A New 3D Image Switching Method in Arc 3D Display by Selecting Desired Arcs in Arc Array by Projectors with Different Illumination Angles for Changing Depths

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ABSTRACT

We can successfully achieve rewriting or switching 3D images in Arc 3D display by separately illuminating desired arc-shaped scratches in 3 × 3 scratch array when array pitch is 29 mm according to projector resolution of 1 mm. Perceived depth can be changed by illumination angle change.

1 INTRODUCTION

3D displays are promising for digital signage because of easily attracting attention of walking people. 3D digital signage needs 3D glassless, large but simple and inexpensive system, wide viewing angle and smooth motion parallax for walking or stereoblind people. One of precious 3D displays having all these features is Arc 3D display [1].

However, conventional Arc 3D display has difficulty in rewriting or switching its 3D images. This is because, as perceived depth in Arc 3D display is conventionally changed by arc radius change, many arc-shaped scratch array with many changeable radii will be necessary for rewriting or switching Arc 3D images. On the other hand, by using various illumination angles for changing Arc 3D image depths as shown in Fig. 1, only arc-shaped scratch array with the same radius is enough for rewriting or switching 3D images.

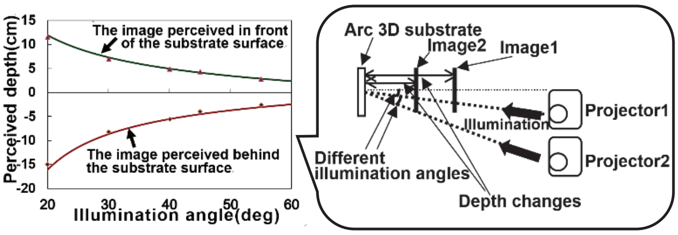


Fig. 1. Perceived depth dependences on illumination angle in Arc 3D display

In this paper, by using various illumination angles for changing 3D image depths, we propose a new method for making possible to rewrite or switch 3D images with various different depths in Arc 3D display.

2 A NEW 3D IMAGE SWITCHING METHOD IN ARC 3D DISPLAY

Our proposed method is composed of grid arrangement of arc-shaped scratches with the same radii and several projectors with various illumination angles.

Figure 2 shows a principle of our proposed method for rewriting Arc 3D images. As shown in upper illustration, various shape of 3D image can be obtained by illuminating only desired arc-shaped scratches of scratch array. Perceived depths can be changed by changing illumination angle as shown in Fig. 1, that is, by selecting the projector of desired illumination angle as shown in lower illustration of Fig. 2.

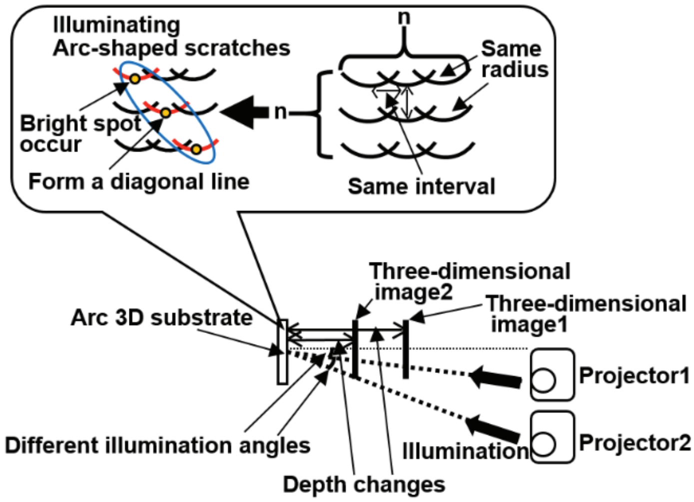


Fig. 2. Proposed method of 3D image switching in Arc 3D display

However, one of problems for selecting desired arc-shaped scratch by using projector is difficulty in separeted illumination around crossing point of neighborhood scratches because of very narrow gap under projector resolution as shown in Fig. 3. In upper and middle illustrations, scratch area apart from top or center regions of scratches can be separately illuminated. However, at small array pitches, top or center regions of scratches have many cross points, resulting in difficulty in separated illumination by horizontally overlapping. This leads to small separable illumination regions and large non-separable regions at small array pitches.

On the other hand, as shown in lower illustration by increasing array pitches, large non-separable regions are disappeared and non-separable regions are restricted to cross points themselves.

To overcome this problem, we evaluated separated illumination possibility of neighborhood scratches by changing pitches of scratch array.

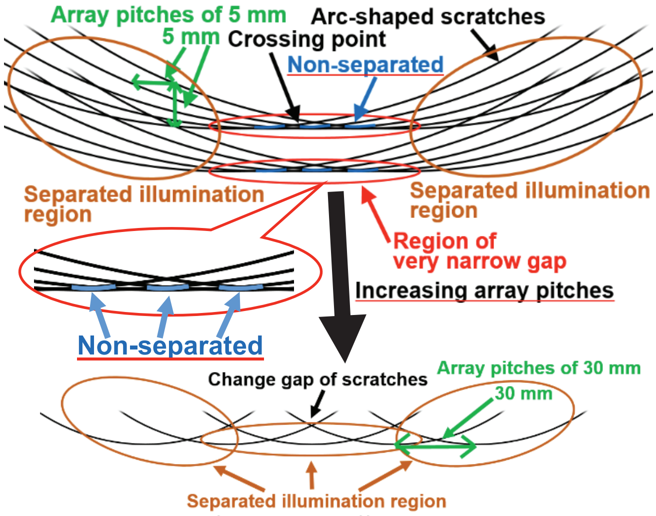


Fig. 3. Problem of selecting difficulty by non-separated arc shaped scratches and its solution by increasing pitches

3. EXPERIMENT 1: SEPARATED ILLUMINATION OF DESIRED ARC-SHAPED SCRATCHES (GRID-LIKE ARRAY: 3 × 3)

We have evaluated separated illumination possibility of neighborhood scratches at grid-like array: 3 × 3 of arc-shaped scratches.

3.1 The experimental system of estimating 3D image switching method of arc 3D display

Figure 4 shows the experimental system of estimating 3D image switching method of arc 3D display. Grid-like array: 3 × 3 of arc-shaped scratches had array pitches of 29 mm and 30 mm with arc radius of 7 cm. Designed arc-shaped scratches were three obliquely arranged scratches as shown in left illustration of Fig. 2. Illumination projector angle was 30 degrees from below. Vertical resolution of the projector was 1 mm on Arc 3D display surface.

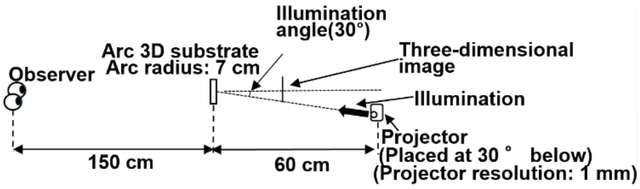
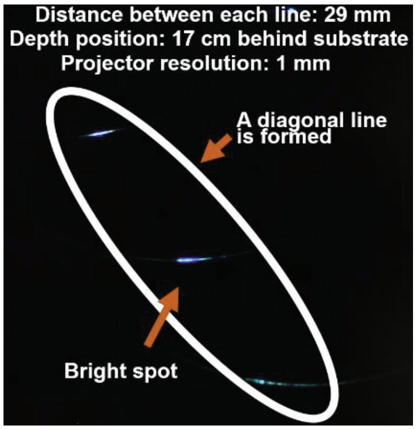


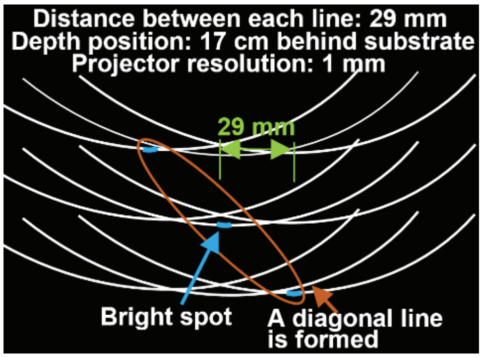
Fig. 4. Experimental system of estimating 3D image switching method of arc 3D display

3.2 Separated illumination possibility of neighborhood scratches by changing pitches of scratch array.

Figure 5 shows the (a) photograph and (b) its illustration of selecting three obliquely arranged scratches as shown in left illustration of Fig. 2 when array pitch is 29 mm. 3D image depths can be perceived at 17 cm behind Arc 3D display surface. This photograph shows that separated illumination of desired arc-shaped scratches can be successfully obtained.



(a) Photograph



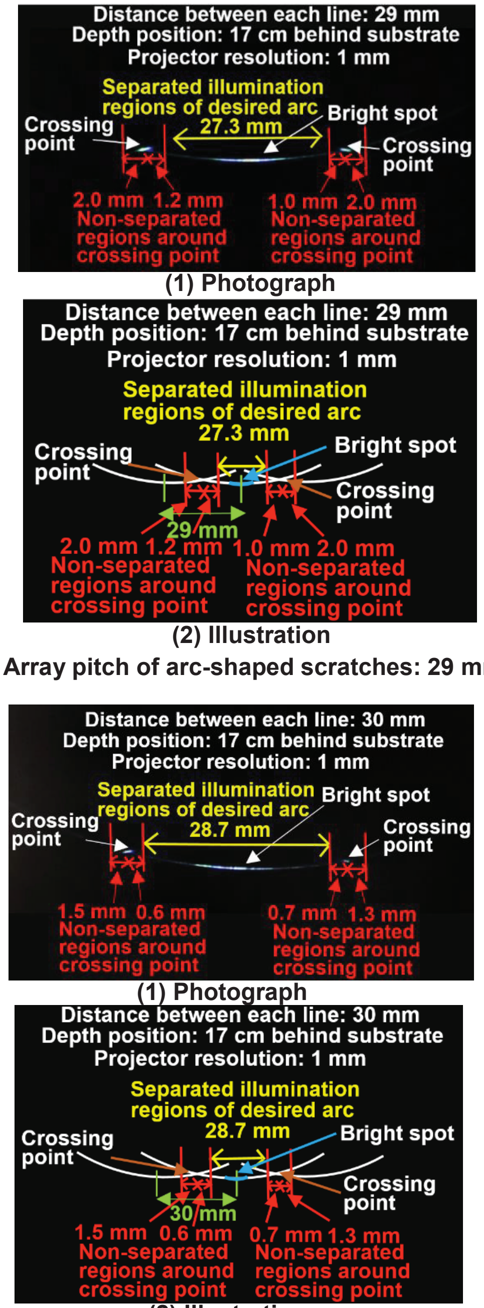
(b) Illustration

Fig. 5. Separated illumination of desired arc-shaped scratches (a diagonal line (3 × 3))

In order to evaluate separated illumination possibility of neighborhood scratches around crossing point of neighborhood scratches, precise photographs and their illustrations between neighborhood crossing points are shown in Fig. 6 at array pitches of (a) 29 mm and (b) 30 mm according to projector resolution of 1 mm.

Figure 6(a) shows, at array pitch of 29 mm according to projector resolution of 1 mm, inseparable region of neighborhood scratches around crossing point is 1.2 mm on the right side and 2.0 mm on the left side from left crossing point, and 2.0 mm on the right side and 1.0 mm on the left side from right crossing point. Separable region between neighborhood crossing points is 27.3 mm. This separable region of 27.3 mm is large enough as compared to array pitch of 29 mm.

Figure 6(b) shows, at array pitch of 30 mm according to projector resolution of 1 mm, inseparable region of neighborhood scratches around crossing point is 0.6 mm on the right side and 1.5 mm on the left side from left crossing point, and 1.3 mm on the right side and 0.7 mm on the left side from right crossing point. Separable region between neighborhood crossing points is 28.7 mm.



(1) Photograph

(2) Illustration

(a) Array pitch of arc-shaped scratches: 29 mm

(1) Photograph

(2) Illustration

(b) Array pitch of arc-shaped scratches: 30 mm

Fig. 6. Difference of separated illumination regions by array pitch difference according to projector resolution of 1 mm

4 EXPERIMENT 2: SEPARATED ILLUMINATION OF DESIRED ARC-SHAPED SCRATCHES WITH ALTERNATELY VERTICALLY-SHIFTED ARRAY OF 5 × 5

To reduce non-separated regions of arc-shaped scratches, we propose a new method for changing arrangement of arc-shaped scratches from simple grid-like array to alternatively vertically-shifted array as shown in Fig. 7. We have evaluated separated illumination possibility of neighborhood scratches in a new method of grid-like array: 5 × 5 with alternately vertical shift by 15 mm.

4.1 Proposed method of arc-shaped scratches with alternately vertically-shifted array

Figure 7 shows illustration of proposed method of alternatively vertically-shifted array to reduce non-separated regions of arc-shaped scratches. Grid-like array: 5 × 5 of arc-shaped scratches of array pitches of 30 mm with arc radius of 7 cm are alternately shifted by 15 mm in vertical direction. By using a new arrangement with alternately vertical shift, non-separated region can be restricted to very small part composed of only cross points themselves.

The same experimental system for estimating 3D image switching method of arc 3D display was used as shown in Fig. 4. Designed arc-shaped scratches were five obliquely arranged scratches as shown in Fig. 7. Illumination projector angle was 30 degrees from below. Illumination vertical resolution of the projector was 1 mm on Arc 3D display surface.

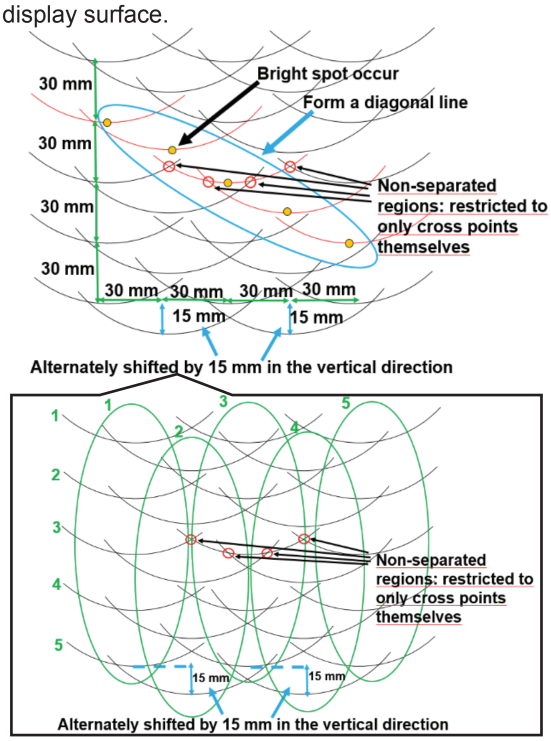
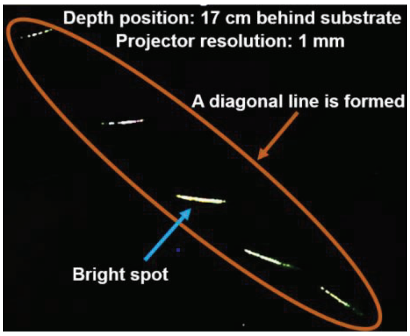


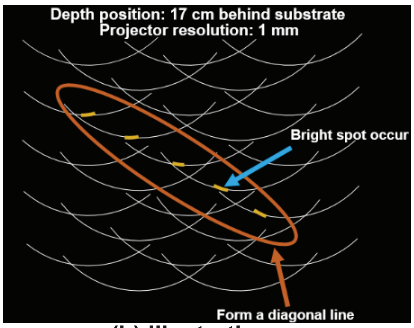
Fig. 7. Illustration that Grid-like array with alternately vertically-shifted array by 15 mm

4.2 Separated illumination possibility of neighborhood scratches with alternately vertically-shifted array

Figure 8 shows the (a) photograph and (b) its illustration of selecting five obliquely arranged scratches as shown in Fig. 7. 3D image depths can be perceived at 17 cm behind Arc 3D display surface. This photograph shows that separated illumination of desired arc-shaped scratches can be successfully obtained.



(a) Photograph



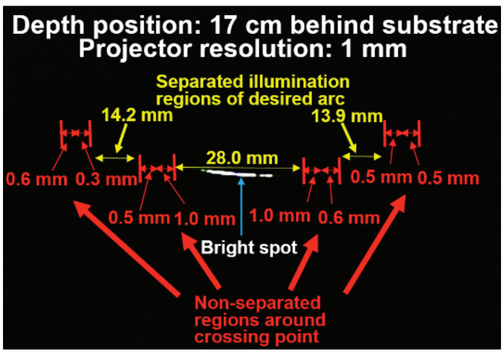
(b) Illustration

Fig. 8. Separated illumination of desired arc-shaped scratches with alternately vertically-shifted array

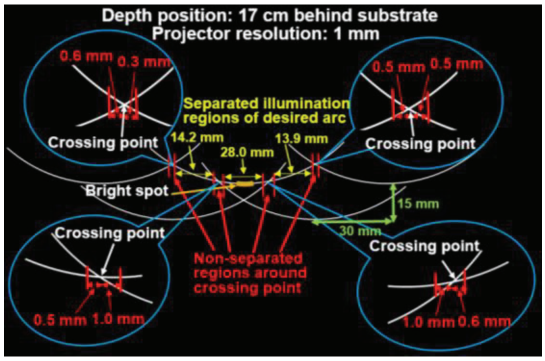
In order to evaluate separated illumination possibility of neighborhood scratches around crossing point of neighborhood scratches, precise photographs and their illustrations between neighborhood crossing points are shown in Fig. 9 according to projector resolution of 1 mm.

Figure 9 shows arc-shaped scratches at alternately shifted array by 15 mm in vertical direction according to projector resolution of 1 mm. Inseparable regions of neighborhood scratches around crossing point are 0.3 mm on the right side and 0.6 mm on the left side from left-edge crossing point, and 1.0 mm on the right side and 0.5 mm on the left side from second left crossing point, and 0.6 mm on the right side and 1.0 mm on the left side from second right crossing point, and 0.5 mm on the right side and 0.5 mm on the left side from right-edge crossing point. Separable regions between neighborhood crossing points are 14.2 mm, 28.0 mm, and 13.9 mm.

Thus, inseparable regions are reduced as compared to simple grid-like array as shown in Figs. 3, 5 and 6.



(a) Photograph



(b) Illustration

Fig. 9. Separated illumination regions with alternately vertically-shifted array according to projector resolution of 1mm

5 CONCLUSIONS

We evaluated separated illumination possibility of neighborhood scratches in array arrangement of arc-shaped scratches in Arc 3D display.

At array pitches of 29 mm and 30 mm, separated illumination of desired arc-shaped scratches can be successfully obtained.

By changing pitches of scratch array, as separable region difference between at array pitches of 29 mm and 30 mm is about 1.4 mm, separable region is normally changed according to array pitch change. This indicates that minimum limitation of array pitch will be estimated because separable region can be easily changed by changing array pitch.

We also proposed a new arrangement of scratch array in order to reduce inseparable region. By alternatively vertically-shifted array arrangement, inseparable regions can be successfully reduced.

Thus, we can successfully achieve rewriting or switching 3D images in Arc 3D display by separately illuminating desired arc-shaped scratches.

ACKNOWLEDGMENT

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