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The use of color in scattered light for 3D touchable holographic light-field display

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1. Introduction

Recently, the 3D user interface (UI) has been developed by lots of studies. For realizing intuitive, simple, and low-cost 3DUI, we have been developing a 3DUI based on the 3D real-image display and the touch detection system to the image, which is named as 3D touchable holographic light-field display. Our UI system consists of a projector and an off-axis convex-mirror-array hologram for light-field imaging, and a camera and a computer for the touch detection. Figure 1 shows the overview of the system. As shown in Fig. 1, a camera behind the transparent hologram is used to detect the touch of the 3D image via sensing scattered light. In our previous study, we demonstrated such UI with floating 2 buttons with simple thresholding processing [1]. This paper extends the number of color in our 3DUI based on a color-recognition algorithm, and experimentally evaluates the accuracy in color of the algorithm.

2. Color recognition algorithm of scattered light

After capturing scattered light from an object touching to a 3D image, the data is processed for recognition of its color. At first, the event of touch is detected by background subtraction, noise reduction, and thresholding. Next, the distance of RGB values between captured and registered data is calculated to recognize the touched color. Note that the registered data with known color labels have to be made in advance. Figure 2 shows the experimentally obtained RG values with known color labels. As shown in Fig. 2, the values of each data have variances along its orthogonal bases in practical situation, thus we used the Mahalanobis distance for calculating the distance. To avoid the false color recognition, we put thresholds in the distances.

3. Experiment

We experimentally evaluated the accuracy of the color recognition by using the setup of 3DUI in Ref. 1 with a DCI 4K projector (VPL-VW500ES by Sony). In the experiment, we displayed floating buttons with 7 colors simultaneously, touched them with a white plastic pencil, and captured the scattered light by a camera. Afterwards, we compared the color-recognition result and the known color label. We obtained accuracy through 20 touch-recognition experiments in each color.

The achieved accuracy of the recognized color was 49% using Mahalanobis distance with current setup. The accuracy was 24% greater than that with Euclid distance.

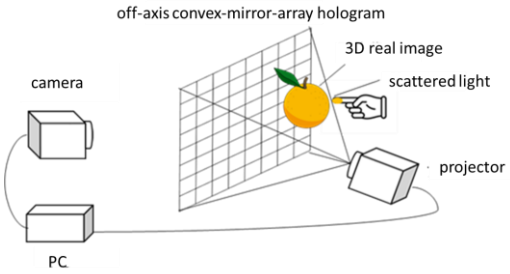

Figure 1. Overview of the system.

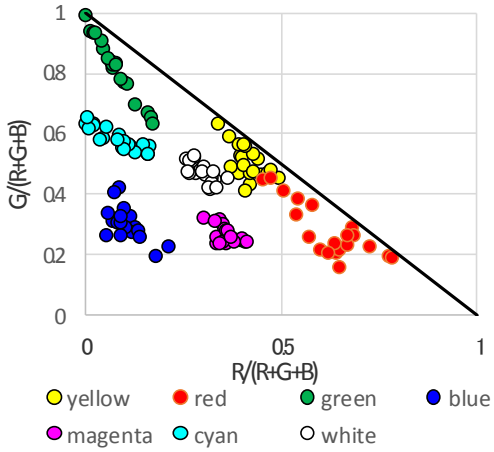

Figure 2. Distribution of RG data of the scattered light from a touching object in our 3DUI.

4. Conclusion

We developed a color-recognition system of scattered light for our 3D touchable UI, and evaluated the accuracy of the recognition. Currently we used 7 colors as an example, however, the limit of the color number and the resultant accuracy will be investigated in future works. Our system is intuitive, simple, and low-cost as 3DUI, thus it can be applied to interactive digital signage, safe dial lock, sanitary UI for medical purpose, and so on.

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References

[1] M.Yamaguchi and R.Higashida, Appl. Opt. **55**, A178-A183 (2016).