2021 年度　修士論文概要					
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論文題目	AR Paper Document Zoom Glasses System for Presbyopic People 老視者のための実際の紙ドキュメントが拡大されたように見える AR 拡大眼鏡システム				

1 Introduction

E-books are easy to be zoom-in, but older people are prone to presbyopia and they are more inclined to read printed books. Although reading glasses are often used when the people suffering from presbyopia to read paper document, it is necessary to repeatedly remove and put on the glasses, when they are for example taking notes and other operations on a desk. It is difficult to cope with such complex situations even if using multifocal glasses. By the way, the automatic display zoom system of a smartphone and a tablet for presbyopic people has been proposed in our laboratory [1]. In this paper, I propose an AR paper document zoom system using see-through HMD glasses. Presbyopic people can read enlarged paper documents easily through the glasses.

2 System over view

In order to realize AR paper document zoom-in, a camera is of course needed to shoot at paper document. The image information in the reader's field of view is needed to be shot in real time first. The camera is mounted on a HMD glasses (Fig. 1(a)). Then the paper document area is extracted from camera image to prepare for only document area zoom-in. It is not a simple task to extract the document area from general scene image. A paper may bend, and the edges of it may not become smooth straight lines. The paper material is able to be similar color of background. The background situation will also become complex, and sometimes there may be a frame image like a paper document. In order to validating my idea of AR zoom glasses, it is assumed for a prototype system that the paper document is a clear white rectangle in dark color background that is not white, and does not bend. The reader's hands or other things do not cover the corner of it. However the paper can be rotated in 3D space. Finally the clipped document area is overlaid in the user's field of view through the AR glasses (Fig. 1(b)), and a user-adjustable magnification is provided.

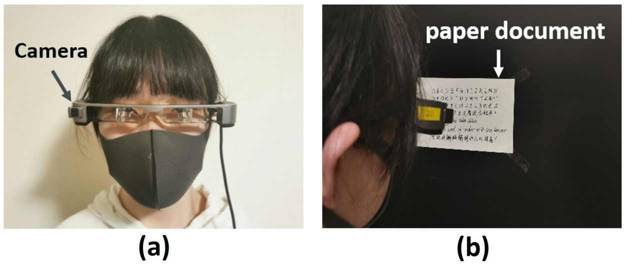

Figure 1: (a) See-through HMD glasses, (b) Appearance of an experiment.

3 Prototype system

First a camera on the HMD obtains the user's field of view image. Based on the assumption mentioned above, several scans in different directions are performed to obtain the four vertices of the target area. The highest and lowest vertices in the target area are identified, and a slope between the two points is calculated (Fig. 2(a)). The remaining two vertices are scanned from side edges to center (Fig. 2(b)). When a user holds a document, the user's hand may cover the target document area, in which case occlusion occurs in the area. In particular, when the hand covers the vertices of the target document area, the accuracy of determining the target area will be reduced. To solve this problem, the target area is scaned multiple times in four parallel directions, up, down, left and right, to obtain the coordinates of the boundary points of the target area (Fig. 3(a)). Based on these coordinates, the correct slope is calculated and filtered to construct a linear equation. The intersection points of each line are calculated by the equation to obtain the coordinates of the vertices of the target area. No matter how the area is rotated or how many vertices are missing, these covered vertices can be correctly identified, and at the same time, slight variations of

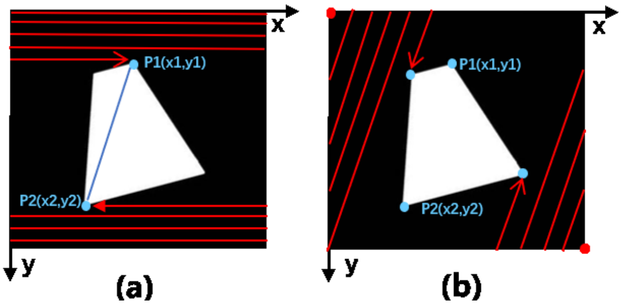

Figure 2: (a) Determine the highest and lowest feature points, (b) Determine remaining two feature points.

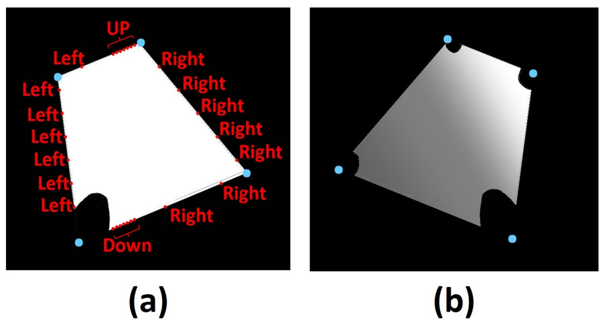

Figure 3: (a) Determination the missing vertex, (b) Determination with lighting variation.

lighting do not affect the results (Fig. 3(b)). Although the user sees the dark color background and white paper that are originally included in the field of view (Fig. 4(a)), they also see the enlarged part of the paper extracted from the camera image (Fig. 4(b)). It is difficult to take an AR seen photo through an HMD, an illustrative composite image is shown. The point of the document as the center of the view stays after enlarged (Fig. 4(c)). An user sees AR overlaid view like the illustrative composite image as the field of view (Fig. 4(d)).

4 Experiment and conclusion

An HMD glasses device; EPSON BT-300 was used to build the prototype system (Fig. 1(a)). I selected a few readers whose age around 50 as I experimental subjects. Although its focal length was not written on the manual, I found this HMD glasses could fit to presbyopic people whose focus length of 300mm and 500mm respectively in the pre-experiment. In the experiment, First I needed subjects to face a black plate with white document (Fig. 1(b)), and move to a distance that is difficult to see. Then I asked them to

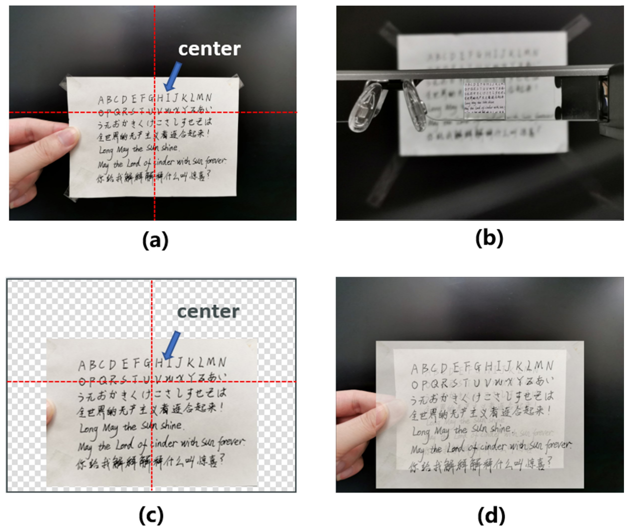

Figure 4: (a) Field of view from camera, (b) Zoom-in view through glassses, (c) Enlarged image for display, (d) Illustrative composite image as field of view.

read the text on the white document, and take some notes about it in the meantime. Next, I asked subjects to wear the HMD, and perform the same work again. When a subject click the zoom button of the system, it starts scanning the camera image. The paper area is automatically recognized, and the enlarged area is overlaid on the HMD (Fig. 4(b),(d)). Subjects can change magnification of zoom manually. After all these, I used a questionnaire to obtain the reading experience and feelings of all the experimental subjects on whether they were equipped with HMD or not. Subjects indicated that it is easier to operate than adjusting the glasses and moving head or the document to focus, and to find the appropriate magnification using touchpad. They also mentioned that this system can make it more convenient to take notes or other hand's tasks. In the future, target area recognition should be generalized for, i.e. any background or any document, by applying CV technology. It is important how the technique compares to bifocal or progressive lenses. I also would like to detect the distance between the eyes and the paper document, and determine whether enlarge operation is needed automatically [1].

References

[1] Huiyi Fang and Kenji Funahashi, "Automatic display zoom for people suffering from presbyopia", SIGGRAPH, 2018.