Performance Evaluation of Quadtree & Hough Transform Segmentation Techniques for Iris recognition using Artificial Neural Network (Ann)

Falohun A.S.[1], Ismaila W.O.[2], Adeosun O.O[3]
[1,2,3] Ph.D Department of Computer Science And Engineering
Ladoke Akintola University of technology, Ogbomoso, Nigeria
All correspondence should be directed to: Falohun A. S. , Ismail W.O and Adeosun O.O. Department of Computer Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
P.M.B 4000 Ogbomoso, Oyo state
Phone No: +234-803-563-4931.

Abstract
In this work, Quadtree and Hough transform segmentation techniques were evaluated in terms of recognition time, training time and segmentation time while artificial neural network (ANN) was used for training the iris images. The system was implemented using Matrix laboratory (MATLAB). On evaluating the performance of the two segmentation techniques, results showed that Quadtree segmentation technique proved faster during the three stages i.e Segmentation, Training and Recognition stages.

KEYWORDS: *Neural network, Quadtree, Feature Extraction,*

1. Introduction

Recognition is a form of remembering characterized by a feeling of familiarity when something previously experienced is again encountered. It is an act in the process of identifying a body on the basis of past sighting or experience. This can be given a scientific approach by making the recognition theory which has a proof that can be globally experimented. Representing and recognition of patterns is relatively difficult due to the factors that affect the look of a face not to mention the body as a whole. A solution to this problem would be creating a technology that would provide reliable automatic recognition of individuals based on their physiological or behavioral characteristics, a technology such as, biometric.

Biometrics measures biological characteristic such as fingerprint, iris pattern, retina image, face or hand geometry; or behavioral characteristic such as voice, gait or signature. It uses these characteristics to identify individuals automatically. Ideally the characteristic should be unique to the individual, stable over time and easily measurable.

1.1 Biometric Systems

A biometric system is essentially a pattern-recognition system that recognizes a person based on a feature vector derived from a specific physiological or behavioural characteristic that the person possesses. That feature vector is usually stored in a database after being extracted. A biometric system based on physiological characteristic is more reliable than one based on behavioural characteristics.

Biometric systems work by first capturing a sample of the feature, such as recording a digital sound signal for voice recognition, or taking a digital colour image for face recognition. The sample is then transformed using some sort of mathematical function into a biometric template. The biometric template will provide a normalized, efficient and highly discriminating representation of the feature, which can then be objectively compared with other templates in order to determine identity. Some biometric systems have gained wide acceptance in various applications, the most common being finger print and face print. Other biometric systems such as iris are gradually gaining acceptance because of their high performance, efficiency, and ease of use.

1.2 Iris Recognition

Image processing techniques can be employed to extract the unique iris pattern from a digitized image of the eye, and encode it into a biometric template, which can be stored in a database. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates.

Compared with other biometric technologies, such as face, speech and finger recognition, iris recognition can easily be considered as the most reliable form of biometric technology [1]. one of its applications include controlling door systems using iris signature [2].

In line with the basic steps in Biometric systems operation, iris recognition involves the following process viz: Image capturing, iris Segmentation,

Iris Normalization, Feature encoding, and Matching. [3].

2. Iris Segmentation

This step involves isolating the actual iris region in a digital eye image. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. Also, specular reflections can occur within the iris region corrupting the iris pattern. A technique is required to isolate and exclude these artefacts as well as locating the circular iris region. The success of segmentation depends on the imaging quality of eye images.

Segmentation of iris images using Quadtree data structure and Hough transform were chosen in this study. The performance of the two methods mentioned above were evaluated and compared using training, segmentation and recognition time.

The segmentation stage is critical to the success of an iris recognition system, since data that is falsely represented as iris pattern will corrupt the biometric templates generated, resulting in poor recognition rates.

2.1. Existing Iris Segmentation Techniques

A detailed review of five major segmentation techniques will be given, two (the last two) of which is proposed to be evaluated.

Daugman's Integro-differential Operator makes use of an integro-differential operator for locating the circular iris and pupil regions, and also the arcs of the upper and lower eyelids. The integro-differential operator is defined as:

$$\max_{(r,x_p,y_o)}\left|G_\sigma(r)*\frac{\partial}{\partial r}\oint_{r,x_o,y_0}\frac{I(x,y)}{2\pi r}ds\right| \quad (1)$$

where $I(x,y)$ is the eye image, r is the radius to search for, $G_\sigma(r)$ is a Gaussian smoothing function, and s is the contour of the circle given by r, x_0, y_0. The operator searches for the circular path where there is maximum change in pixel values, by varying the radius and centre x and y position of the circular contour. The operator is applied iteratively with the amount of smoothing progressively reduced in order to attain precise localization. Eyelids are localized in a similar manner, with the path of contour integration changed from circular to an arc.

Also used in segmentation is ***active contour models*** for localizing the pupil in eye images [4]. Active contours respond to pre-set internal and external forces by deforming internally or moving across an image until equilibrium is reached. The contour contains a number of vertices, whose positions are changed by two opposing forces, an internal force, which is dependent on the desired characteristics, and an external force, which is dependent on the image. Each vertex is moved between time t and t + 1 by

$$v_i(t+1) = v_i(t) + F_i(t) + G_i(t) \quad (2)$$

where F_i is the internal force, G_i is the external force and v_i is the position of vertex i.

For localization of the pupil region, the internal forces are calibrated so that the contour forms a globally expanding discrete circle. The external forces are usually found using the edge information. In order to improve accuracy Ritter *et. al.* used the variance image, rather than the edge image.

A point interior to the pupil is located from a variance image and then a discrete circular active contour (DCAC) is created with this point as its centre. The DCAC is then moved under the influence of internal and external forces until it reaches equilibrium, and the pupil is localized.

The *Wildes method* proposed in 1997 by [5], performs its segmentation in two steps. First, the image intensity information is converted into a binary edge map. Secondly, the edge point votes to instantiate particular contour parameter values. The construction of the edge map is accomplished through the gradient-based canny edge detector. In order to incorporate directional toning, the image intensity derivatives are weighted to favor ranges of orientation. For example, on the iris/sclera border, the derivatives are weighted to be selective for vertical edges. The second step is made through the well known circular Hough transform where each edge points votes for particular contour parameter values. This method is clearly the most common in iris segmentation approaches, having as a principal disadvantage the dependence of threshold values on the edge-map construction. This fact can obviously constitute one weak point as far as the robustness is concerned and includes an ability to deal with heterogeneous image characteristics.

The *Hough transform* is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and iris regions. Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the centre coordinates x_c and y_c, and the radius r, which are able to define any circle according to the equation

$$x_c^2 + y_c^2 - r^2 = 0 \quad (3)$$

A maximum point in the Hough space will correspond to the radius and centre coordinates of the circle best defined by the edge points.

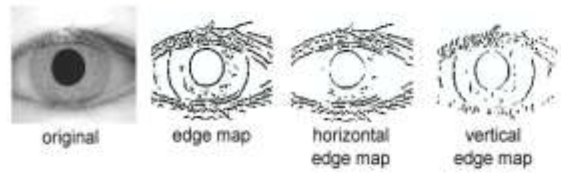


Figure 1 (a) an eye image (*020_2_1 from the CASIA database*)
(b) Corresponding edge map
(c) Edge map with only horizontal gradients
(d) Edge map with only vertical gradients.

However, in a related work, [6] implemented a two-level segmentation technique for the black (African) iris images combining Hough transforms and the Integro-differential operator due to the difficult colour contrasts of those eyes from the tropics.

Quadtree

The *Quadtree* decomposition is an analysis technique that involves subdividing an image into blocks that are more homogeneous than the image itself. This technique reveals information about the structure of the image.

The Basic principle of the Quadtree data structure involves dividing a square image into four equal-sized square blocks, and then testing each block to see if it meets some criterion of homogeneity. If a block meets the criterion, it is not divided any further. If it does not meet the criterion, it is subdivided again into four blocks, and the test criterion is applied to those blocks. This process is repeated iteratively until each block meets the criteria.

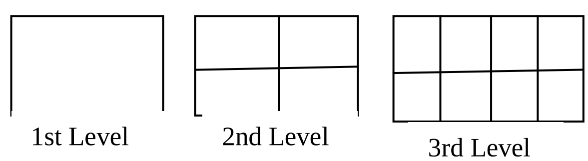


Figure 2. First three levels of a Quad tree

3 Simulation Results

3.1 The Interface

An interface was designed using MATLAB Graphic user interface (GUI). This interface conjugates all separate tasks involved in the evaluation process on a single user friendly environment. The system is actually an Artificial Neural Network (ANN) Iris Recognition system with two Segmentation techniques (Quadtree and Hough transform) incorporated in it. Both Segmentation processes were also designed in the same environment. The interface was designed to enable a view of all results gotten from each of the evaluation points satisfying the ultimate goal.

It is basically the platform of the entire process.

Artificial Neural Networks is incorporated because of its ability to learn, given a specific task to solve, and a class of functions.

ANN comes in at the point of database training after the segmented iris has been encoded.

It also accounts for the final stage which is matching the tested Iris to its corresponding encoded version, in other words, recognition.

3.2 Performance Evaluation

Evaluations were made at three (3) different areas or points in the course of the system execution.

These three evaluation points are:

- Point of segmentation (Segmentation Time)
- Point of ANN database training (Training Time)
- Point of Template Matching (Recognition Time)

These Evaluations were made on various Iris images available in our database, ensuring that each of them was examined with both segmentation techniques.

The average results of the experiments are as presented below.

1. The average segmentation time was calculated thus:

$$\text{Average Segmentation time} = \frac{\text{Total Time Taken}}{\text{Number of Iris Tested}}$$

Bar Chart showing Average Segmentation Time

Figure

It can be deduced from the graph that segmentation time for Hough transform is very long (averaged of about 22 Secs) compared to that of Quadtree which is a second.

2. The average Training time was calculated thus:

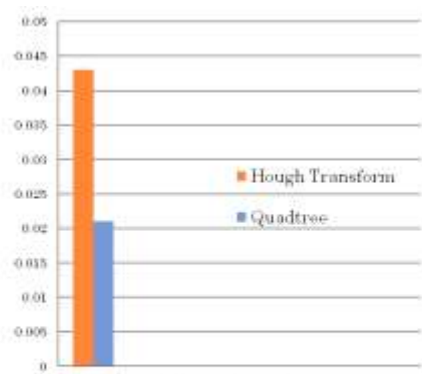
$$\text{Average Training time} = \frac{\text{Total Time Taken}}{\text{Number of Training instances}}$$

Bar Chart showing Average Training Time

From the Graph, it took more than 2 minutes to train the database with an Iris segmented using Hough transform technique while Quadtree on the other hand used over a minute.

3. The average Recognition time was calculated thus:

$$\text{Average Recognition Time} = \frac{\text{Total Time Taken}}{\text{Number of Recognized Iris}}$$



Bar Chart showing Average Recognition Time

The Graph indicates that it takes a longer time for the recognition system to recognize an iris image that was segmented with the Hough transform technique compared to that of Quadtree.

4. Conclusion

The results showed that Quadtree segmentation in ANN-trained iris recognition system is faster at the segmentation, training and recognition stages compared to Hough segmentation in the same ANN environment.

5. References

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