Dynamic stereograms based on eye convergence for displaying multilayered images

Michi Sato
The University of Electro-Communications
michi@kaji-lab.jp

Hiroyuki Kajimoto
The University of Electro-Communications
kajimoto@kaji-lab.jp

1 Multilayered graphics

This study proposes a simple method to display volumetric data such as MRI images. Currently, 3D representation using binocular vision is quite popular; however, although this method can display a 3D surface model, it is quite difficult to grasp the internal structure of the model from a 3D representation. Furthermore, the resolution is not sufficient for many practical applications, such as diagnosis.

Another currently used method is multilayered graphics, which presents cross sections of volumetric 3D data. Some volumetric 3D displays are capable of showing such graphics [1][2]. Traditionally, many types of spinning [3][4][5] or stacked [6] screen(s) have been invented. However, they are too large in practical use. Although a method using a commercial 2D flat screen is practicable, it requires that the depth or index of the images be explicitly selected by the user [7]. Therefore, an intuitive and simple method to select cross-sectional images is required.

To this end, our idea is to use the convergence of the user's eyes. As the convergence is semi-automatically modulated according to the distance of the image, it can be used as an index for image selection.

2 Convergence-controlled dynamic stereogram

The key feature of our method is the use of a dynamic stereogram. A typical stereogram is a pair of images that fuse when the convergence angle matches the disparity; such a stereogram requires the user to adjust the convergence. In contrast, our method automatically presents a dynamic stereogram in which the disparity between images matches the user's current convergence angle.

The system is composed of a gaze tracker (EyeTech Digital Systems, Inc., TM3 with 1° accuracy) and a PC monitor (Figure 1).

The procedure is summarized as follows:

1) A set of multilayer images (for example, a set of MRI cross-sectional images) is prepared.
2) The gaze tracker determines the positions of the user's eyes.
3) The depth of convergence is calculated.
4) An image with the same depth is selected and displayed with the appropriate disparity.

Figure 2 illustrates the display method. Although the prepared multilayer images are not stereoscopic (i.e., only one image is prepared for a given depth), the images are displayed as a stereogram. The convergence angle measured by the current gaze tracker is accurate to within 1°, which limits the maximum distance between the screen and the user's head to 1 m. This system is the initial display method that a common PC monitor operates as volumetric 3D display without glasses.

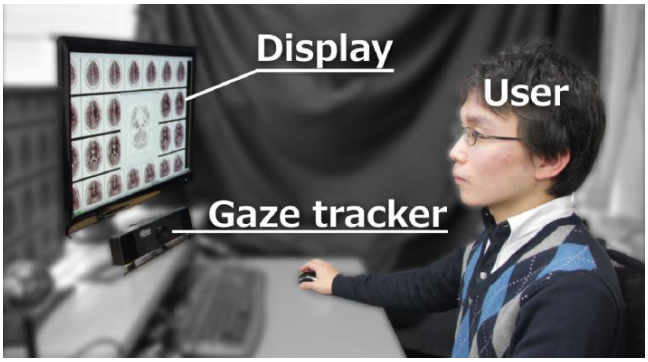

Figure 1. System overview.

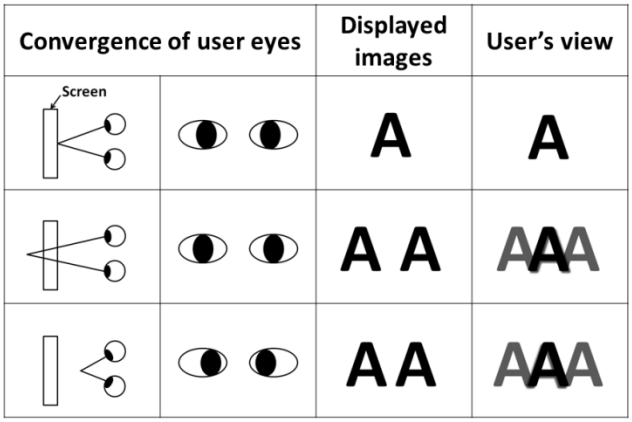

Figure 2. Display method.

An important consideration of this system is a difficulty of optional vergence control. Some users cannot freely control their convergence. They are presented with real small markers in front of the screen as references for convergence control (Figure 3). The distance between the display and the user is about 60cm, and the reference markers are located within 30cm from the display. The other consideration is vergence-accommodation conflicts. Therefore, the range of convergence depth of our system is fall within comfortable zone that vergence-accommodation conflicts are not induced [8][9].

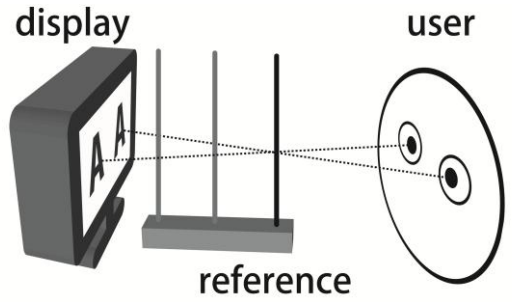

Figure 3. An example of reference markers. In fact the reference bars are quite small (less than 5mm diameter).

Although our system has the advantages compared with prior works as referred to above, it shows a pair of unnecessary ghost images with an intended image (Figure 2). In order to avoid them, another type of the system is being developed in which a typical 3D television is used instead of a 2D monitor. Furthermore, the reference markers can be displayed translucently with it. Such a simple system could not only be applied to the display of medical cross-sectional data but could also be used a novel gaze input application and selecting layers on graphic software.

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