.

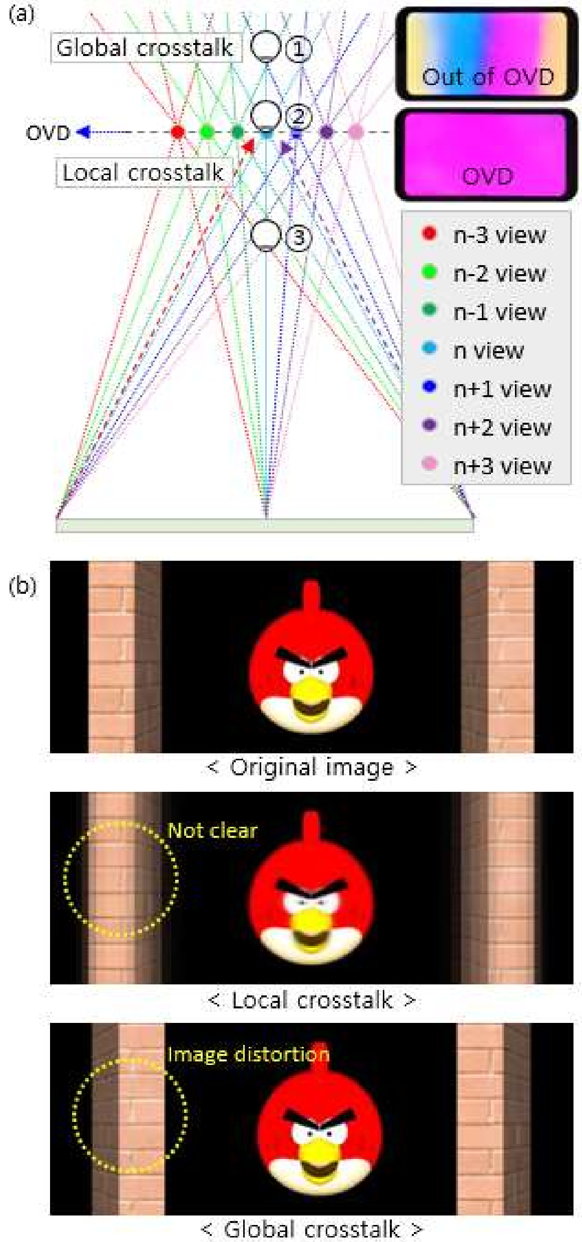

Fig. 2 (a) crosstalk definition (b) crosstalk influence

Second, even though the images for each view are precisely gathered at one point, images from different views may be recognized depending on the display position when the viewer does not watch accurately from the optimal viewing distance (OVD). This phenomenon is named as "global crosstalk". The photo in Fig. 2(a) is taken by assigning images with different uniform colors for each view for easy understanding. When viewing the display at the OVD, the entire image is viewed as one point of view, showing the same color. However, at a position out of the OVD, image from different views is displayed depending on the position of the display. As a result, the viewer perceives distorted image quality such as 3D effect. Fig. 2(b) is an easy-to-understand illustration of the main effects of local crosstalk and global crosstalk.

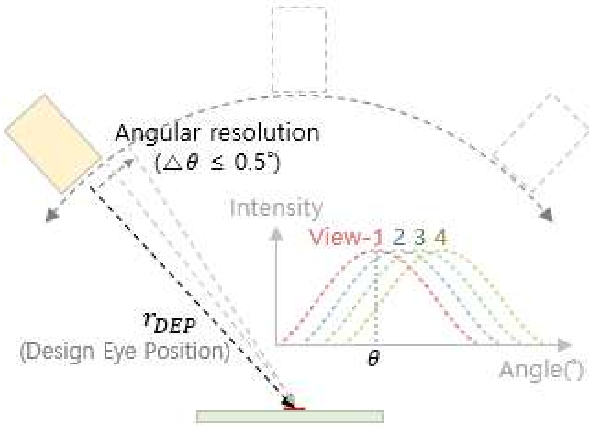

Fig. 3 IDMS crosstalk measurement method

Currently, crosstalk of glasses-free 3D is mainly evaluated by the standard evaluation method defined by IDMS as shown in Fig. 3. The IDMS standard evaluation method drives a specific view and rotates a luminance meter to evaluate at intervals of less than 0.5 degrees to obtain a profile. After that, different views are sequentially driven to evaluate the luminance profile according to the angle of each view in the same way. After obtaining the luminance profile of each view, crosstalk is calculated as the ratio of the luminance of the intended view to sum of the luminance of the unintended views at the corresponding position as shown in equation (1). However, the IDMS standard evaluation method calculates the crosstalk with the luminance value of the central part of the display, so that only the local crosstalk value of the central part can be obtained. In addition, it takes a very long time to measure one view at an interval of less than 0.5 degrees, but the information that can be obtained is quite limited.

$$X_{(i)} = \frac{\int_{j=1}^{n} [L_j(\theta) - L_K(\theta)]}{L_i(\theta) - L_K(\theta)} - 1 \quad (1)$$

3 New crosstalk measurement method

In this study, a new evaluation method and a method to quantify two crosstalks (local crosstalk and global crosstalk) are proposed to compensate for the shortcomings of the IDMS standard evaluation method. The new crosstalk evaluation method is a method of using 2D luminance measuring equipment to evaluate a luminance profile according to the position of the display screen for each view, and then calculate the crosstalk by using them.

Fig. 4 shows the method of measuring crosstalk with a 2D luminance meter and the images evaluated for each view according to the viewing distance. At the position of OVD, the image at the corresponding view (n) on the entire screen of the display looks the brightest, but when it deviates from the OVD, the image at another view is recognized as the brightest depending on the position of the display screen.

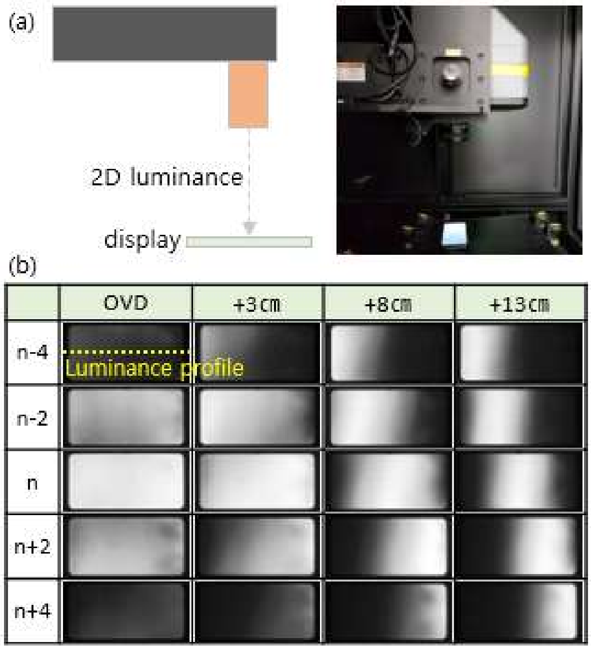

Fig. 4 (a) new crosstalk measurement method (b) measurement image according to view

Fig. 5 is a luminance profile according to the position of the display screen evaluated by the new measurement method. As can be seen from the graph, at the OVD, the image of the intended view is perceived as the brightest in the entire display area, but when viewing from a location out of OVD, the brightest view on the display varies depending on the position on the display screen. As described above, the degree to which images from different views are mixed at a specific location on the display (local crosstalk) is related to the clearness of the image, and the degree to which the perceived view varies depending on the display location (global crosstalk) is related to the distortion such as three-dimensional effect. Since these two crosstalks have different perceived characteristics, the crosstalks were defined separately, and the formula for quantifying them can be simply defined as Equation (2), (3).

$$X_{global(i)} = \frac{\int_{j=1}^{n} [L_j(\theta) - L_K(\theta)]}{L_i(\theta) - L_K(\theta)} - 1 \quad (2)$$

$$X_{local} = \frac{\int_{j=1}^{n} [L_j(\theta) - L_K(\theta)]}{L_{\max}(\theta) - L_K(\theta)} - 1 \quad (3)$$

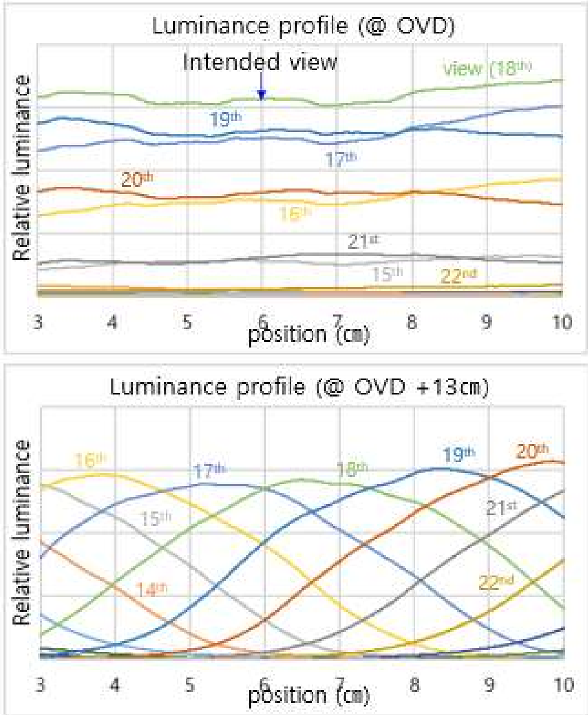

Fig. 5 luminance profile according to view

As shown in equations (2) and (3), global crosstalk is calculated as the sum of the luminance of the image from the other views compared to the luminance of the image from the intended view. Plus local crosstalk is calculated as the sum of the luminance of the image from the other views compared to the luminance of the view image perceived as the brightest at the location. Through the new measurement method, it is possible to quantitatively calculate how much the images from different views are mixed at the position of the display. Figure 6(a) is the result of calculating the crosstalk according to the position of display screen of the multi-view 3D display with an 30cm OVD. As a result of the evaluation by the new measurement method, it can be confirmed that the image looks dizzy as the viewing distance is closer, regardless of the OVD, and the more images from different views are visible on the display screen as the distance is away from the OVD.

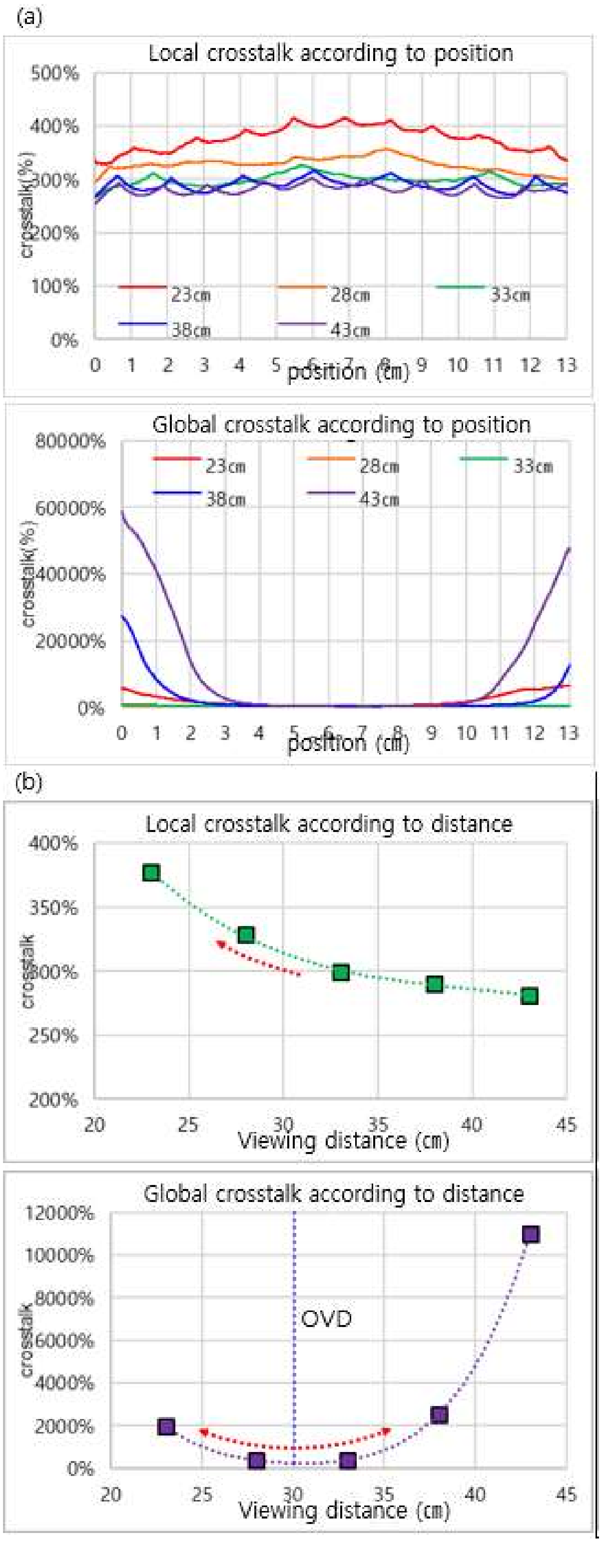

Fig. 6 (a) crosstalk according to position
(b) crosstalk according to viewing distance

4 Results

It is very important to define and quantify the crosstalk of glasses-free 3D. In this study, we defined two types of crosstalk: local crosstalk for the dizziness felt by viewers when images from different views are mixed, and global crosstalk, which causes distortion in image quality such as three-dimensional effect. However, the IDMS standard evaluation method, which is the current evaluation method, does not evaluate these two separately, and among them, only a fraction of the data can be obtained. On the other hand, the new measurement method proposed in this study can calculate each defined crosstalk, and it will be possible to quantify how much dizziness and how much image quality distortion occurs when viewing an actual display depending on the viewer's position.

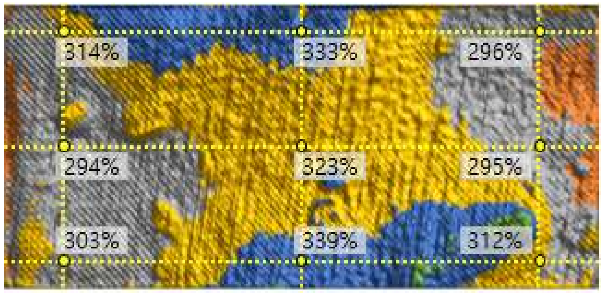

Fig. 7 crosstalk uniformity

In addition, as shown in Fig. 7, it is possible to check the uniformity of crosstalk for each screen position of the display when evaluating with a new evaluation method. Therefore, it is judged that it will be able to help in the selection of a crosstalk improvement direction when developing a 3D display. In the future, it is judged that the calculated crosstalk value and the crosstalk that a person actually feels can be more accurately verified and improved through a cognitive experiment.

References

[1] Atanas Boev "Crosstalk measurement methodology fot auto-stereoscopic screens" 2007 3DTV conference

[2] Minkoo Kang "Adaptive viewing distance in super multi-view displays using aperiodic 3-D pixel location and dynamic view indices" Vol. 26, No. 16 | 6 Aug 2018 | OPTICS EXPRESS 20661

[3] Hyungki Hong "Influence of depth and 3D crosstalk on blur in multi-view 3D displays" Journal of the SID 25/7, 2017