Eye Tracking Using A Novel Approach

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Abstract— **In this paper we introduce the new method for computing the 2D position of an eye and its gaze direction from a single camera and one light source. The method is based on distance algorithm compound with skeleting and layering algorithm for detecting the central point of gaze. After above steps we have been used reversed distance algorithm to correct probable error.**

Next, the direction of gaze can be computed from comparison of this central point with calibration's points that we call them "point of space limited".

At the end, we compare our method with other method like cross-line that has been used in newest eye tracking equipments and found that our method worked clearly better.

Keywords— **eye tracking, distance algorithm, skeleting method**

I. INTRODUCTION

Human computer interface plays an important role in virtual reality systems. How to provide an effective and robust communication channel has continued being an intensive research issue.

An eye gaze tracking is a device that can compute the direction of gaze, i.e., the line of the sight of the eye if information about the scene is available the point of regard can compute as the intersection of the direction of gaze with a scene object. The scene can easily be constrained to a computer screen also the direction of gaze and point of regard information made available to any computer application as another form of input device. Eye gaze tracking has helped psychologists, neurologists and ophthalmologists for several decades to study and build theories and models about eye movements and their behaviors. Several eye gaze tracking methods have been developed in such studies, from physical probes, electric muscular activity to magnetic sensors and a wide range of optical and visual techniques.

Eye-tracking devices were initiating in military applications for guiding weapons systems while freeing the pilot's hands for guiding the aircraft through combat aerial maneuvers.

Usually, these devices include a detection device to detect the bioelectromagnetic signals or image sequences generated by eye movements. There have been various eye-tracking systems developed over the past 30 years.

The image-type eye tracking system that we adopted in this study consists of a charge-coupled device (CCD) camera, an image capture card and monitor.

The eye-tracking device has become one of the most important human–machine interfaces in which eye movements are related to the information-processing demands of a task. For example, in the eye-tracking experiments by Lin et al. [1], a new search method superior to the existing methods, was used. The eye opening and closing actions activate additional commands, used for controlling robots.

In order to save much computer search time on the image of the face, this system uses many search checkers to search the binary shadows. When coming across extraneous features, it can quickly skip over them without performing a detailed template comparison. This method is called diagonal-box checker search. This system allows the handicapped an opportunity to perform some simple tasks without the help of others.

Wagner and Galiana [2] adopted template matching with correlation calculation to find the locations of eyes. Spindler and Chaumette [3] used an off-line calibration and gaze coordinate. filtering for a visual servo task. Grattan and Palmer [4,5] developed a microcomputer based system to cancel differential reflection from the eyeball. The input blink is used to activate the data presentation as a binary tree or matrix scan.

Xie et al. [6] for condition that the head movements are much slower than the iris movements, presented a method to compensate the head movements using cascaded tracking of the white and dark regions in the eye's image.

Martin and Schovance [7] suggested a very complicated eye movement control model with muscle mass and tendon tension parameters. Allison et al. [8] used an integrated head and eyetracking system to investigate compensatory vestibulo-ocular responses.

The measurement of three-dimensional (3-D) viewing behavior requires a relatively large computational effort. Talmi and Liu [9] used highlight detection and displacement vector transformation in the determination of the 3-D eye position. In 3-D multimedia system visualization, eye blinking can be detected by calculating the values of the squared frame differences of the facial image blocks [10]. Human visual tracking and evaluation systems comprise a field of significant interest and importance.

Here we used simple image-processing method to boost our process to reach the smaller calculating time.

We use some simple method like distance algorithm and combine them in suitable.

Our method can be used for moving mouse to real point of view on monitor as tool for handicap person. This application will be considered else where.

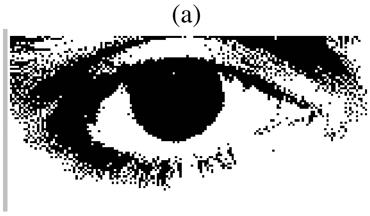
II. MATERIALS AND METHODS

In this method, we assume that head to be fix. We prepare this fixation with camera that has been coupled to some kind of head band structure. This complex, fix camera in front of eye and cancel effect of head movement on camera images.

Camera gives us gray scale images. For first step we have been thresholded these images with single or multi threshold(s). Using of simple threshold help us to make our process faster which is our main aim in this paper. Although limitation of this simple threshold model is that light source must have higher intensity.

In this paper we have been used single threshold to make two-level images. This image contains eye ball, eyelash and some part of eyebrow. Fig 1 has been shown a sample image and result of single thresholding. We have been chosen a single threshold based on experimental results.

(a)



(b)

Fig. 1 (a) Original image (b) Result of single thresholding

Next step was separation of eye ball from other parts of image. It helped us to concentrate on important part of image and gave us the possible eye ball location for other images to make our process faster.

The eye ball area has been calculated from some of primary information like distance between eye and camera and eye size that had been gave to system in the beginning.

Eye ball detection start with layering algorithm to make black area of two-level image thin. Its aid to disappear thin parts of image that refers to thin subject like eyelash. Layering can layer black area in one step which has been shown in Fig 2 and also its effect on simple black area shown in Fig 3.

0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0

(a)

1	1	1	1	1	1	1
1	2	2	2	2	2	1
1	2	3	3	3	2	1
1	2	3	4	3	2	1
1	2	3	3	3	2	1
1	2	2	2	2	2	1
1	1	1	1	1	1	1

(b)

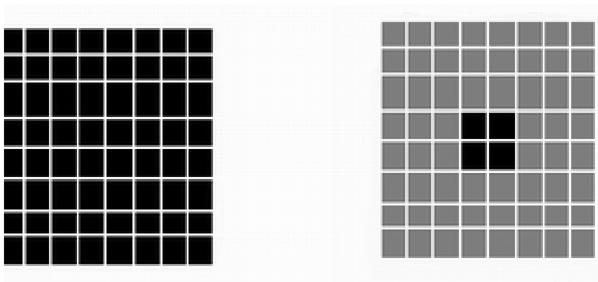
Fig. 2 One-step layering. (a) Zeros and ones respectively correspond to white and black pixels (b) one-step layering have been detected possible central pixels of black area

This skeleting based on Equation (1) use distance algorithm for layering and this help us to separate eye ball.

(1)

$$w(i,j) = w(i-1,j-1) + w(i.j) + w(i-1,j) + w(i,j-1) + w(i+1,j) + w(i,j+1) + w(i+1,j-1) + w(i-1,j+1) + w(i+1,j+1)$$

That w is value of pixels.



(a) (b)

Fig. 3 (a) Sample black area (b) Central detected with one-step layering

As can be seen from Fig 1, biggest number show us central part of area (in this case 4), so after separation of eye ball from other part using thinning and elimination this part with usage of one-step layering method we can extract central part of eye ball.

After detection of central pixels of pupil we must calibrate this location with previous information that got them from user calibration-test in the beginning. Finally, we have been used distance algorithm in reversed form to confidence given pixels.

As seen in fig 4 this reverse form begins from central candidate pixel and reaches to the edge of the pupil area. Values of edge pixels have been utilized as guideline to determine that calibration is needed or not. We measure this possibility from following Equation.

$$w_{\max} - w_{\min} \leq C \quad (2)$$

That $w_{\max}$ and $w_{\min}$ are maximum and minimum value of edge pixels values and C is maximum value of this difference in calibration process.

The ability to transfer central pixel(s) of pupil to real point of view on monitor is other thing that calibration-test has been prepared. This information extracted from user when looking at calibration points on monitor that we call them "points of space limited".

We have been calculated central pixel of pupil when user looked at 8 points on the edge of monitor and central point of it and have been utilized these points as references of our transfer calibration.

5	4	4	4	4	4
5	4	3	3	3	3
5	4	3	2	2	2
5	4	3	2	(1)	2
5	4	3	2	2	2
5	4	3	3	3	3

Fig. 4 Reversed distance algorithm method. Value of central candidate pixel is one and begin to grow until reach edge of area

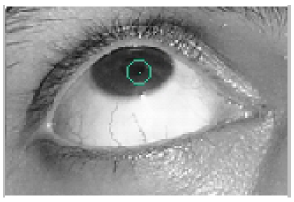
Final result of our process (finding central point of pupil) has been shown in Fig 5.

Fig. 5 Center gaze location as result of process

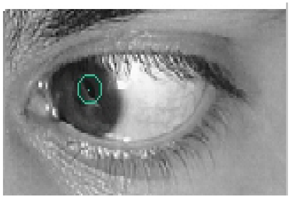
III. Result

We have been implemented above algorithm with visual basic 6. We have simulated this model by 50 gray scaled images of eye and obtained very promising results**.**

You can see our results for sample extreme gaze locations (up, left, right) in Fig 6.



(a)



(b)

(c)

Fig. 6 Result on (a) extreme up, (b) extreme left (c) extreme right gaze location

IV. Conclusions

Our aim in this paper was reach to faster algorithm than other processes. Comparison of this method result with other methods have been shown that speed of our algorithm is higher, that this speed could help us to process more images per second.

Also, Consequence of this finding was smoother real eye tracking when point of view move fast because of saccade event.

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