Smart Eye-Tracking System

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Abstract— **This project is a smart eye tracking system which is designed for people with disabilities and elderly people. The concept of this research is to apply eye movement to control appliances, wheelchair and communicate with caretaker. This system comprises four components, imaging processing module, wheelchair-controlled module, appliances-controlled module and SMS manager module. The image processing module consists of webcam and C++ customized image processing, the eye movement image is captured and transmitted to Raspberry Pi microcontroller for processing with OpenCV to derive the coordinate of eye ball. The coordinate of eye ball is utilized for cursor control on the Raspberry Pi screen to control the system. Besides the eye movement, the eye blink is applied in this system for entering a command as when you press Enter button on keyboard. The wheelchair-controlled module is a cradle with two servos that can be moved to two dimensions and also adaptable to other wheelchair joysticks. This system also remotely controls some appliances and communicate with caretaker via send message to smartphone.**

Keywords— **eye tracking, wheelchair, people with disabilities, elderly people, Raspberry Pi, image processing.**

I. Introduction

Presently, wheelchairs became important for elderly and disabled persons. The electrical wheelchairs are available in market mostly controlled by using a joystick control system. In some case such as totally paralysis person in amyotrophic Lateral Sclerosis (ALS) and Parkinson disease, it may be very difficult or impossible for such patient to use such type of system. There are several researches attempt to develop other techniques for controlling electric wheelchair for those patients to improve quality of their life. Such as brain-controlled wheelchair [1], The brain signal (Electroencephalography, EEG) is captured by electrode cap that is placed on the user's scalp then this signal translated into movement commands but it have many disadvantages such as spend a lot of time for setup the system, slow response, expensive, etc. Voice controlled wheelchair [2], patients speak command to move the wheelchair but the drawback of voice controlled wheelchair is the low immune to noisy environment that can bother system to incorrectly respond.

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This project aims to develop a prototype of an smart eye tracking system that can controlled appliances, electric wheelchair and communicate with caretaker via send message to smartphone.

II. Research Method

This system comprises four components including imaging processing module, appliances-controlled module, wheelchair-controlled module and SMS manger module. The imaging processing module is the main module of this system that start with webcam that installed on eyeglass as show in figure 2 (a) to capture the eye images and transmit to Raspberry Pi for image processing which is based on C++ with OpenCV to obtain position of eye ball and define eye blink. The eye movement is also employed as the cursor control on the Raspberry Pi screen eye blink, is used for entering command, therefore these feature can be used to control several applications.

(i) Circular Hough transform

The circle Hough transform (CHT) is algorithm to detect circle, First the edge of circle will be found by using Hough gradient method after that, in each pixel on the edge of this circle will be created other circle so the position that have the most pixels accumulation from this circle creation is center of circle which we would like to detect as figure 1. Because of the shape of eye ball is circle hence we can apply this algorithm to detect it.

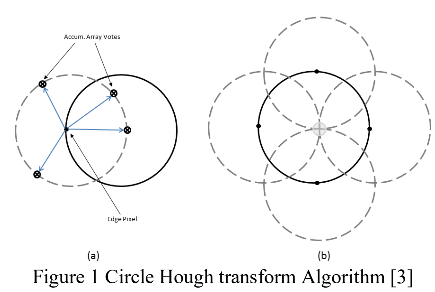
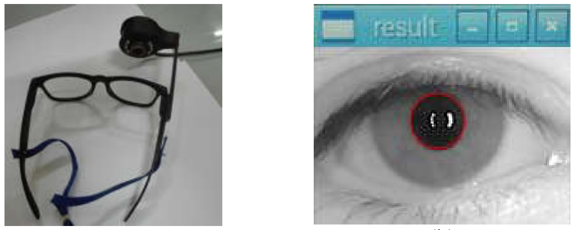


Figure 1 Circle Hough transform Algorithm [3]



(a) (b)

Figure 2 (a) webcam that installed on eyeglass as (b) eye ball detection based on circle Hough transform

(ii) Eye blink detection

The eye blink detection is used to simulate the enter keyboard. To detect the eye blink, the number of black pixel in the pupil area is measured. The change from high to low of the dark pixel number is designated for the eye-blink detection; i.e. the enter key.

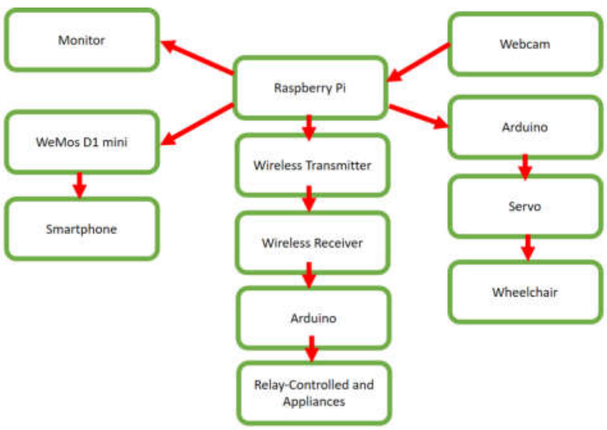
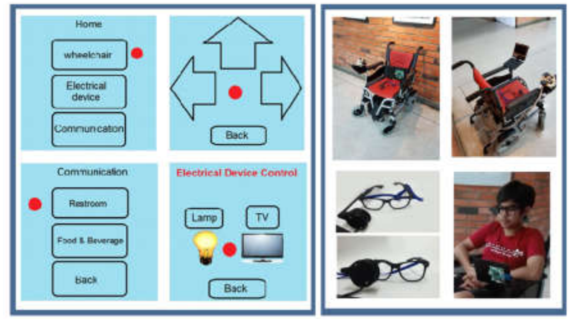


Figure 3 The system overview of the smart eye tracking system

The webcam is connected to Raspberry Pi microprocessor that not only performs digital image processing but it also interacts with other module including appliances-controlled, wheelchair-controlled and SMS mange module. Appliances controlled module, another Arduino is used to receive command from Raspberry Pi by wireless communication, the Arduino will turn relay on or off according to the command of Raspberry Pi, this relay is used to turn Appliances on or off. In wheelchair control, we designed cover of wheelchair joystick that can move wheelchair joystick in two dimension with two servos as show in figure 5. In SMS mange module, The WeMOS D1 mini is used to send the massage to Blynk Application [4], it also receives command from Raspberry Pi.



(a) (b)

Figure 4 (a) Cursor control on the Raspberry Pi Screen (b) wheelchair-controlled

(iii) Eye position Control

The eyeball position is used to control the mouse cursor position. Algorithm for eyeball position is as follows.

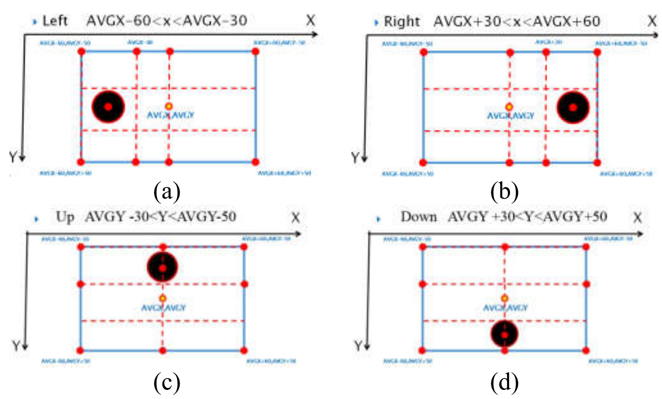
(I) Determine the average position of eyeball. The average position, denoted as AVGX and AVGY are the average of position of eyeball in relaxing position, i.e. eyeball looking forward

(II) Detect the current position from Hough circle detection. Computer the deviation of current position from average point denoted the deviation as x and y.

(III) Determine the motion direction of eyeball as

Turning left if $-60<x<30$
Turning right if $30<x<60$
Turning up if $-30<y<-50$
Turning down if $30<y<50$

Figure 5 shows the four motion directions.



(a) (b) (c) (d)

Figure 5 Eyeball motion direction

III. Experimental and Result

The eye movement and blink were used to controlled user interface for smart eye tracking system as show in figure 4. The movement of the cursor will be moved following eye movement. The result to control wheelchair movement, turn appliances on or off and communicate with caretaker as show in figure 6, 7 ,8 respectively.

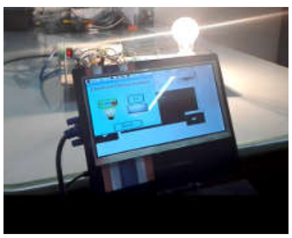
(a) Stop

(b) Forward

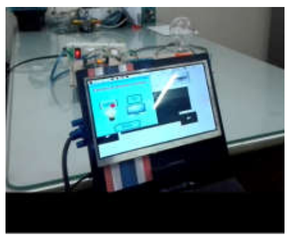
(c) turning right

(d) turning left

Figure 6 the wheelchair-controlled module (2 dimensional rotating stage)

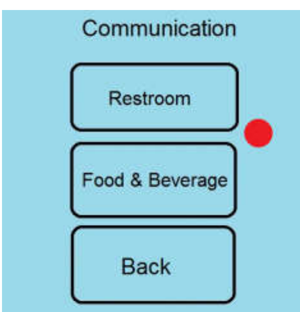


(a)

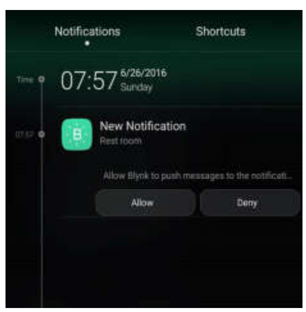


(b)

Figure 7 (a) turn on the lamp (b) turn off the lamp



(a)



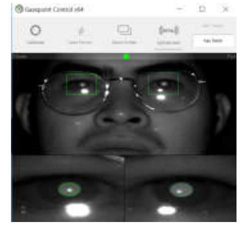
(b)

Figure 8 (a) User interface on raspberry Pi monitor (b) Notification on smart phone

(iv) Comparison with the commercial eye tracking system

We have compared the purposed system with commercial eye-tracker modules- the Gazepoint GP3 Eye tracker. The composition table is shown in table 1.

(a)



(b)

Figure 9. (a) Gazepoint GP3 Eye tracker module (b) Eye tracking by Gazepoint GP3 Eye tracker.

Table 1 Comparison with commercial module

	Eye tracking by camera installed on eye glass	Eye tracking by Commercial eye tracker module
Fast Respond	Satisfied	Outstanding
Low cost	Lower $20	At least $700
contactless eye tracking system		
Specification	 CPU 900 MHz or faster, 1GB RAM	 Intel core i7 or faster, 8 GB RAM
Screen size	Compatible with all display	Compatible with 24″ displays or smaller

Table 1 : Comparison Table

(v) Testing

To test the tracking performance, we design the phantom consisting of 5 red dots on various location as shown in figure 10. The subject was asked to stare at the red dot for 10 second. The position is collected for 10 times. The average and standard deviation was computed and tabulated. The result was showed in table 2. The results demonstrate the compatible tracking performance when compared with the commercial one.

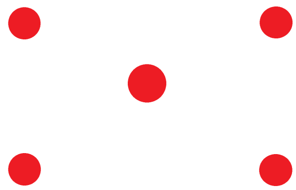


Figure 10 Tracking tested phantom

		Eye tracking based circle Hough transform(CHT)		Eye tracking by Commercial eye tracker module	
		x-axis	y-axis	x-axis	y-axis
Central middle	AVG	20.587	16.357	**19.6245**	17.698
	STD	17.589	16.2145	23.9902	12.7427
Upper right	AVG	16.547	15.479	15.2581	16.52848
	STD	18.2648	19.5269	22.3691	25.2887
Upper left	AVG	16.528	19.478	18.4856	18.5988
	STD	21.5609	17.2348	20.5979	21.6327
Lower right	AVG	17.587	18.568	16.4367	16.1479
	STD	16.4156	22.9870	22.1560	21.8797
Lower left	AVG	18.5689	17.5686	15.8791	17.4189
	STD	24.526	22.5970	23.2565	21.5791

Table 2 : precision of cursor position denoted by AVG(average) and STD(stand deviation)

IV. CONCLUSION AND DISCUSSION

The smart eye tracking system is presented in this paper. It not only to control wheelchair movement but it also controls appliances and communicate with caretaker. The eye movement is used to control cursor that appear on monitor and eye blink used for entering command but the disadvantage of this system is a webcam that attached on eyeglass is large size, it will be bother vision of user However, our system is good enough to be used for people with disability. In the future work we would like to improve performance of this system based cost-effective condition.

ACKNOWLEDGMENT

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Reference

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