# Personally Supported Dynamic Random Dot Stereogram by Measuring Binocular Parallax

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## ABSTRACT

We present a novel approach to the use of gaze tracking as a means of supporting the experience of a Random Dot Stereogram (RDS). RDS is a method for producing an apparently noisy image that actually contains a stereoscopic scene, which becomes visible under a certain parallax of the eyes [1]. Although adjustment of eye convergence is required for RDS, many people have difficulty in making this adjustment. We implement a system by which most can stably experience stereoscopic images from RDSs. We confirmed that the times users took to find stereoscopic scenes in dynamic RDSs (d-RDS) were significantly decreased compared with presenting d-RDSs with fixed parallax. We also demonstrate this system as a means of secure information display when users input a password.

## Author Keywords

Random dot stereogram; eye tracking; security

## ACM Classification Keywords

H5.2. Information interfaces and presentation: User Interfaces – *Input devices*

## INTRODUCTION

Gaze input has been studied for many years [2] [3]. In most cases, it allows users to input information without using their hands, which is an important application, critically so for disabled people. Gaze-tracking devices can be classified to two types: one detecting a monocular eye movement and the other detecting a binocular eye movement.

In most cases, monocular eye movement is used for input, with the rare exception of using binocular eye movement for realizing 3D space interaction. Kudo et al. used divergence eye movement as a "pressing" operation by moving participants' viewpoint forward [4]. Sato used binocular parallax as method of selecting a cross-section of 3D data, such as a MRI image [4]

We use binocular eye measurement as a new way of creating a personally-supported random dot stereogram (RDS). RDS is a set of seemingly random dots that produces a stereoscopic image when the eyes have a certain parallax [1]. Many books covering RDSs provide cognitive entertainment. However, although it is necessary to adjust eye convergence to view the stereoscopic image, there are large individual differences in this adjustment capability.

We present a system that can assist most individuals to experience stereoscopic images from RDSs by measuring a binocular eye parallax and then generating the RDS with the correct parallax in real-time.

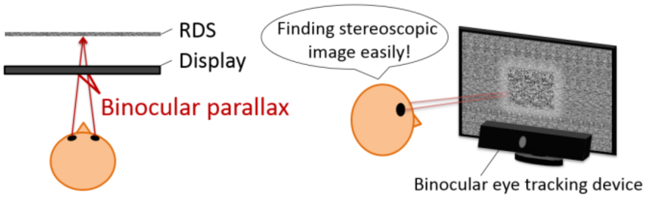

**Figure 1. Concept of stereoscopic support in d-RDS.**

## EVALUATION

We evaluated the efficacy of our method after confirming the accuracy of the depth estimation. Our hypothesis was that the time users took to find stereoscopic image in d-RDSs generated by our method significantly decreased compared with presenting d-RDSs with fixed parallax.

### Experimental setup

A chin support was set up on a desk 700 mm in front of the display to fix the eye position. Although eye parallax was necessary before generating d-RDS in our system, a preliminary experiment revealed that for some people, intentionally staring at the back of the display without any cue was difficult. Therefore we provided markers in front of the display and showed users mirror images of the markers reflected on the display. Two mirror images were set at 211 mm and 700 mm behind the display.

AH '15, March 09 - 11, 2015, Singapore, Singapore

### Experimental method

We prepared two conditions. One was our method, in which users were asked to look at one of two mirror images of the markers. D-RDS with correct parallax based on measurement of binocular parallax was presented to the user. They were asked to look at two mirror images one after another in 10 sets. In the other condition, d-RDSs with fixed parallax, which varied from 30 pixels to 100 pixels in the display plane, were presented randomly. Participants were allowed to see two mirror images to keep the conditions fair. The d-RDS contained either a circular, square, or triangular shape that changed randomly. Response time was measured.

### Results

Figure 2 shows the average time that each participant required to find the stereoscopic image and the total average. The average time of our method (1.3 s) was significantly smaller than that with fixed parallax (2.6 s) (t-test: p-value = 0.000573 < 0.05). This result shows that our method has the ability to present personally-supported d-RDS to the user.

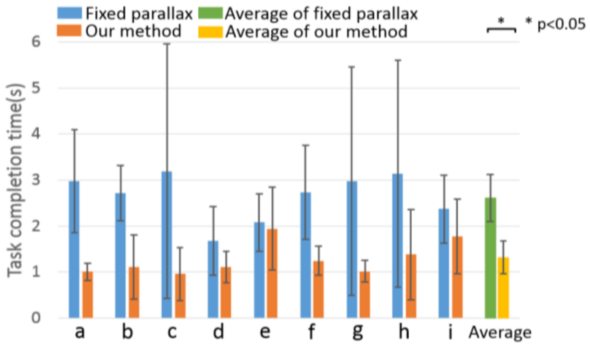

**Figure 2. Average time that each of the 9 participants needed to find the stereoscopic image and their total average in each of the two conditions.**

## APPLICATION TO SECURE DISPLAY

We developed a system that allows the stable observation of a d-RDS. From another point of view, this system allows a specific individual in front of the display to observe the stereoscopic images while nearby individuals cannot see it. Thus, the system might be used as a means of secure information display. We developed a password input system and evaluated the usability of this system.

### Experimental method

We prepared a combination of three shapes, circle, square, and triangle, as a three-character password. The passwords were composed of three combinations of each shape, giving 27 combinations. The participants were asked to remember a randomly generated password for each trial. Three mirror images of markers were prepared for the same reason as in the previous experiment. Figure 3 shows the setup of the experiment and d-RDS containing three shapes. We also presented a small circle drawn by the RDS that represents the cursor (in the right side of Figure 3, it is on the triangle). We recorded the time required for one character and for three characters, as well as error rates. 8 volunteers participated in the experiment, 10 sets for each participant.

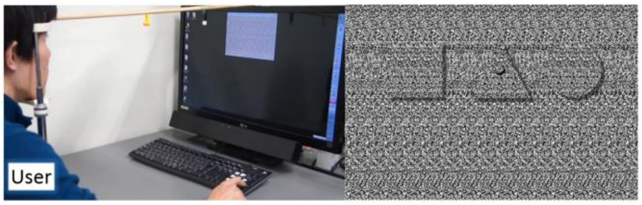

**Figure 3. Setup of the experiment and the appearance when the user found the stereoscopic image in the d-RDSs.**

### Results and discussion

The average time that users input one character (all 240 times) was 2.03 seconds and three characters (all 80 sets) was 12.2 seconds. The error rate was 7.1% (17/240). Overall, users could find the stereoscopic image in the first second and could select and input one character in the next second. Three-character input took 12 seconds because it contained a selection of mirror images of markers. The total error rate was high, but 10 out of 17 errors were generated by a single participant, and the average error rate of the other participants was 3.3%. The participant might have pressed the enter key before the eye position was fixed.

## CONCLUSION

In this paper, we presented a method of using a binocular gaze tracking device as a new means of supporting the stereoscopic experience in RDS. We confirmed that the time that users took to find a stereoscopic image was significantly decreased in our method compared with presenting d-RDS with fixed parallax, which shows the efficacy of our method. We also presented an application to use RDS as a means of secure information display.

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