Non-Intrusive Eye Gaze Direction Tracking Using Color Segmentation And Hough Transform

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***Abstract*— This paper presents a method to detect and track the movement of the eye in a controlled context based on image processing techniques with minimal hardware support. Primary image processing techniques used in this paper are color segmentation and Hough Transform for circle detection. This system is capable of detecting the movement of the eye and its direction with reasonable accuracy.**

I. INTRODUCTION

Research on eye gaze tracking has started as early as 1936 by Mowrer whom succeeded in making automatic recordings of the orientation of the eye in the head, and thus the direction of gaze [1]. The research into eye gaze sparked more interest than any other types of human-computer interaction as the movement of the eye can imply a lot of information. The movement of the eye can be used as a way to help express feelings and in people with disability as a way to communicate.

The techniques of locating the eye gaze can be categories as intrusive and non-intrusive. Intrusive methods require the subject to wear certain devices like special contact lens or electro-oculography that enables tracking on the eye-gaze. Non-intrusive methods, on the other hand, enable the subject to be free from wearing any kind of devices. Non-intrusive methods include red-eye effect [2][3][4][5], feature detection [6][7] and neural network [8][9]. For this project, a non-intrusive method is chosen for the detection and tracking of the eye gaze. As the focus of this research is on eye gaze tracking, images were captured in a controlled context where only close-up view of the subject's face is taken. The head is assumed to be in a stationary position and the subjects do not possess features such as beard, moustache, wear glasses, or close their eyes. The feature detection technique is suitable for the purpose of eye detection as it does not require the subject to wear any devices. Feature detection technique relies mainly on the unique features of the eye such as the circular shape of the eye. This technique can then be combined with other motion detection techniques to track the movement and direction of the eye gaze.

II. HOUGH TRANSFORM FOR CIRCLE DETECTION

Hough Transform is a technique used to detect simple shapes such as straight lines, circles and ellipses. A parameter space called the accumulator cell or Hough space is created with a-axis and b-axis having a minimum and maximum of the expected range. The coordinate of these cells in the ab-plane is used to create lines in the xy-plane. Two points (x_1, y_1) and (x_2,y_2) in xy-plane are represented in ab-plane using

$$y_i = ax_i+b \tag{1}$$

In the detection of circles, instead of using equation (1), the equation for circle is used:

$$(x-a)^2 + (y-b)^2 = r^2 \tag{2}$$

The equation for circle detection contains three unknowns (a, b, r). Thus, the accumulator cell needs to be change from a two-dimension to three-dimension for the three unknown values.

Equation (2) can be viewed as a constraint on the possible circle parameters in a given point (x, y). This also means that the loci of points (a, b) are also constraining a distant r from the point (x, y) [10]. Thus, it can be said that point (x, y) should be located at the locus of the circle with a centre of (a, b) and a distant of r from each other. The accumulator cell is created by using possible discrete value of a, b and r. Then for each of the detected edge pixel (x, y) of the possible circle, a solution is generated in the accumulator cell. The value of (a, b) is incremented for a fixed value of r by traversing a circle in discrete increment of θ using the following equations [10]:

$$a = x + r\cos\theta \tag{3}$$

$$b = y + r\sin\theta \tag{4}$$

As in the line detection, for each interception of the generated circle in the accumulator cell, the cell where it intercepts is incremented by 1. The possible condition in the accumulator cell is shown in Fig. 1.

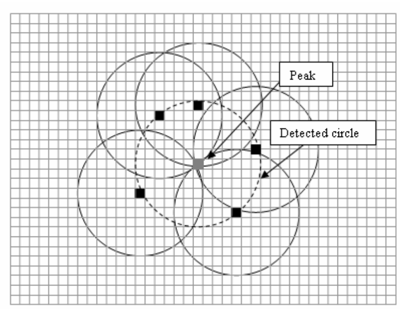

Fig. 1. Accumulator cell for circle detection. [10]