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Human Eye Pupil Detection Technique Using Circular Hough Transform

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ABSTRACT

Eye tracking refers to measure gaze positions and movement to reveal what individuals are looking at. Thanks to the advances of eye tracking technology, there are growing numbers of research focus in using eye tracking to study human behavior. In order to improve the accuracy of the eye gaze tracking technology, this paper presents a novel pupil detection algorithm based on intensity level with canny edge detection technique. Field programmable logic array (FPGA) based hardware implementation of the proposed technique is presented, which can be used in iris localization system on FPGA based platforms for iris recognition application.Threshold based pupil detection algorithm was found to be most efficient method to detect human eye. An implementation of a real-time system on an FPGA board to detect and track a human's eye is the main motive to obtain from proposed work. The Pupil detection algorithm involved thresholding and image filtering. The Pupil location was identified by computing the center value of the detected region.

Keywords: *Pupil Detection; Hough Transform; Canny Edge Detection.*

1.0 Introduction

Eyes movement state recognition is to research how to detect the visual process of gazing accurately and non-intrusively. With the research of gazing direction, we can obtain the location information of saccade selection and monitoring process in people's variable observation, and take it as a channel of Human Computer Interaction. There are four forms of eyes movement state, Vergence movement, VOR, saccades and Smooth pursuit, which manifest as the movement of pupil center. Therefore, the movement information of pupil center is key feature of the gaze tracking and how to extract it directly impacts on the precision and accuracy of gaze tracking system**.** The eye detection or eye tracker is the sensor technology that permits a device to get to know distinctly where our eyes are focused and it regulates our presence, attention, drowsiness, consciousness and other fatigue states. This intelligence shall be used for acquiring the deep accurate and understanding in to consumer behavior or to model the new interfaces across diverse devices. When comes to eye tracking in the real world the three factors comes to our mind that is construe the human behavior, allows hand free interplay, and user experiences of the humanized user interfaces. By adjoining the eye tracking with other input modules, for instance keyboard, mouse, and voice. Employing the eyes as a pointer at a screen the methods of eye tracking facilitates interoperation with nodes and other gadgets when the user unable to resort their hands as a input form. Iris localization is a prime and first stage in an iris recognition algorithm, which involves detection of iris boundaries.

2.0 Literature Review

Eye tracking is a technique used in perceptive science, iris recognition [6], human-computer Interaction[7], advertising, medical research, and other areas. One simple method [8] is a camera focused on eye and recording their movements as the observer looks at some kind of stimulus and then these records are processed by imageprocessing software. Most of the modern [9],[10] systems use infrared beams to create acorneal reflection, from which the angle of measure can be calculated. Most of them use a frequency of at least 30Hz to capture the details of the very rapid eye movements.

In [11] Zhu and Q. Ji proposed different eye detectionmethods like template, appearance, and feature based methods. The eyes were exactly

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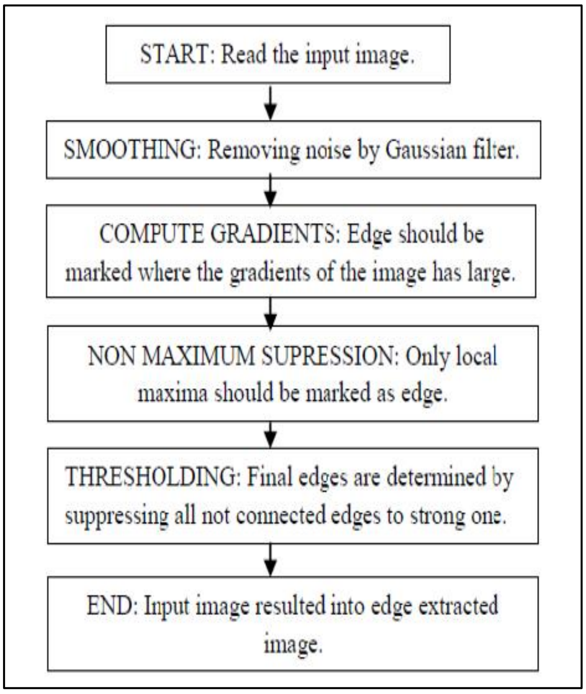
detecting in these methods and also it is expensive in computational part. In [12], author given details about a fast eye detection scheme for use in video streams. In[13], author developed a face detection algorithm using MCT and Ada Boost. In [14], author developed an eye detection method using AdaBoost training with MCT-based eye features. Morphological techniques verify the image with a small template called structuring element.

3.0 Pupil Detection Algorithm

Edge detection is a very important area in the field of Computer Vision. Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. They can show where shadows fall in an image or any other distinct change in the intensity of an image. Edge detection is a fundamental of low-level image processing and good edges are necessary for higher level processing. The problem is that in general edge detectors behave very poorly. While their behavior may fall within tolerances in specific situations, in general edge detectors have difficulty adapting to different situations. The quality of edge detection is highly dependent on lighting conditions, the presence of objects of similar intensities, density of edges in the scene, and noise.

Fig 1: Flow Graph of IRIS Segmentation System



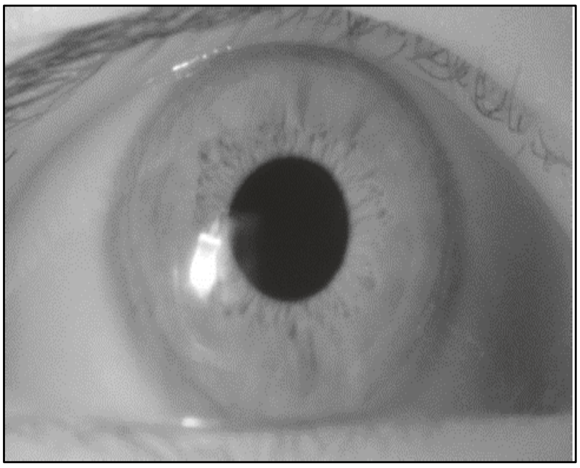
This algorithm consisting of 5 different steps: (i)Smoothing: convolution of image pixel values and Gaussian smoothing filter values yields blurred image, this smoothing is mainly to remove the noise of image. (ii) Finding gradients: gradient magnitude is computed using two 3x3 convolution masks; after smoothing, to find out gradient values at each pixel, sobel operator is used. The sobel operators in two directions x and y are as shown in figure 5. Magnitude and direction of gradient of a pixel is given by the equations (1) and (2).

$G = (Gi2+Gj2)$ … (1)

$\theta = \arctan(Gj/Gi)$ (2)

(iii) Non-maximum suppression: the pixels which are of non-maximum values will get suppressed and replaces values with '0' except points at local maxima. (iv) Double thresholding: in order to extract only the strong edges present in image, thresholding concept is used, which makes easier to remove false edge points. To make this thresholding more accurate double thresholding is utilized and two values are used, where one of the threshold value is double of the other. and (v) Tracking of edges by hysteresis: edge points will be tracked by suppressing the most of edges that are not have connection with the strong edge line. The CHT is a fundamental procedure utilized as an important part in DIP, for recognizing objects with shape of circle in digital picture. The reason for this method is to find out circles in improper picture inputs. The circle edge points are created by "voting" in Hough parameter space and after that selecting the nearby maximum edge values in the matrix of accumulators.

Fig 2: Pupil Localization



3.1 Canny edge detection

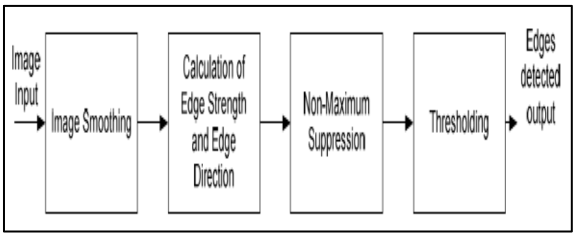
The canny edge detector first smoothes the image to eliminate gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (non maximum suppression). The gradient array is now further reduce remaining pixels that have not been suppressed.

Hysteresis uses two thresholds and if the magnitude is below the first threshold, it is set to zero (made a non edge).

If the magnitude is above the high threshold, it is made an edge.

And if the magnitude is between the 2 thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a gradient above second threshold.

Fig 3: Block Diagram of the Stages of the Canny Edge Detector



A block diagram of the Canny edge detection algorithm is shown in Figure 3. The input to the detector can be either a color image or a grayscale image. The output is an image containing only those edges that have been detected.

3.2 Calculation of the strength and direction of edges

In this stage, the blurred image obtained from the image smoothing stage is convolved with a sobel edge operator.

The canny edge operator is a discrete differential operator that generates a gradient image. Horizontal and vertical Sobel operators that are used to calculate the horizontal and vertical gradients, respectively.

3.3 Calculating edge direction

Edge direction is defined as the direction of the tangent to the contour that the edge defines in 2-dimensions [1: 690].

The edge direction of each pixel in an edge direction image is determined using the arctangent

The edge strength for each pixel in an image obtained from equation A = arctan (Gy/Gx) is used in non-maximum suppression stage.

The edge directions obtained from equation are rounded off to one of four angles--0 degree, 45 degree, 90 degree or 135 degree--before using it in non-maximum suppression.

3.4 Non-maximum suppression

Non-maximum suppression (NMS) is used normally in edge detection algorithms. It is a process in which all pixels whose edge strength is not maximal are marked as zero within a certain local neighborhood.

This local neighborhood can be a linear window at different directions of length 5 pixels. The linear window considered is in accordance with the edge direction of the pixel under consideration for a block in an image.

3.5 Advantages of edge detection

Edge detection forms a pre-processing stage to remove the redundant information from the input image, thus dramatically reducing the amount of data to be processed while at the same time preserving useful information about the boundaries.

Thus edge detection provides basic information which is used for extracting shapes like lines, circles and ellipses by techniques such as Hough Transform.

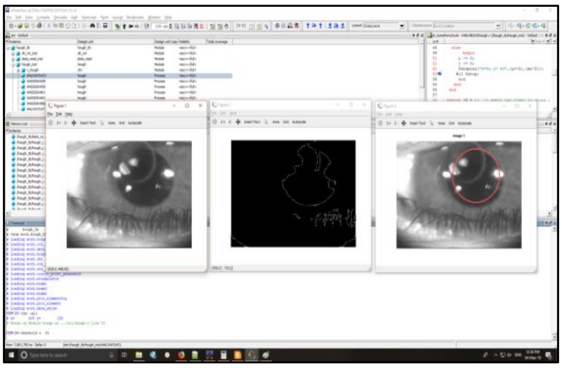
4.0 Circular Hough Transform

The edge detected from the Canny edge detector forms the input to extract the circle using the Circular Hough Transform. In Circular Hough Transform, voting procedure is carried out in a parameter space. The local maxima in accumulator space, obtained by voting procedure, are used to compute the Hough Transform. Parameter space is defined by the parametric representation used to describe circles in the picture plane, which is given by equation. An accumulator is an array used to detect the existence of the circle in the Circular Hough Transform.

Dimension of the accumulator is equal to the unknown parameters of the circle.

5.0 Results

Fig 4: Output Image with Pupil Detection



Simulation of proposed technique is done by Modelsim and output is viewed through Matlab

6.0 Conclusions

Eye tracking and eye movement analysis may be particularly interesting for the applications depending on user-computer dialogue since they represent measures which can provide valuable information about the visual and attentional aspects of human. In this work, we proposed dedicated hardware architecture for eye detection. In order to detect eyes with different sizes without so much computational work and without using databases of different sizes for each image, we have developed a threshold based pupil detection method. Pupil detection is experimentally tested with 100 human eyes which gives 95% result successfully. Hardware reduction is also improved than existing method.

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