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IRIS SEGMENTATION USING GA BASED CIRCULAR HOUGH TRANSFORM (GACHT)

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ABSTRACT

Iris recognition system consists of a sequence of stages, each stage perform specific functions on the captured image of the human iris. The first stage is automatic segmentation of iris from the eye image. In this paper, new proposed algorithm designed and implemented using Genetic based Hough Transform algorithm (GACHT) to implement the first stage of iris recognition system with the developed Genetic Algorithm. GACHT was used to detect the Iris and Pupil segments which in turn is a outer and inner circles, the accuracy of any Iris recognition system should be depend on the right region of the Iris, which is done in this paper using and evolutionary algorithm called GACHT algorithm.

Introduction

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, the retina [1], and the one presented in this paper, the iris. 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 color 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.

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Most biometric systems allow two modes of operation. An enrolment mode for adding templates to a database, and an identification mode, where a template is created for an individual and then a match is searched for in the database of pre-enrolled templates

Iris is gaining lots of attention due to its accuracy, reliability and simplicity as compared to other biometric traits. The human iris is an annular region between the pupil (generally darkest portion of the eye) and sclera. It has many interlacing minute characteristics such as freckles, coronas, stripes, furrows, crypts and so on as seen in figure (1). These minute patterns in the iris are unique to each individual and are not invasive to their users. These properties make iris recognition particularly promising solution to society. The concept of automated iris recognition has been initially proposed by Flom and Safir [1]. This paper proposes an iris Segmentation algorithm that can be used to determine the inner pupil boundary without any sort of preprocessing required on the captured iris image. The outer iris boundary can be detected by circular summation of intensity approach from the known pupil center and radius.

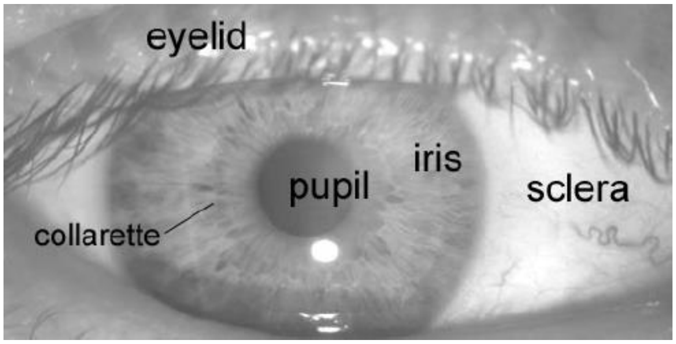

Figure 1 – A front-on view of the human eye.

Image Acquisition

The iris image should be rich in iris texture as the feature extraction stage depends upon the image quality. Thus, the image is acquired by 3CCD camera placed at a distance of approximately 9 cm from the user eye. The approximate distance between the user and the source of light is about 12 cm. The image acquisition setup is omitted in this paper and a standard iris database (CASIA) was chosen to offer us the required iris

Circular Hough Transform (CHT)

CHT methodology

The Hough transform was first introduced by Paul Hough [1,2] in 1962 to detect straight lines in bubble chamber data, the transform consists of parametric description of a feature at any given location in the original image's space. Duda and Hart [2] improved the Hough technique and extended it to detect other algebraic curves and they suggested that the detection of straight lines using Hough transform may most usefully parameterized by its normal form, i.e. an important advantage of the normal form over other parameterization methods is that the range of (ρ,θ) is bounded. Due to the above advantage, the (ρ,θ) form has become the most familiar parameterization method of line detection in using Hough transform, and the associated transform is termed the standard Hough transform. For the conventional (standard) implementation, the Hough transform essentially

Consists of two stages, the first is an increment stage based on the transform mapping and voting rule. The second stage is an exhaustive search for parameters in the accumulator array and the verification of the candidate shape associated with these parameters.

The Hough transform is robust to noise, and can resist to a certain degree of occlusion and boundary effects. The Hough transform can be used to identify the parameters of a curve which best fit a set of given edge points. This edge description is commonly obtained from a feature detecting operator such as Canny edge detector [3] and may by noisy (i.e. it may contain multiple edge fragments corresponding to a single whole feature). Furthermore, as the output of an edge detector defines only where features are in an image, the work of the Hough transform is to determine both what the features are (i.e. to detect the feature(s) for which it has a parametric or other description) and how many of them exist in the image.

Advantage and disadvantage of CHT:

Hough transform directly detects the object's edges using image global features; it can link every point to form a closed edge in image field. If the shape or edges of objects is known, using Hough transform edges can be detected and points can be linked together easily. The main advantage of the Hough transform technique is tolerant to the presence of gaps in feature boundary descriptions and is relatively unaffected by image noise. Also the Hough transform provides parameters to reduce the search time for finding lines based on a set of edge points, and that these parameters can be adjusted based on application requirements. The disadvantage of Hough transform is that the calculation quantity is very large. With image size increasing, the quantity of data will become too large and the processing quantity of data will be slow. However, there are two major drawbacks from the Hough transform; these drawbacks are the requirements for a large amount of storage and high cost in computation. To tackle these problems, many improvements have been suggested [5]. However, all the improvements are made with the cost of making certain assumptions or by sacrificing the degree of flexibility in the algorithm.

Hough circle transform

CHT uses a three dimensional parameter space (xo, yo, r) where xo and yo are the center coordinates of the circle and r is the radius of the circle as the following equation

$$(x - x_0)^2 - (y - y_0)^2 = r^2 \qquad (1)$$

the parameter vector is

$$\vec{P} = \begin{bmatrix} X_0 \\ y_0 \\ r \end{bmatrix} \qquad (2)$$

Figure (2) shows the implementation of CHT by using the accumulator that store the vectors of (x,y,r) of the circle.

The algorithm of CHT outlined as bellows:
Algorithm CHT

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the threshold T.
radius of circle.

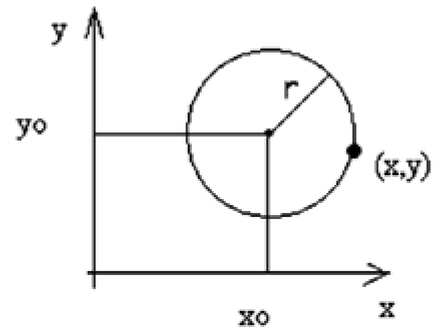


Figure 2 – CHT implementation.

OUTPUT

the Accululator ACC

For each edge point (xo,yo)

For (xo = xo_min ; xo<= xo_max ; xo++)

For (yo = yo_min ; yo<= yo_max ; yo++)

r=sqrt((x-xo)^2 + (y-yo)^2) ;

Accumulator[r][xo][yo]++ ; // Voting

Find local maxima in accumulator [r][xo][yo] that higher T.

The algorithm traverses all the edge points in the image and performs the test for checking the existence of the circle using equation (1).

Genetic Algorithms:

The field of Genetic Algorithms (GAs) was created by Holland in the University of Michigan. The inspiration for the work was the mechanisms of natural selection. Important aspects include the schema theory that seeks to explain the building and manipulation of blocks of data. Goldberg continued the work by increasing the general and theoretical understanding of Gas [6].The classic GA consists of a population of bit (0 or 1) strings that represent a solution to a fitness function. At each generation the individuals are evaluated and assigned a fitness based on their performance. Reproduction between fit individuals is used to form the next generation that replaces some or all of the individuals in the old generation. The cycle of evaluation and generation continues until the optimum function value is discovered or a stable solution has been reached [6].

Genetic Operations

Selection

Selection is the component which guides the algorithm to the solution by preferring individuals with high fitness over low-fitted ones. It can be a deterministic operation, but in most implementations it has random components. One variant, which is very popular nowadays, is the following scheme, where the probability to choose a certain individual is proportional to its fitness. It can be regarded as a random experiment with

$$P_{Select}(I_K) = \frac{f(I_K)}{\sum_{c=0}^{m} f(I_c)} \qquad (3)$$

Where PSelect is the probability of selecting the individual and f(Ik) is the fitness function of the individual.

Crossover:

In sexual reproduction, as it appears in the real world, the genetic material of the two parents is mixed when the gametes of the parents merge. Usually, chromosomes are randomly split and merged, with the consequence that some genes of a child come from one parent while others come from the other parents. This mechanism is called crossover. It is a very powerful tool for introducing new genetic material and maintaining genetic diversity, but with the outstanding property that good parents also produce well-performing children or even better ones. Several investigations have come to the conclusion that crossover is the reason why sexually reproducing species have adapted faster than asexually reproducing ones.

Mutation

Random mutations alter a certain percentage of the bits in the list of chromosomes. Mutation is the second way a GA explores a cost surface. It can introduce traits not in the original population and keeps the GA from converging too fast before sampling the entire cost surface. A single point mutation changes a 1 to a 0, and visa versa. Mutation points are randomly selected from the Npop × Nbits total number of bits in the population matrix. Increasing the number of mutations increases the algorithm's freedom to search outside the current region of variable space. It also tends to distract the algorithm from onverging on a popular solution. Mutations do not occur on the final iteration.

The Population

The GA starts with a group of chromosomes known as the population. The population has Npop chromosomes and is an (Npop ×Nbit) matrix filled with random ones and zeros (Binary GA), that is generated randomly and the size of initial population is determined by the user.

Natural Selection

Survival of the fittest translates into discarding the chromosomes with the highest. First, the Npop costs and associated chromosomes are ranked from lowest cost to highest cost. Then, only the best are selected to continue, while the rest are deleted. The selection rate, Xrate, is the fraction of Npop that survives for the next step of mating. The number of chromosomes that are kept each generation is

$$N_{kept} = X_{rate} \times N_{Pop} \qquad (3)$$

One of important selection algorithm is the tournament selection. Another approach that closely mimics mating competition in nature is to randomly pick a small subset of chromosomes (two or three) from the mating pool, and the chromosome with the lowest cost in this subset becomes a parent. The tournament repeats for every parent needed. Thresholding and tournament selection make a nice pair, because the population never needs to be sorted. Tournament selection works best for larger population sizes because sorting becomes time-consuming for large populations.

GACHT implementation:

Preprocessing stage:

The proposed system initially performs the following operations on the input iris image so that the image can be processed via the GACHT.

1. Generate edge image. This process uses canny filter to generate the edge image with orientation.

2. Initialize the Accumulator. the accumulator used to store the accounting of the point (x,y,r) that is considered as the center of the circle with the radius (r) that is the current edge point (X_0,Y_0) is satisfy the equation (1).

GACHT architecture:

The proposed algorithm initially set up a population of individuals (strings) that represents the mating chromosomes. The population size was chosen to be (500) chromosomes and they are generated randomly. The genetic algorithm used is the binary GA.

Individual representation:

The chromosome contains the (X,Y,R) of the edges points chosen randomly from the space of the edge points of the image. Figure (3) shows the individual configuration.

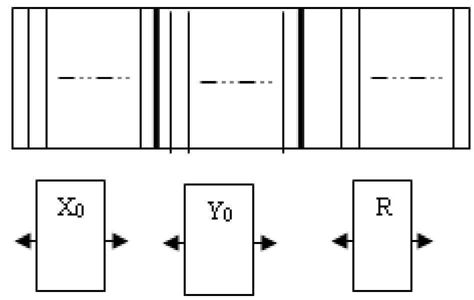


Figure (3). Chromosome configuration

Fitness Function:

The fitness function chosen for GACHT keeps track and maintains an indexed table called Accumulator which is incremented for the edge points (x,y,r) that satisfy the equation (1) which means that the edge points lies on the circumstance of the circle with the determined radius. The determined radius comes from the measured iris radius. The following formula shows the fitness function calculation:

Fitness Formula (1)

If (x0 , y0 , r) satisfy {(x-x0)2- (y-y0)2= r2} Then Fitness(x0 , y0 , r)=Acc(x0 , y0 , r)++

GACHT basically search in the image pixels that are found to be edge points. The maximum value found in the accumulator at the point (X,Y) represents the center of the found circle. Instead searching the overall space, GA perform a guided search by maximizing the value found in Acc. The iterations proceeding until a stopping condition satisfied, which is a determined number of generations

Figure (4) shows the architecture of GACHT algorithm.

The suggested algorithm was implemented using matlab v.7.0 and experimental images were selected to be implemented using the original CHT method and applying it upon the selected images. After that they tested using our GACHT algorithm. The results for both show equivalent results in case of accuracy but was different in speed. The proposed algorithm shows good gain in speed against the CHT algorithm as shown in table (1).

Table (1)gain in speed against the CHT algorithm.....

Image Samples	CHT Exec. Time	GACHT Exec. Time
Sample (1)	**39.3750**	**22.915**
Sample (2)	**51.4840**	**26.423**
Sample (3)	**49.4220**	**27.173**
Sample (4)	**28.4220**	**17.856**
Sample (5)	**37.5000**	**21.457**

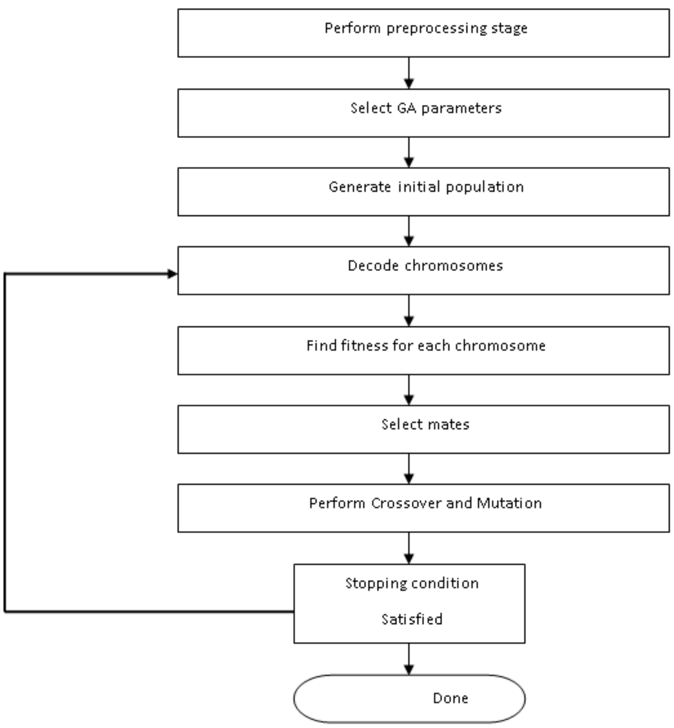
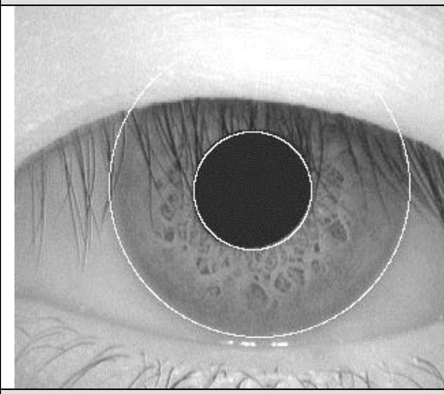
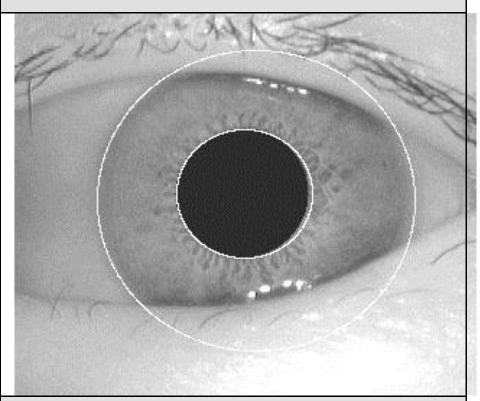
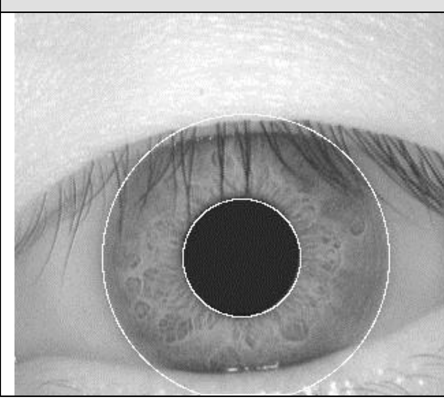


Figure (4) . GACHT architecture

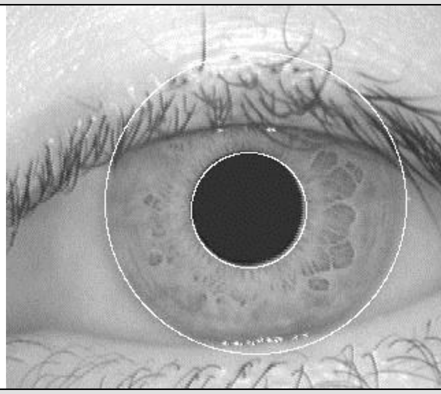
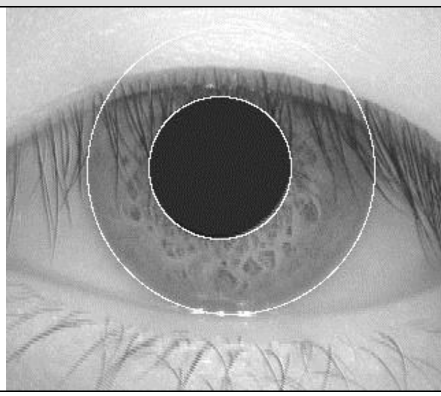
Figure (4) . GACHT architecture

Experimental Results:

When implementing the GACHT algorithm, the image is divided into two regions, Iris and Pupil regions that the GA can find two values in the accumulator the maximum value (1) represents the center of outer circle (Iris) and the second represents the inner circle (Pupil) which in turn let us find in one algorithm multiple circles in one pass as compared to traditional CHT which must fired with one radius value to search.

Image	Output image
(1)	
Image	Output image
(4)	
Image	Output image
(5)	

* During conference sessions, it was shown by discussions form some audience that the results presented by this work is not accurate due to an error in the work of the proposed genetic algorithm. In response, the author has promised to fix this error and present his new results in a later version of this paper.

Image	Output image
(2)	
Image	Output image
(3)	

Discussion and conclusion

The objective of this study is to use Hough transform to detect the Iris and Pupil segments which in turn is a outer and inner circles, the accuracy of any Iris recognition system should be depend on the right region of the Iris, which is done in this paper using and evolutionary algorithm called GACHT algorithm. The proposed algorithm succeeds to find and accurate circles in a very god time compared to the original Circular Hough Transform. This gain has very important benefits in case of online recognition system. The selected image has different radii in noisy environment. Canny edge detector was applied before Hough transform operation. Hough transform is dependent on the edge pixels. For noisy image the edge detection is very critical and the threshold value should be chosen carefully. Very high threshold value might result in the elimination of correct edges (i.e. the less number of edges that can be detected), and a low threshold value might result in long execution time. The GACHT algorithm also has more benefits rather than CHT in case of finding multiple circles in the selected images which reduce the execution time by finding the circles in the final generation by verify the fitness function of two upper individuals in the population, the higher fitness indicate the center of first circle, and so on.

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تقطيع حدقة العين باستخدام الخوارزمية الوراثية بالاعتماد على تحويل هوف الدائري

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الخلاصة

يتكون نظام التعرف على بصمة العين من مجموعة المراحل كل مرحلة تقوم باداء وظائف معينة على صورة الحدقة للعين. المرحلة تتضمن المرحلة الاولى عملية التقطيع (Segmentation) لحدقة العين عن صورة العين. في هذا البحث تم تصميم وتنفيذ خوارزمية جديدة باستخدام تحويل هاو المعتمد على الخوارزمية الجينية (GACHT) حيث ان الخوارزمية المطورة تقوم باكتشاف وفصل دوائر الحدقة والبؤبؤ والتي تمثل الدوائر الداخلية والخارجية للحدقة حيث ان دقة أي نظام تعرف على الحدقة تعتمد على المقطع الصحيح للحدقة والذي نفذ في هذا البحث باستخدام الخوارزمية التطورية المعتمدة تحويل هاو.