Pattern Recognition Presentation

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Topic

An eye behavior measuring device for VR system

Introduction

- Over the several years in technology development, VR(Virtual Reality) became very popular and it varied among many kind of fields.
- However, one the unknown question is what is the most interesting part when the users use the VR system? Within this question this paper aims to design a eye-behavior-measuring device for VR systems.
- At present there are several systems for eye-tracking including:
  - **Piezoelectric eye-tracking system:** It detects eye movement based on electrical measurement of difference between the cornea and the retina. But, sweat may effect electrical signal badly.
  - **Magnetic eye-tracking system:** It similar to piezoelectric but a magnetic field is created to measure eye movement.
  - **Image eye-tracking system:** It applies one-point, linear scanning or matrix scanning. This method is useful for psychometry research.

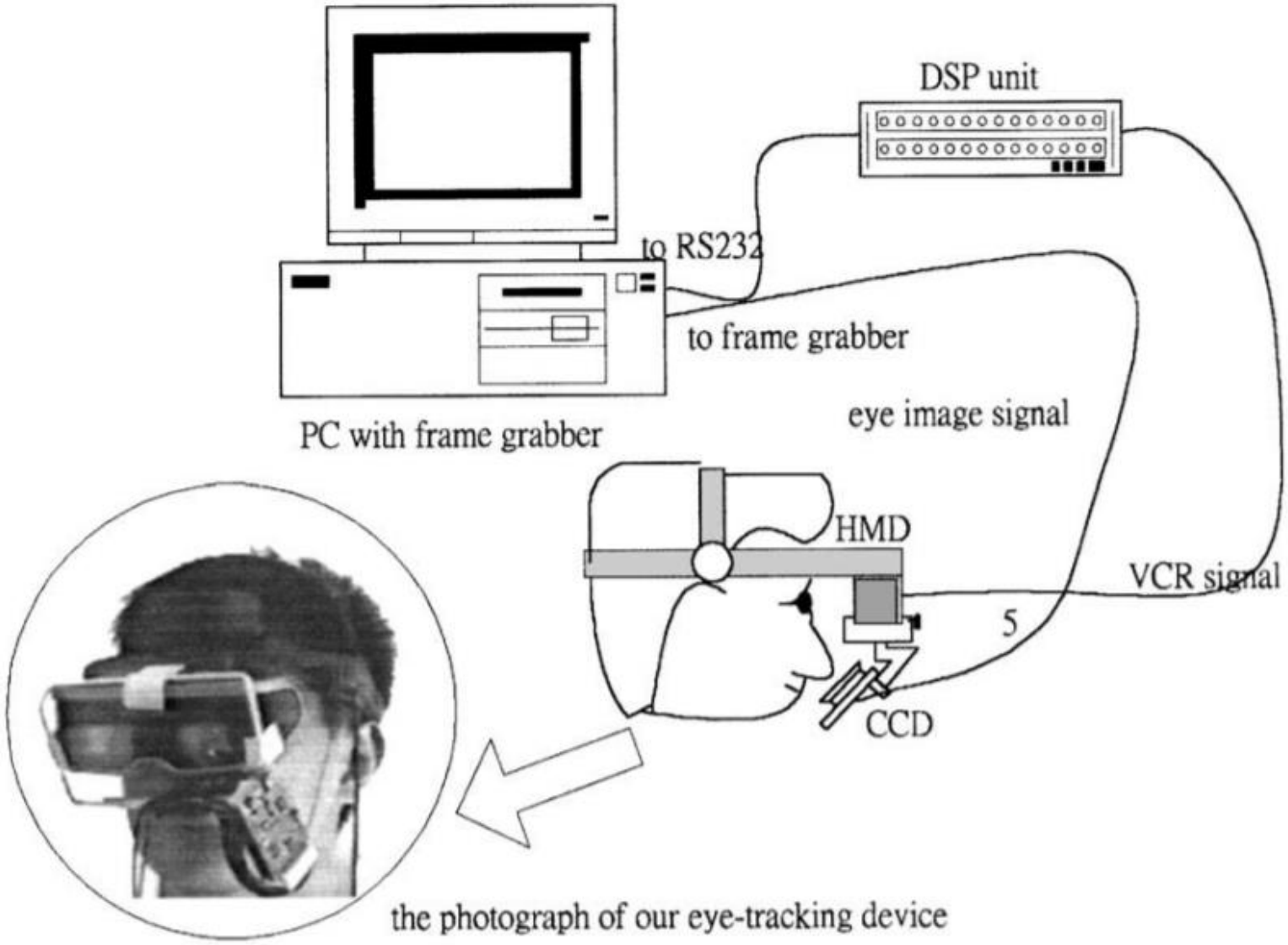


Fig. 1. The arrangement of the eye measurement system for immersion VR.

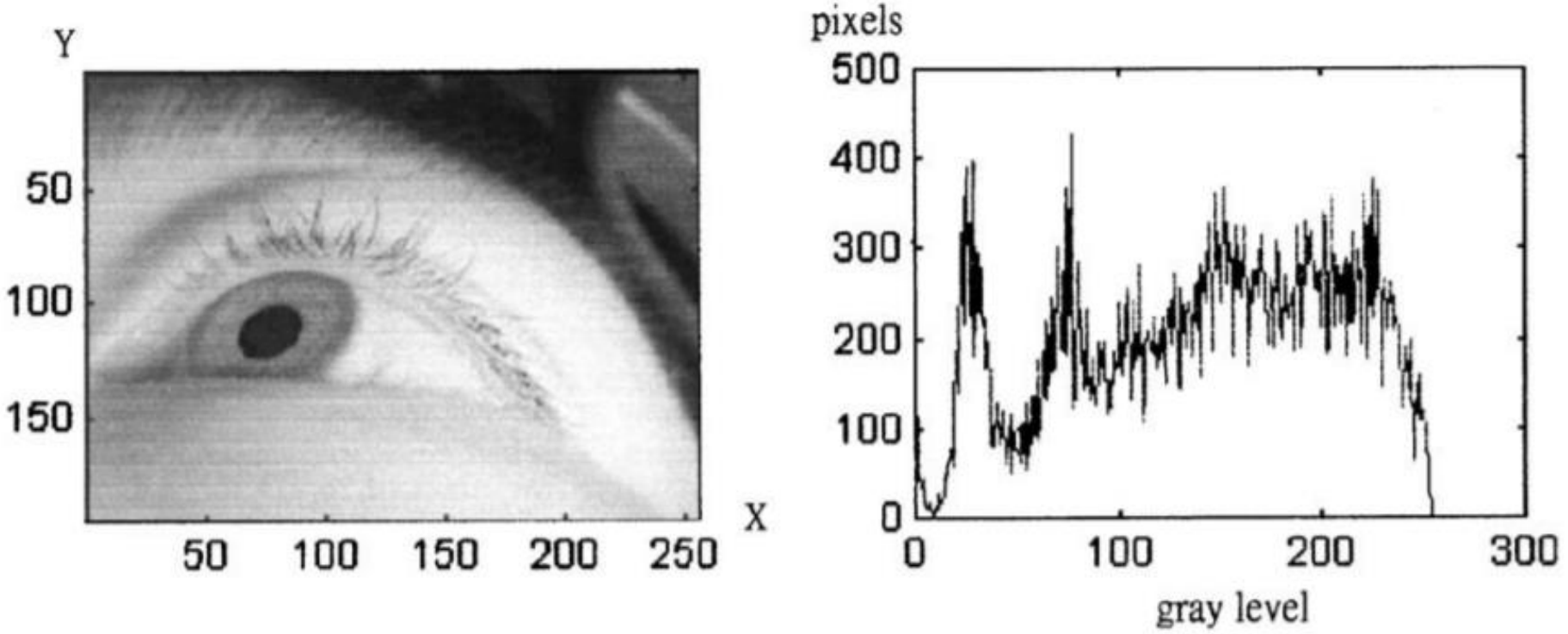


Fig. 2. The histogram of an eye image.

Image Processing for eye behavior evaluation

This method is useful for psychometry, ophthalmology, physiology and VR system.

The steps of this method:

1) Capture eyeball image using capturing device
2) Calculating eyeball position and pupil area from the image utilizing image processing.
3) Displaying the image on the VR and transmit it to the DSP unit in real time.
4) Calculating an average brightness or contrast value using computer.
5) Analyzing the average brightness or contrast value, the eyeball position and pupil area.
6) Recording and reporting the date for all the calculated items.

The eye behavior depends on individual and general parameters such as visual activity, resolution, detection characteristics, different-sized pupil, lighting level of the viewed scene, luminance, contrast, time, type of scenario, the speed of target's motion, target interests.

Here is vertical and horizontal lines are used the check eye location.

The steps of algorithm are:

1. Check the pixels of the image with a search box from left to right and up to down. Check only the right and bottom side of the box. For example, the horizontal line segment B_0B_1 , and the vertical line segment A_1B_1.
2. Summarize the dark pixels in the vertical and horizontal line segments. If that summaries are smaller than thresholds value check the next box.
3. Otherwise, if It is greater than an expanding box is adopted to envelop the dark object.

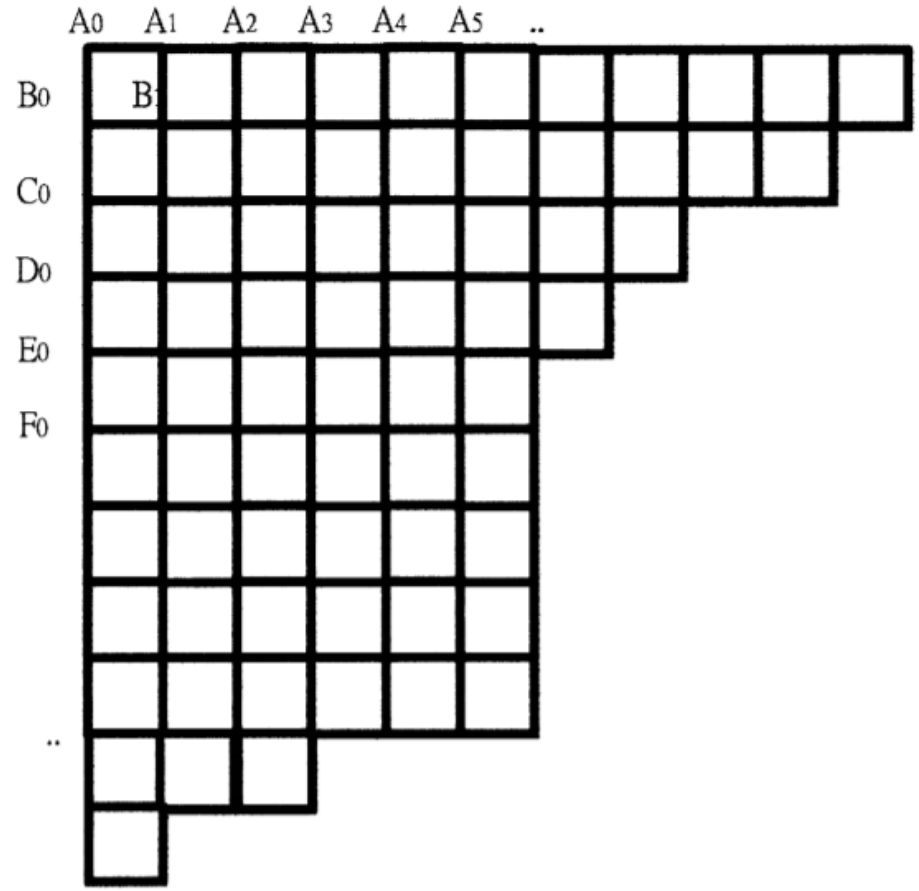
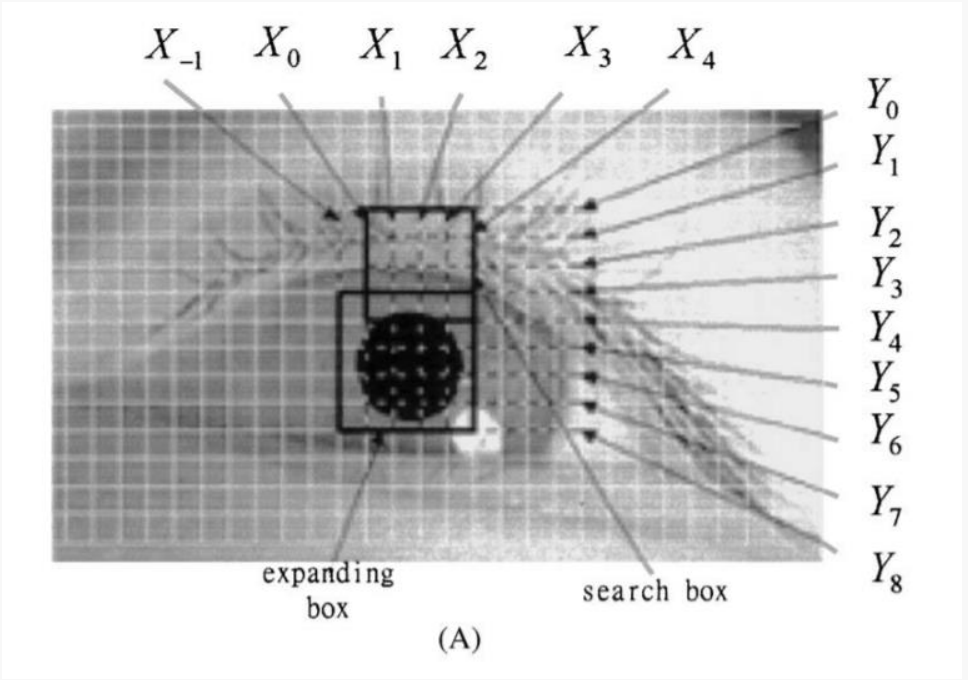


Fig. 3. The search path in the pupil analysis.

[1] Amini AA, Weymouth TE, Anderson DJ. A parallel algorithm for determining two-dimensional object positions using incomplete information about their boundaries. Pattern Recognition 1989;22(1):21–8.

4. Determine horizontal and vertical boundaries for up, left, down, right such as Y_3, X_{-1}, Y_8, X_2 at the picture A.
5. After determining the approximation pupil location in the expanding box, it is calculated to verify that dark part of the image is the pupil.



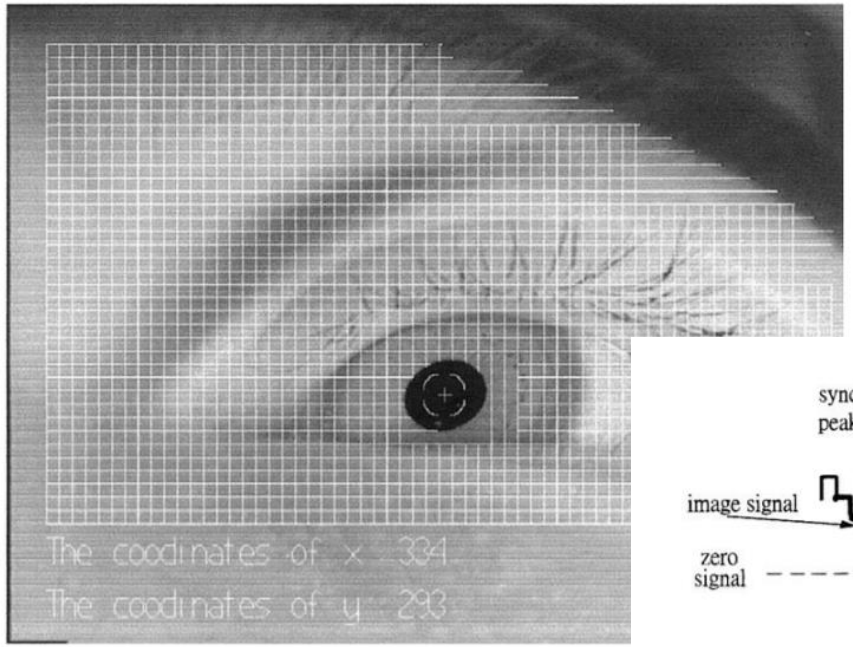
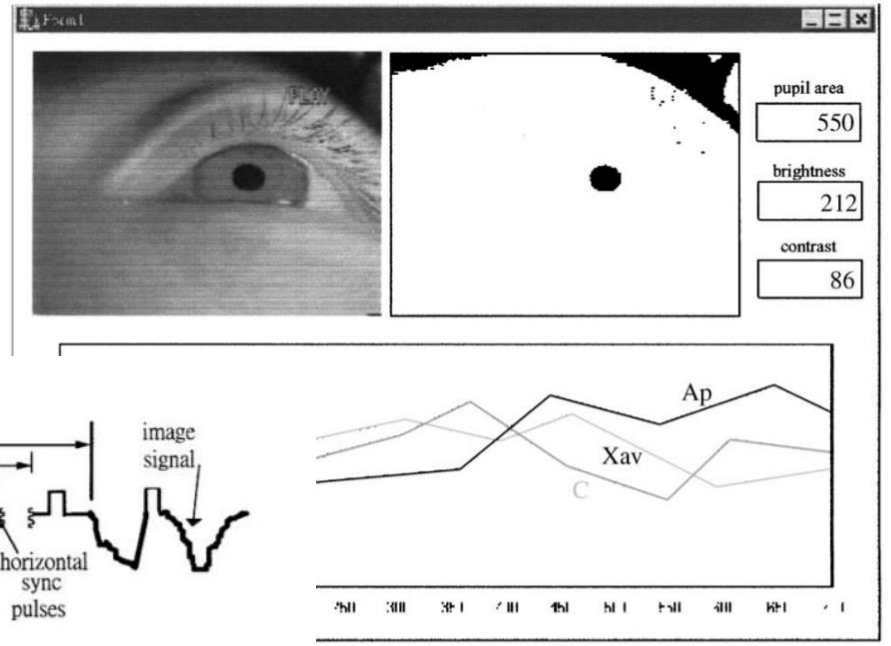


Fig. 5. A pattern recognition computer program used to distinguisl



me and statistical results for analyzing the brightness, contrast value
:e.

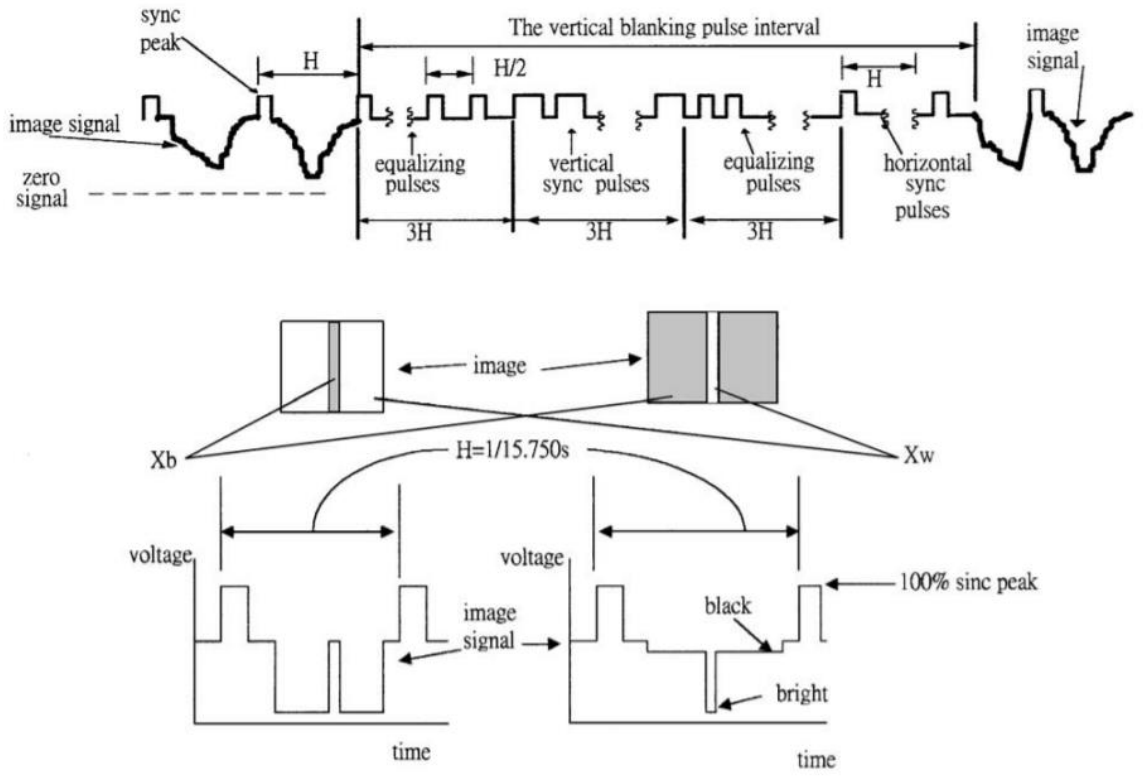


Fig. 7. The DSP unit calculates the average brightness and contrast value of images in the measurement system.

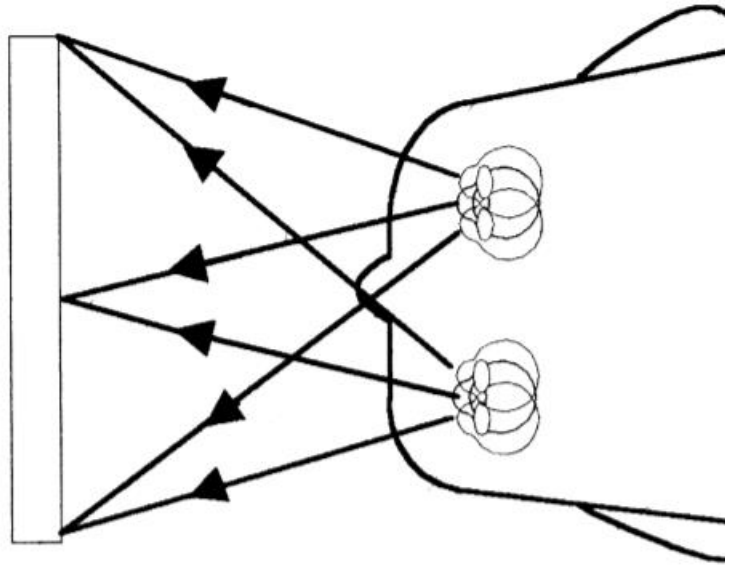
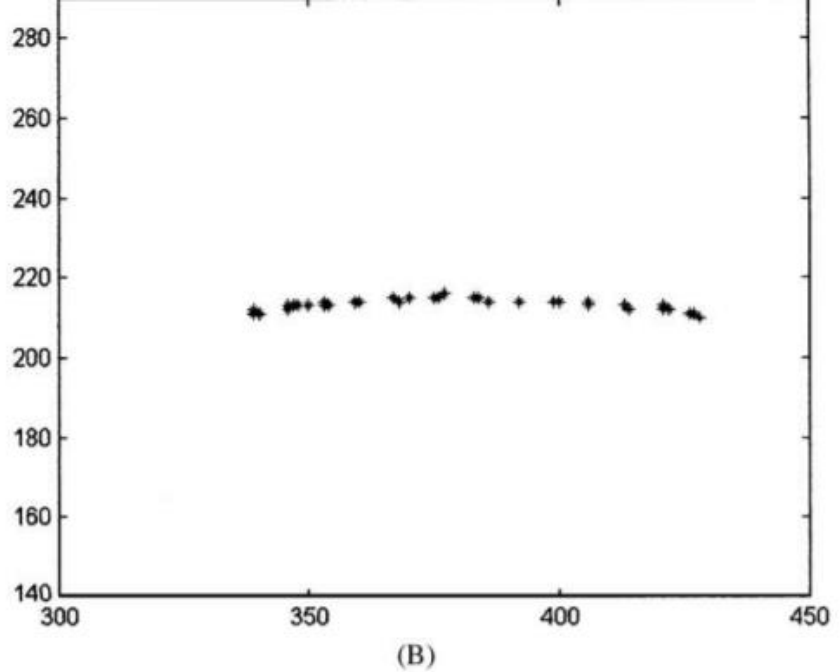


Fig. 8. The eye movements when the subject is gazing



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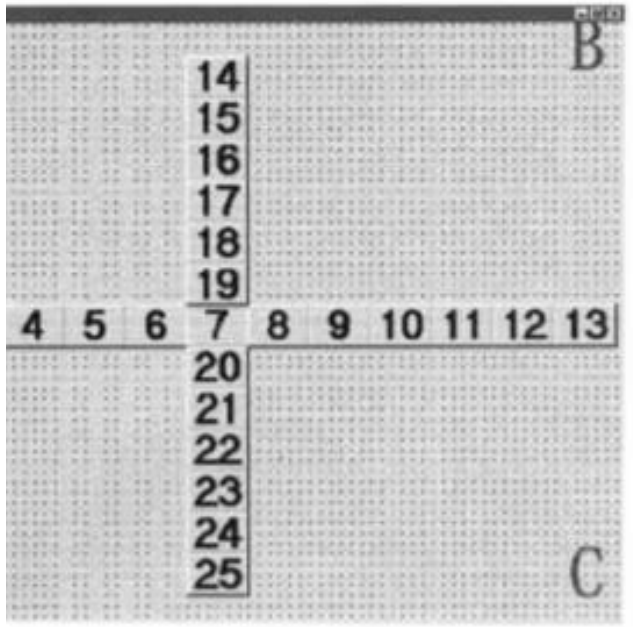

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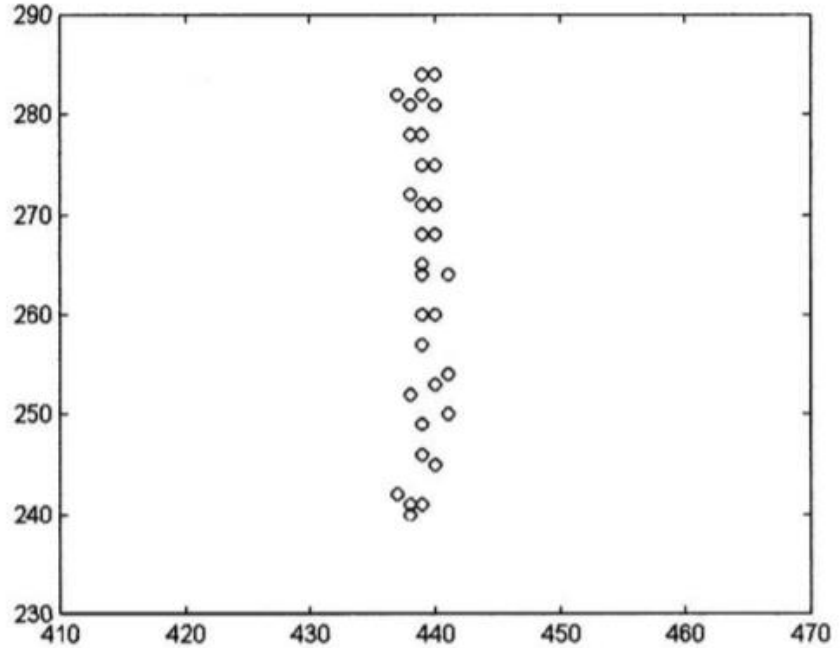

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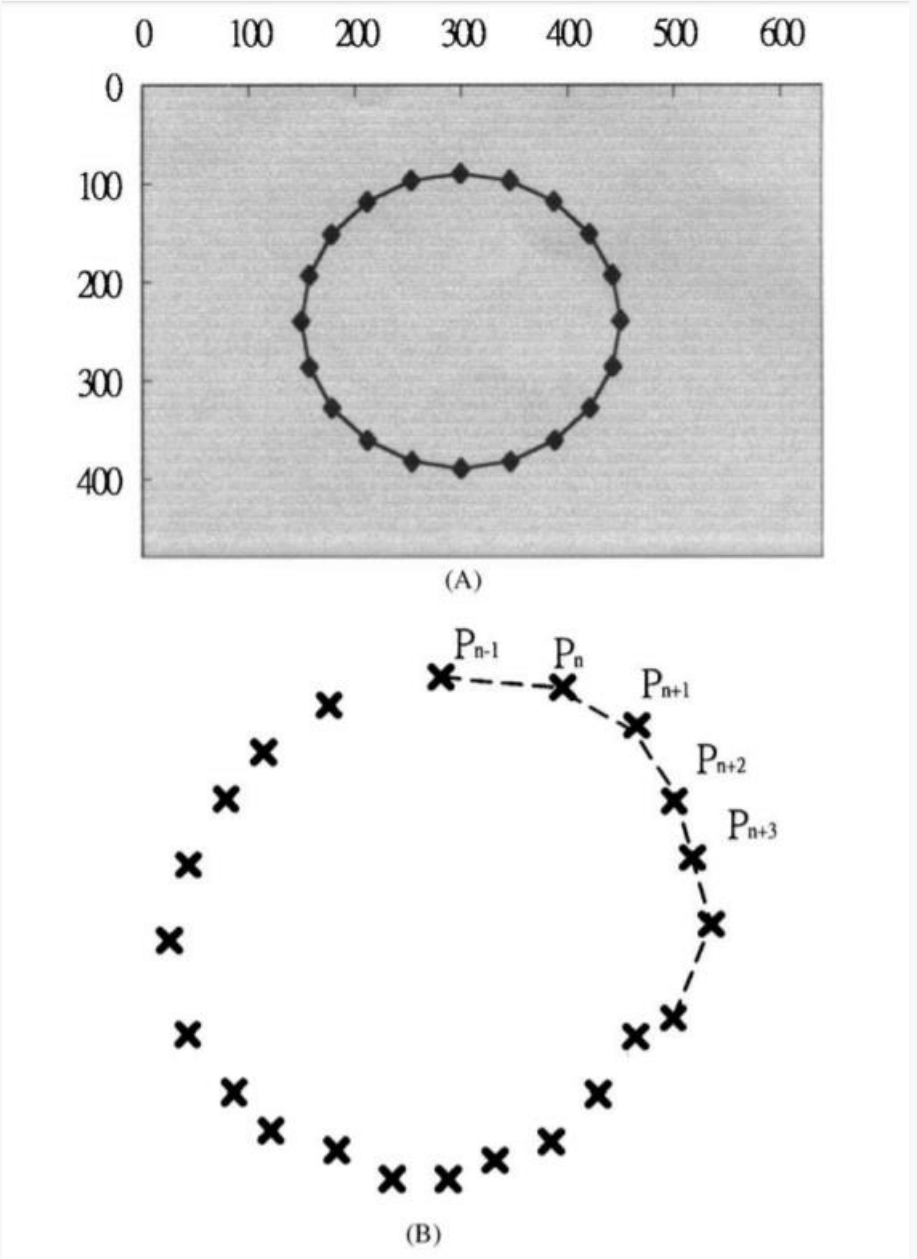
In this method they have 5 coefficients.

1. K1 for the control ability of user
2. K2 for the gazing ability of user
3. U1 for the user's eye activity(A and B images)



4. U2 for the user's concentration
5. U_3 for the user's ability to move his eyes

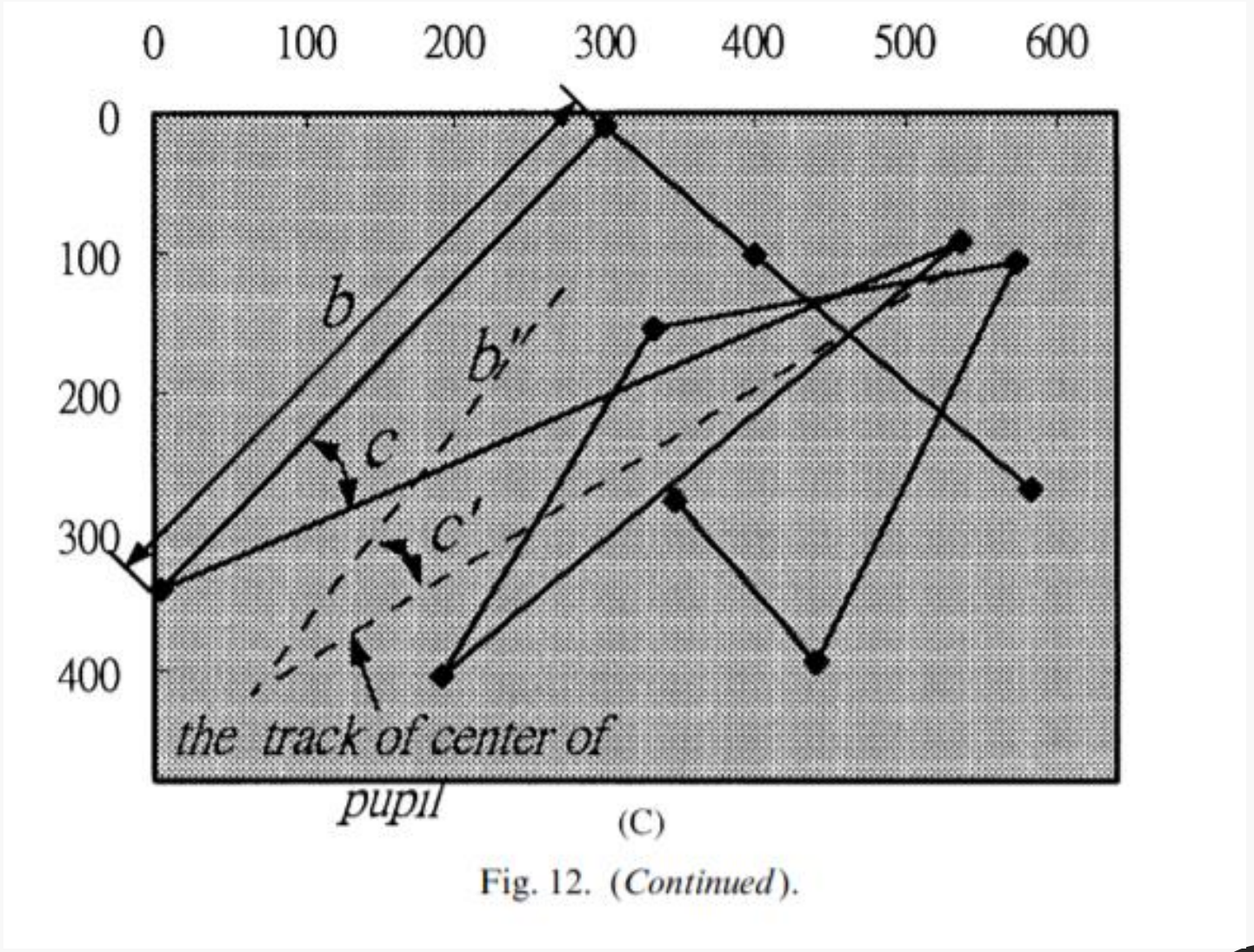
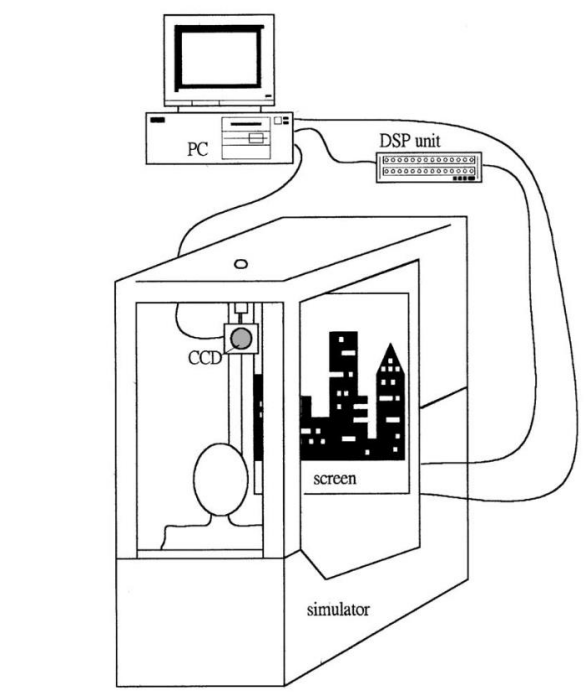


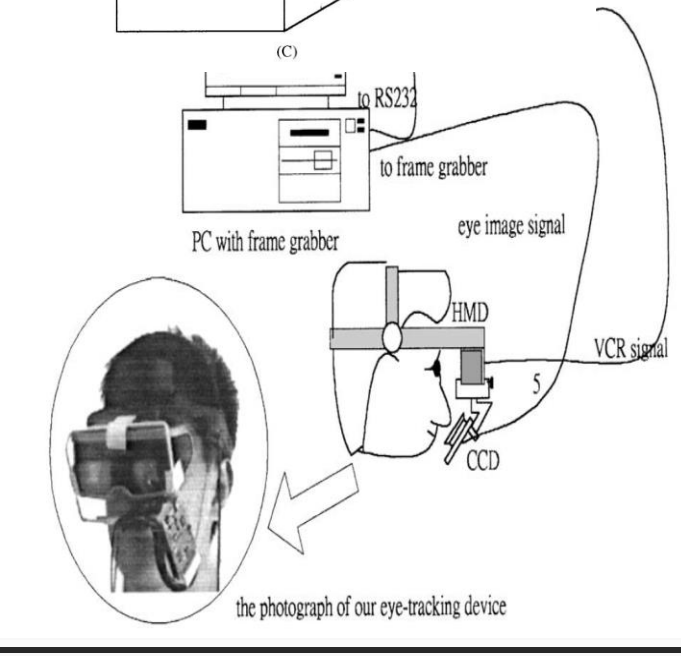
Fig. 12. (*Continued*).

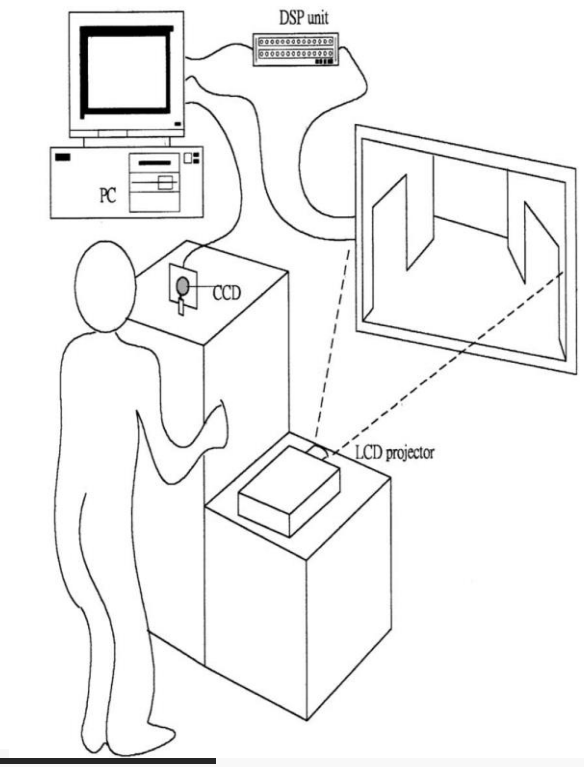
Hardware

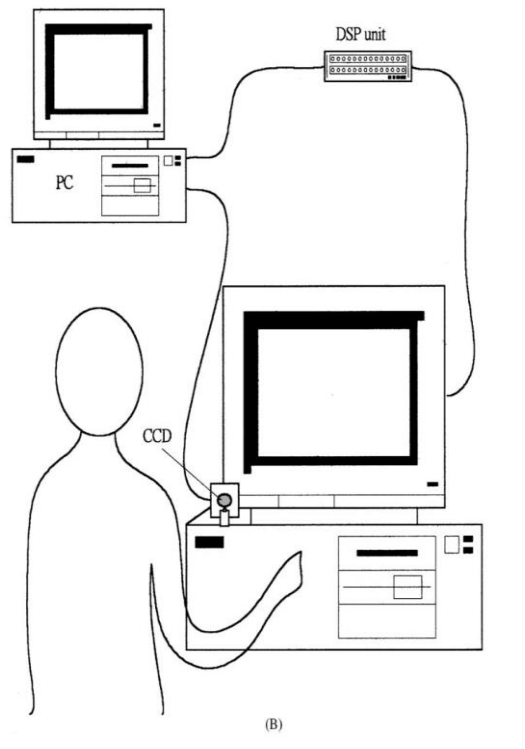
- The system provides an apparatus for tracking eye movement and measuring pupil area.
- This apparatus is used by a person wearing a VR display device and this device consists of following parts:
  - **Removable and Attachable Image Capturing Device (CCD Camera):** It is used for capturing real time image of subject's eyeball. This sensor can capture an image without an additional light source.
  - **Image Captures Card:** It is used for receiving and processing the eyeball images. After processing it calculates the position of the center of the pupil and the entire pupil area.
  - **DSP unit:** It receives the video signal. Then it processes the video signals to obtain average brightness value or an average contrast value.
  - **A Computer:** It receives and analyses the data from the **image capture card** and **DSP unit**.

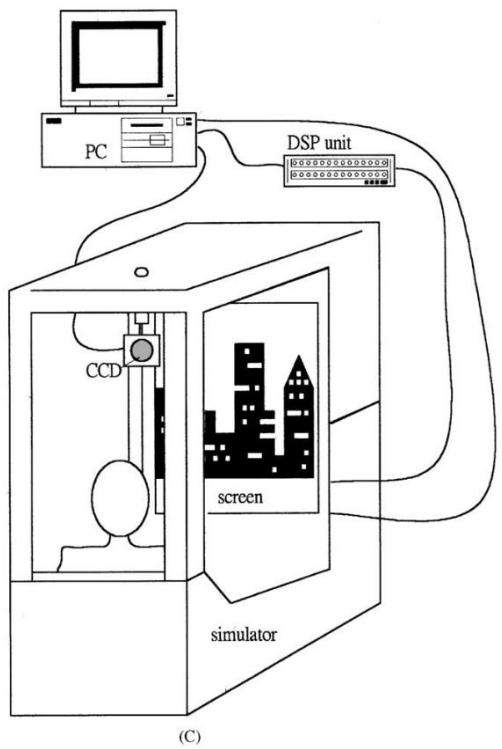
	Projection VR	Desktop VR	Simulator VR
ed o, it gle e	Here, a lens with higher magnification is used. Distortion problem is negligible.	Here, CCD is mounted at the side of the monitor.	Here, the player sits in a big simulator cabin and CCD is mounted on top of the cabin.
	Fig 2	Fig 3	Fig 4











Different CCD Lens

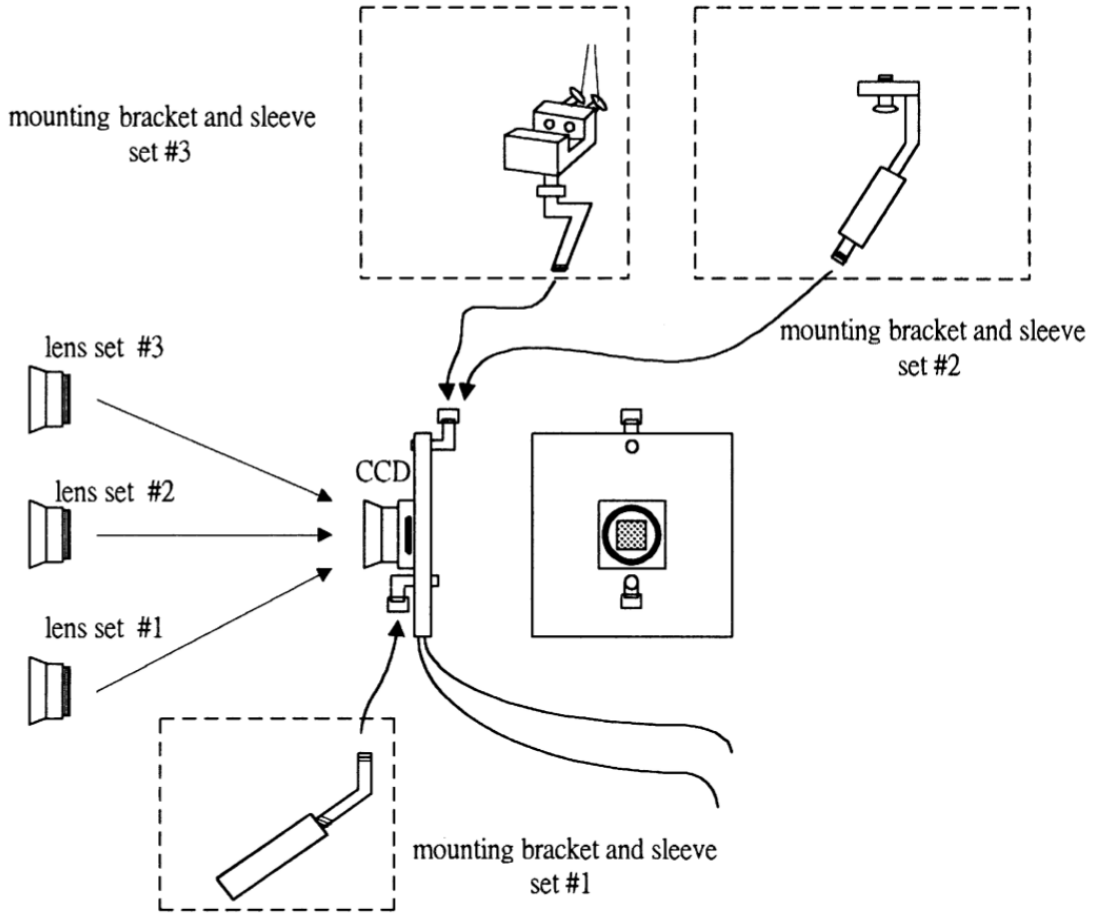
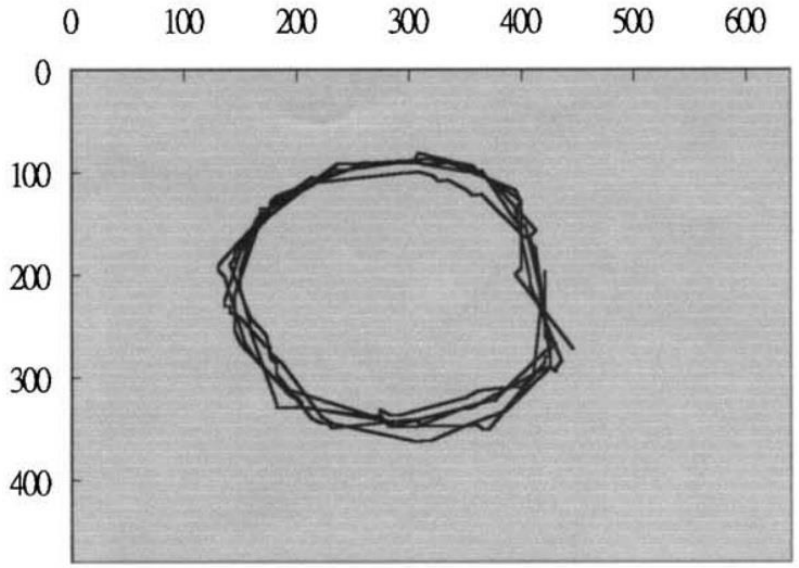


Fig. 13. CCD camera and the lens sets.

Lens set #1	Lens set #2	Lens set #3
It is used in heads-up VR display devices for observing objects near the lens.	It is used in projection TV observing objects far away from the lens.	It is used in personal computer installation kits.

Experiment

- In this experiment they adopted the eye-tracking device with the head-mounted display system. This device configuration could make measurements regardless of how the user turned his head.
- The position of the center of the pupil provided an accurate representation of the eye's point. Calibrations were performed to compensate for system lags and errors, when presented with a rectangular board indicating different positions for eye gazing.
- When the user is watching the screen, the screen brightness and contrast will affect his pupil size. When the screen is bright, the pupil will shrink. When the contrast is low, the pupil will dilate. Here we neglect the contrast C and study the relation of the screen brightness, exciting degree of the user and his pupil size.
- The period of time that the pupil spends at a location is converted into a gray scale image, where increasing darkness indicates increasing time.
- The validity of the calibration process depends on the geometric arrangement of the eye-tracking system and the eye movement Usually
- Below Images shows the tracks for the center point of the eye when the subject is gazing at the **entire target**.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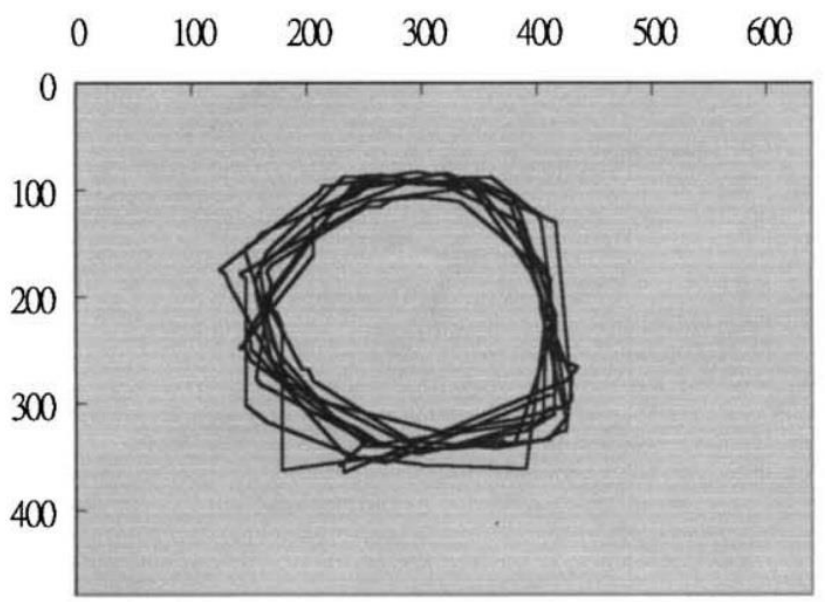
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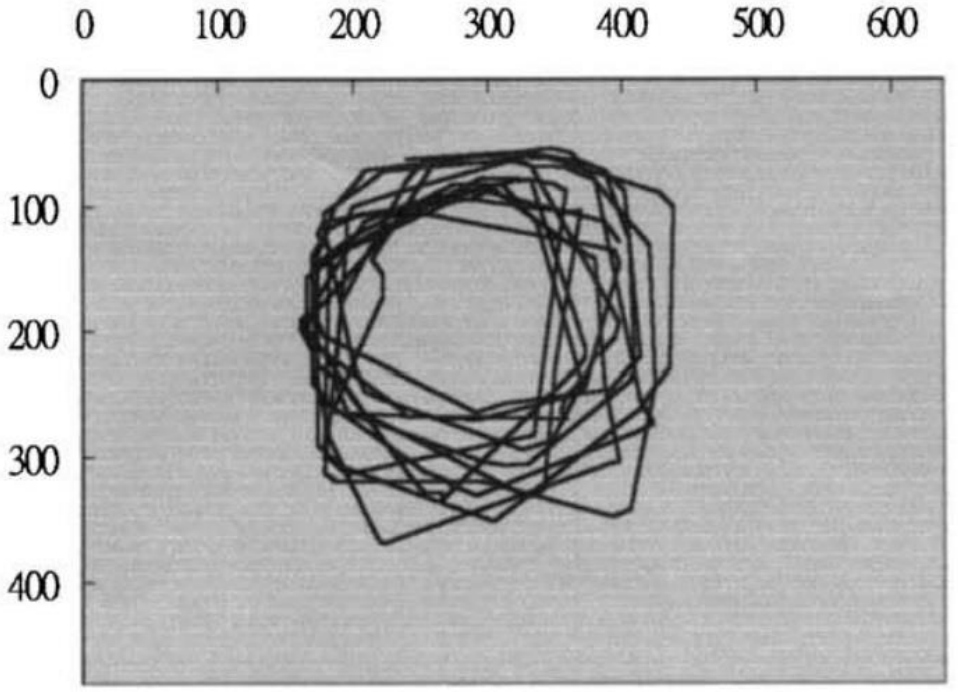
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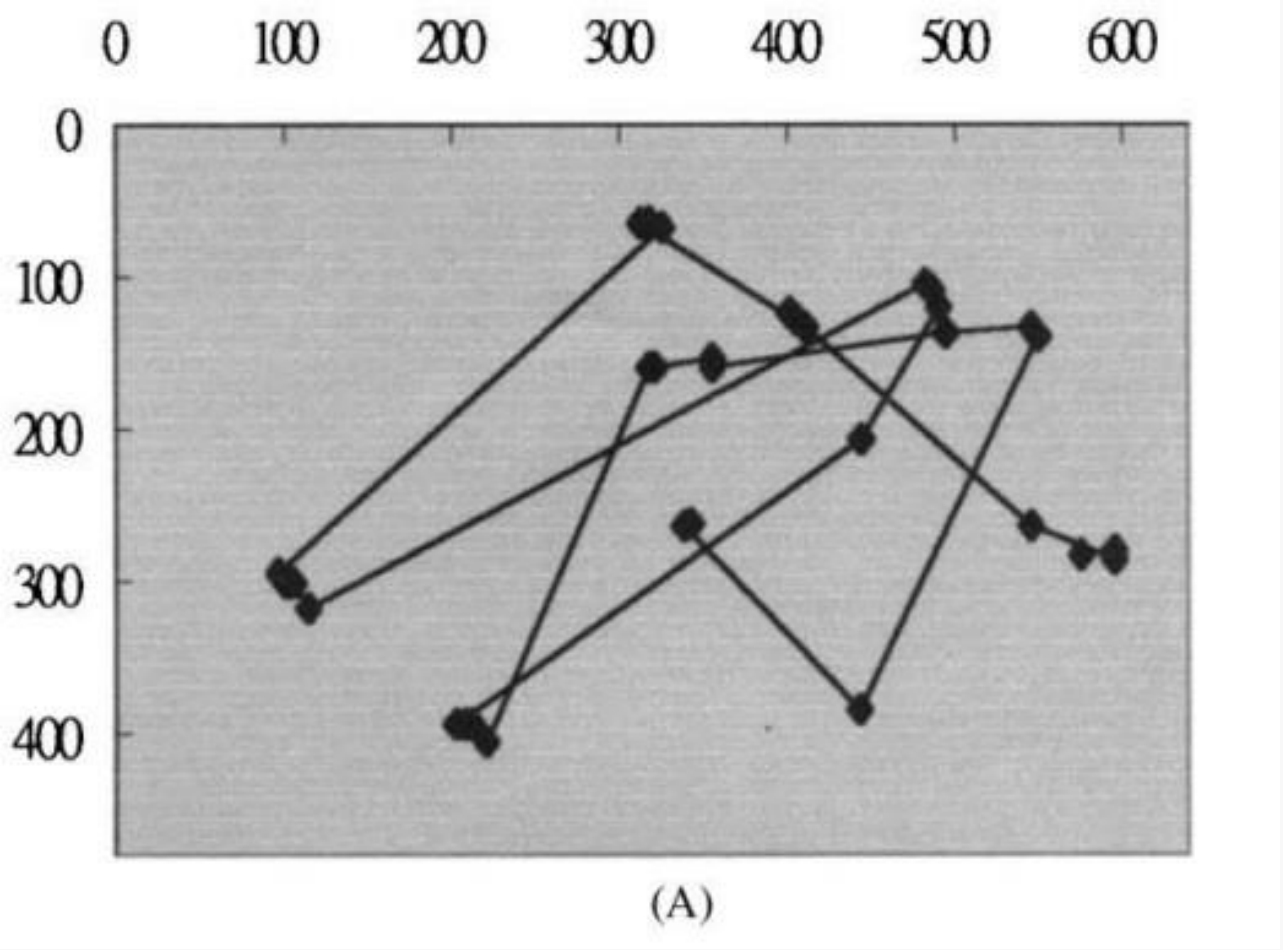
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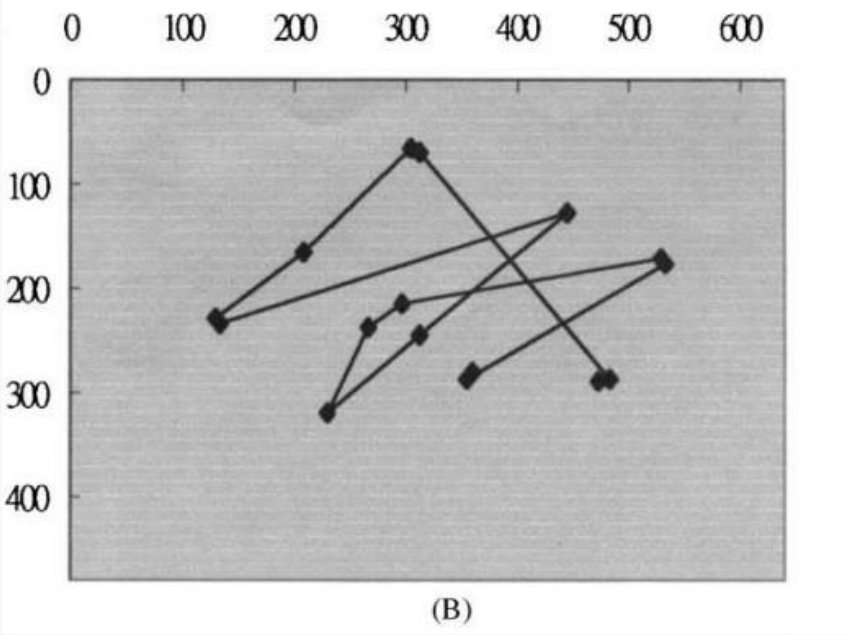
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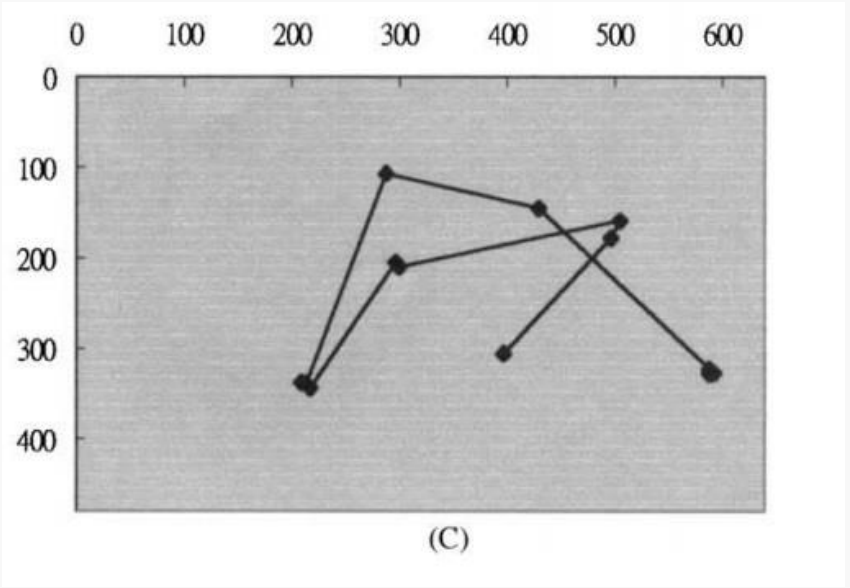
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Conclusion

- In this paper, they presented a new method about eye-tracking system.
- This system can be applied in a VR system for finding the position of subjects' pupils and guide this position into a point on the display screen.
- This research beneficial for psychometry, ophthalmology, physiology and the design of a VR system.