Eye Gaze Tracking to Operate Android-based Communication Helper Application

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***Abstract*— For people with spoken and motoric disabilities, doing some basic daily activities will need some help from another people. Misunderstanding usually happen when people around them can not interpret their desire because of limit. In this paper, an eye gaze tracking system will be built to operate the communication system. The processes which are used in this system, first the face and left eye area of user will be captured by camera on android device and the features will be detected by *Haar Cascade*. Second, from left eye's region, it will be looked for eye center position as user pointer's reference in interface menus using *moments*. User can choose the activity menu by closing their eye in time more than 250ms. The output of this system is an audio that represent activity menu. The system has percentage success rate of left gaze tracking is 80 %, straight gaze tracking is 90 %, and right gaze tracking is 80 %.**

Keywords*— *eye gaze tracking; haar cascade; moments; communication helper system

I. INTRODUCTION

As social people, communication is a basic needs to support the interaction between many people. The information that people want to share with around can be transmitted well. There are some people who have limitations especially when using their motoric function or spoken ability that impact their interaction among people around. As a disability people, there are many daily activities which they want to do with the help of another people. But sometimes, people around don't understand what they want. This android-based communication system which is operated using eye gaze is very useful for that people. Eye gaze system is used as a control in the communication system, so that the user can select the daily activities options which has provided in system.

II. RELATED STUDY

In the previous research, there are some eye gaze tracking developments that built in many tools with human-computer interaction concept. Some of those are using addition hardware, such as infrared (IR) lighting [4] or electroculographs (EOG) [6] that have deficiencies in the cost or complexity. There are some reaserach have built an eye gaze tracking system that implements in desktop environment using web camera mounted in the PC and using head movement [1][5]. Eye gaze tracking system is also implements in communication system but still needs infrared addition [2]. The system use user's eye gaze as a cursor in the computer display to choose any menu in the interface. The implementation of eye gaze system in HCI concept was built in virtual keyboard environment [3]. The user has to make some eye gaze movement either right or left side to choose a character in the keyboard. Eye center coordinat that is used as a pointer reference in keyboard interface is obtained from modification of integral projection. This system is implemented in PC and using one eye as an input.

In this paper, the development from an eye gaze tracking is used to operate android-based communication system that contain any daily menu selection of activities. The daily activity menu can be choosen using eye gaze movement either left or right side. When user has activated the activity menu which they want to do, user can blink in more than 250ms to click that current menu. The choosen menu will sound a word or phrase that represent that menu.

III. PROPOSED METHOD

The most notable eye gaze features in every user's face is iris center. When user look in different side, the position of user's eyeball also change, so do iris center coordinate. With the change of that, it can be used as pointer reference to activate the menu in user interface. Generally, the proposed method can be shown in Fig. 1.

There are six main steps that used in the system. Those steps are initial setup, eye localization, segmentation, eye center detection, pointer movement, and menu click.

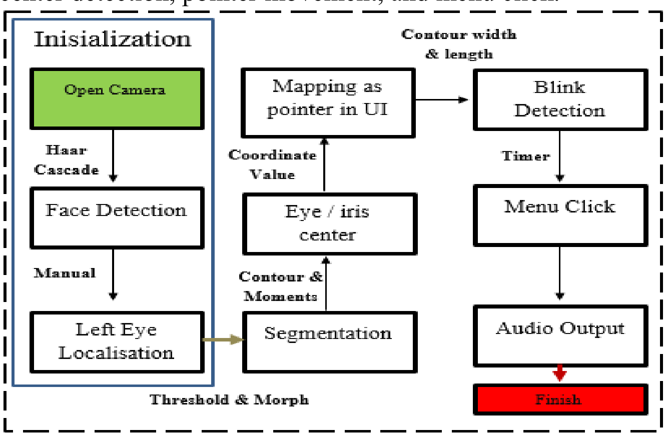


Fig. 1 General proposed method

A. Initial Setup

This research system is built in android device, especially in tablet which has specifications 7 inch LCD display and 2

MP front camera. User can use this system either holding the tablet by themselve or using tab holder. For the first, user has to look in front of the tablet screen with condition all of user's face can be captured by camera. There will be a camera preview in the system, so that user can estimate the best position while run this system. For detail initial setup can be shown in Fig 2.

In Fig. 2 shows that user has to look straight ahead the tablet. The distance between user and tablet is around 30-45 cm. With that position, user's full face can be captured by camera well that will be used as an input in next process.

Fig.2 User Position Initial Setup

B. Eye Localization

All of image processing which is proposed in this system is in grayscale mode. It is caused by easy and simple way to calculate any data from image. To get the eye location, the first step is doing face detection. This is why user's face should to be full captured by camera. The process to detect user's face is using Haar Cascade. This is an object detection method from Paul Viola and Michael Jones which is provided in OpenCV library. With this method user's face can be detected which is shown in Fig. 3 in rectangle box.

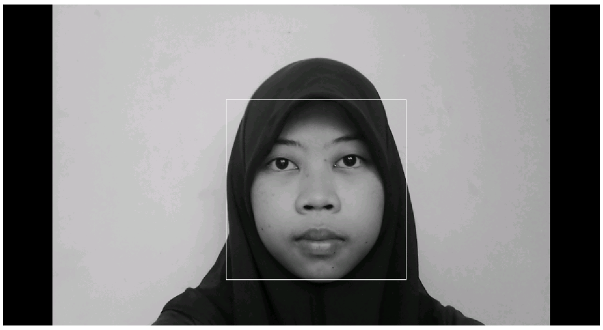


Fig. 3 Face Detection Result

After the user's face success to be detected, the next process is eye localization. In this system only use one eye as input, that is a left eye. This localization is using manual calculation to estimate eye location. The result can be shown in Fig. 4. The formulas to get left eye rectangle box are :

1. **x coordinate** is 1/7 *width* of face rectangle
2. **y coordinate** is ¼ *height* of face rectangle
3. **eye width is** 1/3 *width* of face rectangle
4. **eye height** is 1/5 *height* of face rectangle

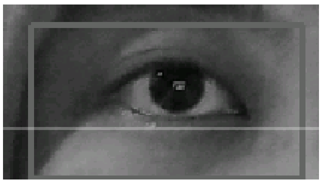
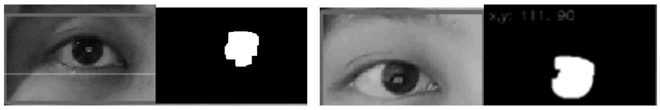


Fig. 4 Eye Localization

C. Segmentation

After user's left eye area is founded, the next step is iris segmentation which aim to separate iris with another valueless object, such as background, shadow, eyelid, etc. To obtain the iris image, inverse binary threshold and morphology is used in this system. The morphology process contains erode and dilation with the same value. But, for thresholding, it has to set manually by user to adapt in any lighting condition. The segmentation result can be shown in Fig. 5.



(a) (b)

Fig 5. Iris Segmentation (a) normal lighting, (b) bright lighting

D. Eye Center Detection

The result that is obtained from previous step will be looked for eye's contour. After contour was applied it will produce the contour of eye's shape, where the middle area of iris will has black colour, and the edge will has brighter colour. It will find the biggest contour of image that's mean an iris area. The biggest contour will reduce another object which still caught by system as a result of segementation process before.

After iris contour is founded, the eye center coordinate can be obtained using moments. It has also provided in OpenCV library. The moments will find the centre mass of eye contour by counting non zero pixel image, or the image which has color besides black. The formula to get x and y coordinate of eye center is shown in equation 1.

$$x = \frac{M10}{M00} \qquad y = \frac{M01}{M00} \qquad (1)$$

where M_{10} is first moment in X and M_{00} all of the area. The result of eye center detection is shown in Fig. 6.

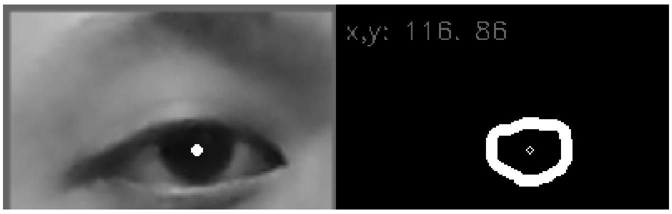


Fig. 6 Eye Center with Moment

E. Menu Design

In the application interface, there are 3 main menu which composed *Makan, Minum*, and *Nyalakan.* Each main menus also has 3 sub menu which is continuation of main menu activity. In one layout, each menu will be located in one column as show in Fig. 7 below.

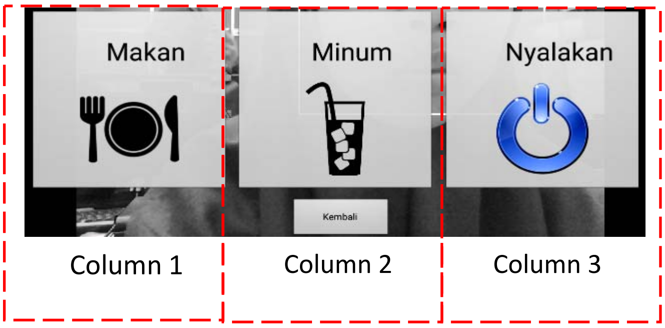


Fig. 7 Menu Location

In addition to the design based on column location, main menu and sub menu design is shown in Fig. 8. *Makan* main menu has sub menu *Buah, Nasi,* and *Roti*. *Minum* main menu has *Air Putih, Jus,* and *Teh* sub menus. While *Nyalakan* main menu has *AC, Televisi* and *Musik* sub menus.

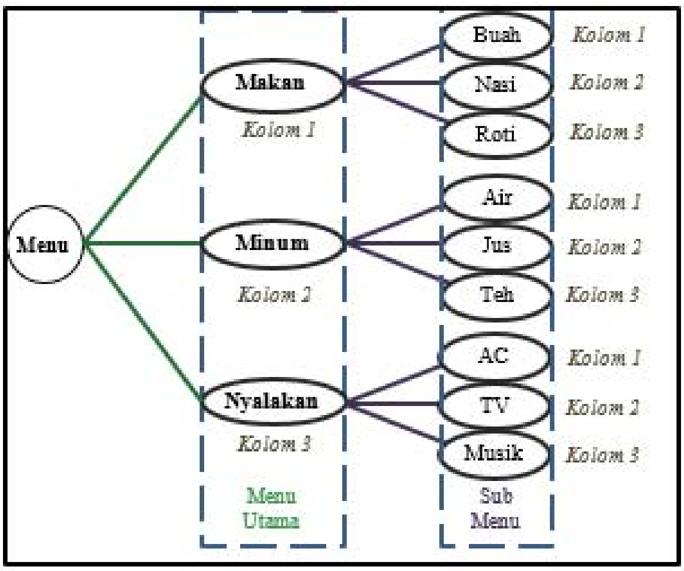


Fig. 8 Menu Design

F. Pointer Movement

After the coordinate of eye center has founded, the next step is making pointer in menu interface based on eye gaze movement. The first initialization of the active menu is on the far left of tablet screen. The active menu is marked by bright blue color background. For example in Fig. 9 the active menu is "Makan" activity.

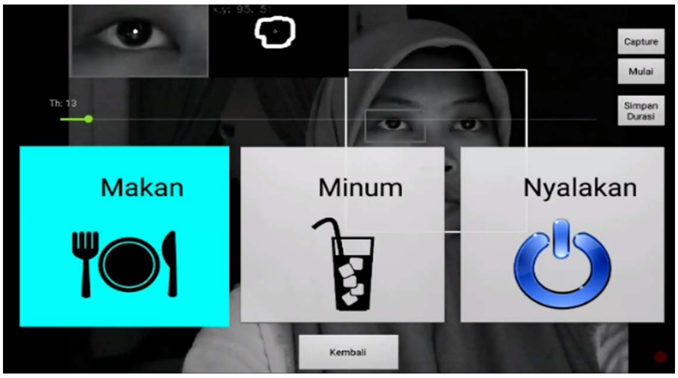
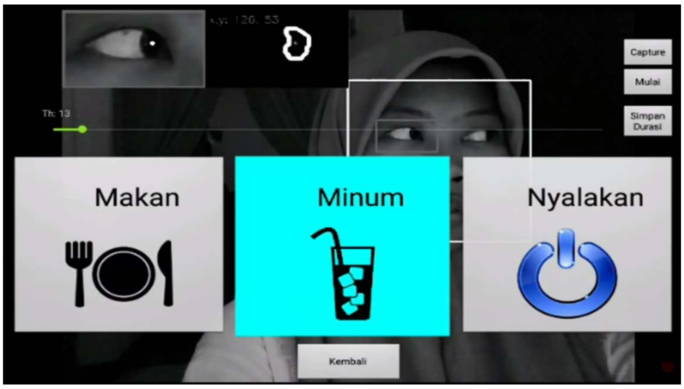
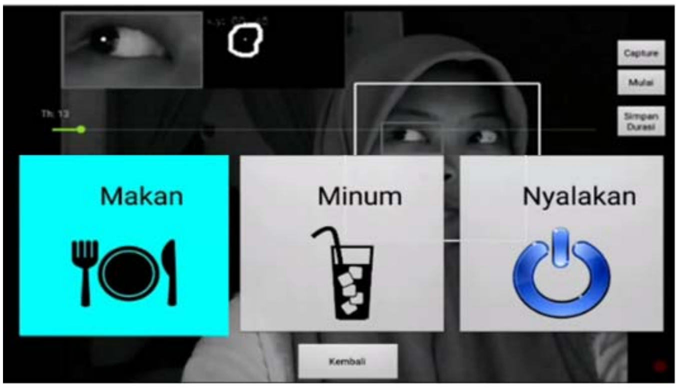


Fig 9. First Condition of pointer

From that first condition the active menu will change based on eye gaze movement either in left or right side. E.g x is current x coordinate of eye and $xmax$ is the biggest previous value of x, than if x is bigger than $xmax$, it means that user look at the right side and the pinter of active menu will change to "Minum" activity. The result of pointer movement can be shown in Fig. 8 below.



(a)



(b)

Fig 10. Pointer Movement (a) right move (b) left move

G. Menu Click

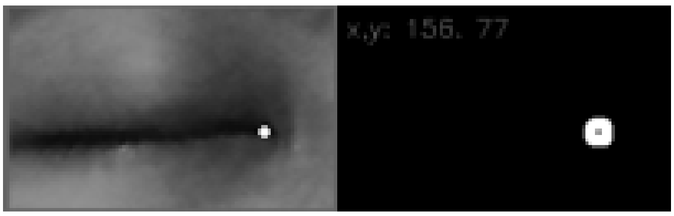
This is the last step in the system, when user has located the pointer in the activity menu that user want, he can click the current menu with blink in more than 250 ms[3]. To detect eye blink, it use the large and long of contour. It give different condition to the system when user only make spontaneous blink and click eye blink. If user only make apontaneoud blink it only happen in duration less than 250 ms. The eye blink classification is shown in the Table I and Fig. 8.

Table I. Eye Blink Classification

Eye Blink Classification		Contour (Large & Long)	Duration (ms)	Action
No Blink		>500 & >100	-	No Action
Blink	Spontaneous eye blink	<500 & <100	< 250 ms	No Action
	Click eye blink		> 250 ms	Choose menu and give audio output.

In the user interface of the activity menu, there is main menu and sub menu. Sub menu is the detailed activity or object from the main menu. For example, in main menu “Makan”, if user clicks that menu, it will show another layout of sub menu contains menu “Buah” , “Roti” and “Nasi”. The pointer movement is also has the same way as the main menu.

(a)



(b)

Fig. 8 Blink Detection (a) No Blink, (b) Blink Detection

IV. RESULT AND EVALUATION

The result of this sytem has many variabel, such as the distance of user look at the display, eye localization, eye gaze tracking, etc. This system is tried to 20 users that have different results. All of the results can be shown more detail in explanation below.

Table II. Distance Examination

User	Distance (cm)				
	15	30	45	60	75
1	X	V	V	V	X
2	X	V	V	X	X
3	X	V	V	X	X
4	X	V	V	X	X
5	X	V	V	X	X
6	X	V	V	X	X
7	X	V	V	X	X
8	X	V	V	X	X
9	X	V	V	V	X
10	X	V	V	X	X
11	X	V	V	X	X
12	X	V	V	X	X
13	X	V	V	X	X
14	X	V	V	X	X
15	X	V	V	X	X
16	X	V	V	X	X
17	X	V	V	V	X
18	X	V	V	X	X
19	X	V	V	X	X
20	X	V	V	X	X

Based on Table II. Above, the optimum distance that suitable with this system is between 30 – 45 cm. All of face area of users can be captured well in those distances. It is important because the first step is face detection that need face captured of user.

After user’s face was detected, the next step is left eye localization. From 20 users, the result is shown in Table III. Below.

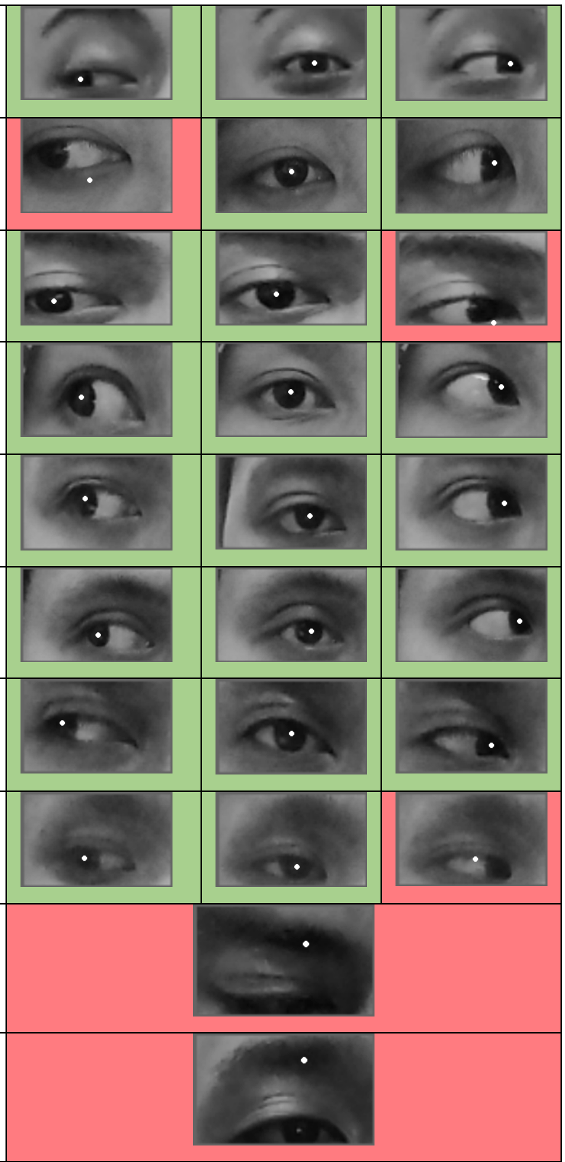
Table III. Eye Left Localization

User	Result	Details
1	Success	Left eye detected
2	Success	Left eye detected
3	Success	Left eye detected
4	Success	Left eye detected
5	Success	Left eye detected
6	Success	Left eye detected
7	Success	Left eye detected
8	Success	Left eye detected
9	Success	Left eye detected

10	Success	Left eye detected
11	Success	Left eye detected
12	Success	Left eye detected
13	Success	Left eye detected
14	Success	Left eye detected
15	Success	Left eye detected
16	Success	Left eye detected
17	Success	Left eye detected
18	Success	Left eye detected
19	Failed	Left eye cropped
20	Failed	Left eye cropped

In the main process, after eye center point was obtained from initialization while looking forward, after that test was done when user look at left side, straight, and right side. The result is shown in Table IV below.

User	Left Side	Straight	Right SIde
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
% Success	80 %	90 %	80 %



Based on TABLE IV, from 20 users, there are two absolute failure in user 19 and 20 where system only detect center point of users eyebrow because the image of eye is cropped. This is because the large and long of eye is smaller than eyebrow contour. So that system ccan not track user eye gaze. Besides, the procentage success rate when users look at left side is 80 % with 4 failure, 90 % when users look forward or straight, and 80 % when users look at right side. Failure image is shown in red colour and green for success track.

H. Duration of Choosing Menu

Testing of duration while user choose each main menu and sub menu is shown in Tabel V. In that table there are 4 menu groups with average duration of it. Main menu groups is average duration when users choose *Makan, Minum,* and *Nayalakan*. Sub menu Makan groups is the average duration when users choose *Buah, Nasi* and *Roti*. Sub menu Minum groups is average duration when users choose *Air Putih, Jus,* and *teh*. Sub menu nyalakan is the average duration when users choose *AC, Televisi,* and *Musik*.

Table V. Average Duration

Menu Groups	Average Duration (seconds)
Main Menu	14,3
Sub menu Makan	25,3
Sub Menu Minum	43,6
Sub Menu Nyalakan	59,7

V. CONCLUSION

Based on experimental results, we can conclude that the process of choosing activity menu by eye gaze tracking can be applied using haar cascade method, moment and contour. All of those methods has weakness and advantages. For haar cascade method, it can detect object especially for face in quick time, but it has weakness if the user make some movement or didn't look straight ahead to the screen.

For moment method, its easy to use because its has provided in the OpenCV library. Despite, the centre mass of object can be founded easily if the countour of object can be obtained well.

From the experimental result, it has conclusion that this system can help users to give information in people around about activity they want to do with choose activity menu by blinking for more than 250ms. The percentage success rate left eye gaze tracking is 80 %, straight gaze is 90 % and right eye gaze tracking is 80 %.

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