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Designing and Implementation of Iris recognition System Using Morphological Bridged Canny Edge Detection and KNN Classifier

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Abstract***: A biometric system provides automatic identification of a character based on a unique feature or attribute possessed by the creature. Most practical iris recognition systems use original algorithms developed by Daugman, and these algorithms are competent to create perfect recognition rates but not includes time requirement in account and extremely suffered when pupil is illuminated with light intensity. For the efficient pupil detection a morphological bridged canny edge detection technique is proposed, which is especially designed to handle pupil occlusion problem. For the feature selection and mining part, most conventional iris recognition systems relies on wavelet features extracted from rubber sheet model, but the wavelet feature extraction is a complex and time consuming process, to handle this problem in this paper rubber sheet model of iris part is exclusively used as feature. The third and most crucial modification proposed in this paper, is in the feature classification part, after feature space formation using rubber sheet model, K- Nearest Neighbor classifier is proposed to achieve highest iris recognition efficiency.***

This paper, proposes three serious modifications in available conventional iris recognition method for real time and efficient iris recognition. Mean wise modification proposed are in the pupil segmentation part, Feature extraction part for conduct pupil illumination problem and iris matching part for providing high speed and efficient iris recognition.

Keywords: Iris Recognition, Morphological Bridge Canny, KNN Classifier.

1. Introduction

A biometric system provides automatic recognition of an human being based on some sort of on its own feature or typical possessed by the character. Biometric systems have been developed based on fingerprints, voice, facial features, hand geometry, handwriting, the retina [1], and the one offered in this thesis, the iris.

Biometric systems work by primary 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 model is then altered using some sort of mathematical function into a biometric pattern. The biometric pattern will provide a normalized, efficient and highly selective representation of the feature, which can then be neutrally compared with other templates in order to find out uniqueness. Most of the biometric systems permit two modes of operation. An enrolment mode for adding templates to a database, and an identification mode, where a template is formed for an entity and then a match is searched for in the database of pre-enrolled templates. A fine biometric is characterized by use of a feature that is; highly unique – so that the chance of any two people having the same characteristic will be negligible, stable – so that the feature does not change over time, and be easily captured – in order to provide handiness to the user, and prevent perversion of the feature.

1.1 Human Iris Structure and Recognition

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. A front-on view of the iris is given away in Figure 1.1. The iris is perforated secure to its centre by a circular aperture known as the pupil. The function of the iris is to manage the amount of light entering from end to end the pupil, and this is completed by the sphincter and the dilator muscles, which alter the size of the pupil. The regular diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter [2].

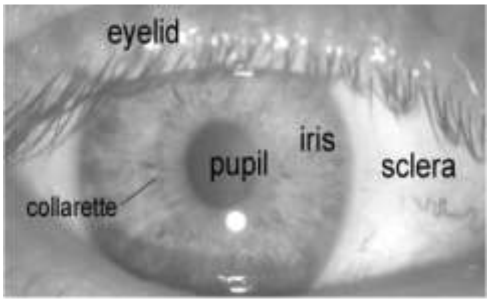


Figure 1-1: A front-on view of the human eye.

Formation of the iris begins during the third month of embryonic life [3]. The unique pattern on the surface of the iris is formed during the first year of life, and pigmentation of the stroma takes place for the first little years. Formation of the exclusive patterns of the iris is random and not linked to any genetic factors [4]. The only characteristic that is dependent on genetics is the pigmentation of the iris, which determines its color. Due to the epigenetic nature of iris patterns, the two eyes of a human being contain completely independent iris patterns, and identical twins possess uncorrelated iris patterns. For extra details on the anatomy of the human eye consult the book by Wolff [3].

The Daugman system has been tested under numerous studies, all reporting a zero failure rate. The Daugman system is claimed to be able to perfectly identify an individual, given millions of possibilities. The prototype system by Wildes et al. also reports flawless performance with 520 iris images [7], and the Lim et al. system attains a recognition rate of 98.4% with a database of around 6,000 eye images. 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]. However, there have been no independent trials of the technology, and source code for systems is not available. Also, there is a lack of publicly available datasets for testing and research, and the test results published have usually been produced using carefully imaged irises under favorable conditions.

2. Proposed Methodology

This work proposes a highly efficient real time iris recognition system. The identified problems involve in traditional iris recognition system are,

i. The process is much complex and not found suitable for real time recognition.

ii. In the first step, that is for iris segmentation part mostly canny edge detector with Hough transform for circle detection has been employed. This process fails to avoid iris occlusion problem and not to draw complete circle and hence provides wrong information about pupil center coordinates and pupil radius.

iii. In case of traditional system, lots of complex algorithms have been proposed by the researchers to extract features of the iris for recognition process, most of the time all these methods were very time consuming; hence an algorithm is required to overcome this problem.

iv. The last but most important part of any iris recognition is the matching process. From the last few years hamming distance was popularly used for iris template matching. This process is also a time consuming and need to replace with the technique which is efficient and less complex.

To overcome the identified problems of conventional iris recognition system, this work proposes following modification on conventional iris recognition system.

1) Development of highly efficient edge detection for iris using Morphological bridged canny edge detection instead of conventional canny edge detection with Hough transform.
2) In feature extraction, formation of feature matrix after preparation of rubber sheet model instead of using 2-D Gabor transform method.
3) For iris feature classification and matching process a highly efficient K nearest Neighborhood (KNN) classifier is proposed which would lead to efficient solution for real time recognition.

The proposed methodology starts with very basic segmentation of iris with modified technique and uses conventional method up rubber sheet model formation and ends with modified matching algorithm based on neural network. Figure (2.1) shows the complete proposed method with the help of flow chart.

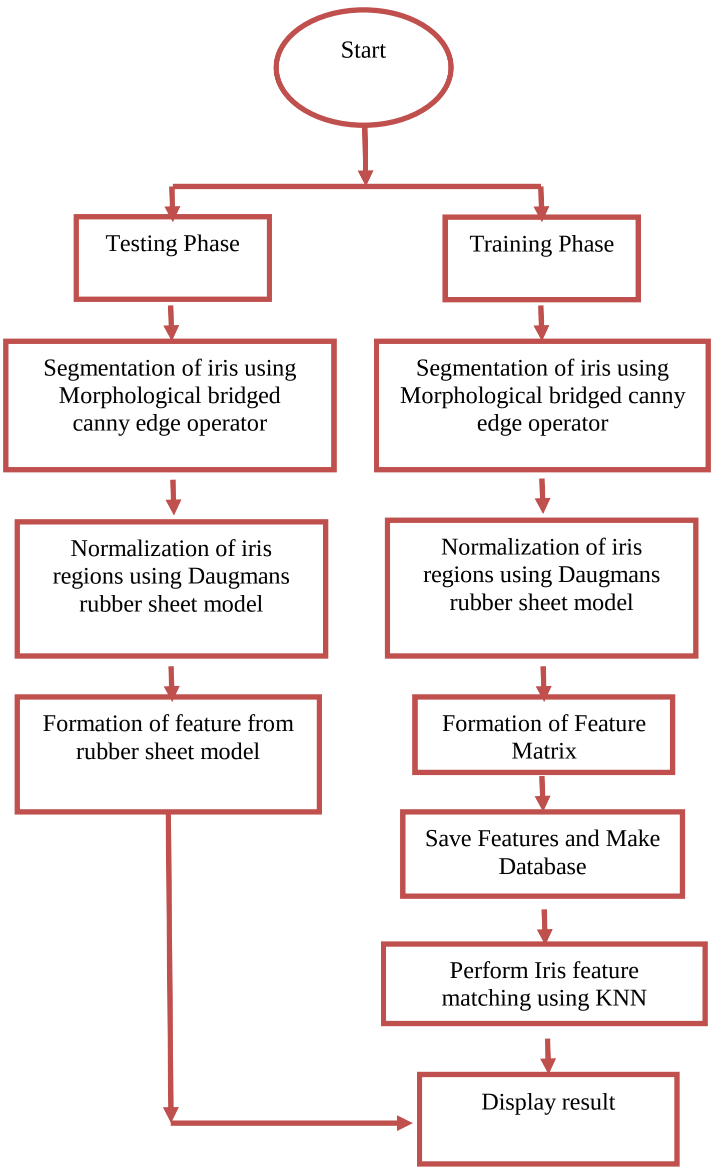


Figure 2-1: Proposed Methodology.

2.1 Morphological Bridging

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. According to available literature, morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grayscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood. Morphological Bridging operation, bridges unconnected pixels, that is, sets 0-valued pixels to 1 if they have two nonzero neighbors that are not connected.

For example:

```
1 0 0          1 1 0
1 0 1  becomes 1 1 1
0 0 1          0 1 1
```

2.2 Normalization

Once the iris region would successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location.

The most commonly used normalization technique is developed by Daugman's and known as Daugman's Rubber Sheet Model.

2.2.1 Daugman's Rubber Sheet Model

The homogenous rubber sheet model devised by Daugman [1] remaps each point within the iris region to a pair of polar coordinates (r, θ) where r is on the interval [0, 1] and θ is angle [0,2π].

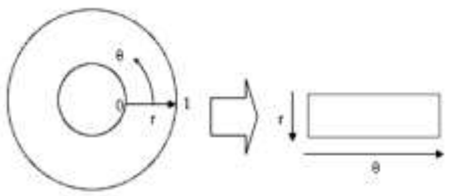


Figure 2-2 Daugman's Rubber Sheet Model

The remapping of the iris region from (x,y) Cartesian coordinates to the normalized non-concentric polar representation is modeled as

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \qquad \ldots(2.1)$$

Where

$$x(r,\theta) = (1-r)x_p(\theta) + rx_l(\theta)$$
$$y(r,\theta) = (1-r)y_p(\theta) + ry_l(\theta)$$

Where $I(x, y)$ is the iris region image, (x, y) are the original Cartesian coordinates, (r, θ) are the corresponding normalized polar coordinates, and x_p, y_p and x_l, y_l are the coordinates of the pupil and iris boundaries along the θ direction. The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modeled as a flexible rubber sheet anchored at the iris boundary with the pupil centre as the reference point.

2.2.1.1 Implementation of Rubber Sheet Model

For normalization of iris regions a technique based on Daugman's rubber sheet model was employed. The centre of the pupil was considered as the reference point, and radial vectors pass through the iris region, as shown in Figure (2-3). A number of data points are selected along each radial line and this is defined as the radial resolution. The number of radial lines going around the iris region is defined as the angular resolution. Since the pupil can be non-concentric to the iris, a remapping formula is needed to rescale points depending on the angle around the circle. This is given by

$$r' = \sqrt{\alpha}\beta \pm \sqrt{\alpha\beta^2 - \alpha - r_I^2} \qquad \ldots(2.2)$$

With

$$\alpha = o_x^2 + o_y^2, \quad \beta = \cos\left(\pi - \arctan\left(\frac{o_y}{o_x}\right) - \theta\right)$$

Where displacement of the centre of the pupil relative to the centre of the iris is given by o_x , o_y, and r' is the distance between the edge of the pupil and edge of the iris at an angle, θ around the region, and r_I is the radius of the iris. The remapping formula first gives the radius of the iris region 'doughnut' as a function of the angle θ.

A constant number of points are chosen along each radial line, so that a constant number of radial data points are taken, irrespective of how narrow or wide the radius is at a particular angle. The normalized pattern was created by backtracking to find the Cartesian coordinates of data points from the radial and angular position in the normalized pattern. From the 'doughnut' iris region, normalization produces a 2D array with horizontal dimensions of angular resolution and vertical dimensions of radial resolution. Another 2D array was created for marking reflections, eyelashes, and eyelids detected in the segmentation stage. In order to prevent non-iris region data from corrupting the normalized representation, data points which occur along the pupil border or the iris border are discarded. As in Daugman's rubber sheet model, removing rotational inconsistencies is performed at the matching stage.

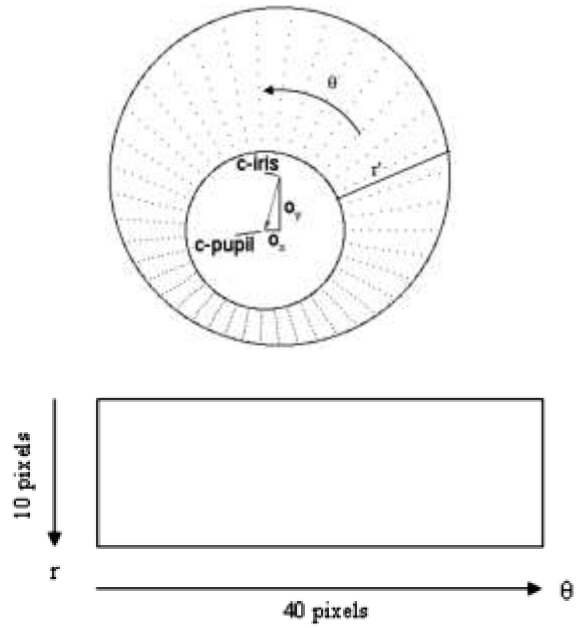


Figure 2-3 Outline of the normalization process with radial resolution of 10 pixels, and angular resolution of 40 pixels. Pupil displacement relative to the iris centre is exaggerated for illustration purposes.

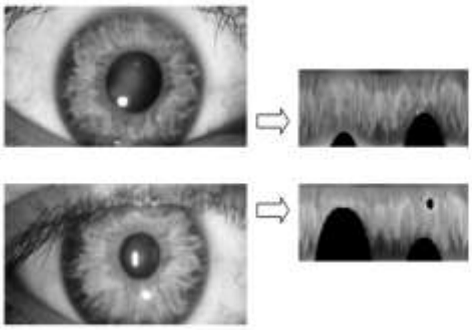


Figure 2-4 Illustration of the normalization process for two images of the same iris taken under varying conditions.

2.3 Feature Encoding and Matching

In the past most commonly wavelet feature extraction or gabor filters have been used to extract features of detected iris after making rubber sheet model. This process is very complex and not applicable for real time operations, because it consumes most of the timing requirement of the complete process. This project work utilized simple concept that, the obtain rubber sheet model itself contains all unique information required to identify an individual person. Hence the basic idea of this project is to convert the rubber sheet model in matrix form and utilize this matrix as a feature matrix of respective eye.

As given in figure (2-4), an iris rubber sheet model is of size 10x40, following steps are proposed to make a unique feasible feature from obtained rubber sheet model.

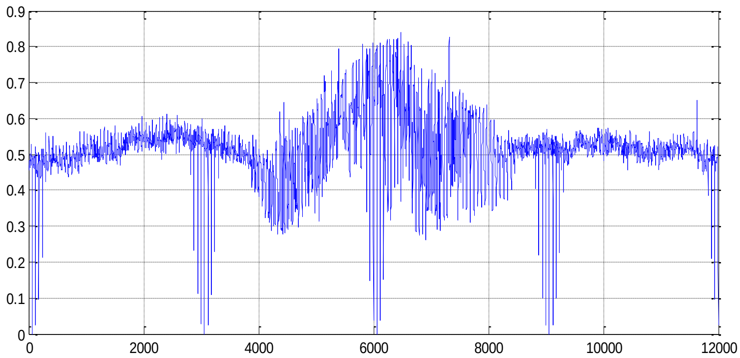
Step 1: arrange the columns of rubber sheet model in vector concatenation form.

Step 2: convert the obtained single column concatenated vector into a row vector.

After step 2 the final iris feature obtained for first iris image of database "1.bmp" is shown in figure (2-5).

(a) first iris image of database "1.bmp"

(b) obtained rubber sheet model



(c) Obtained modified feature from rubber sheet model.

Figure (2-5) Modified iris feature obtained for first iris image of database "1.bmp".

After the formation of feature matrix a KNN classifier matching is proposed in this work for iris recognition process.

2.4 K-Nearest Neighbor Classifier

In pattern recognition, the K-Nearest Neighbors algorithm (or k-NN for short) is a non-parametric cases, the input consists of the k closest training examples in the feature space. The output depends on whether k-NN is used for classification or regression:

- In k-NN classification, the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of that single nearest neighbor.
- In k-NN regression, the output is the property value for the object. This value is the average of the values of its k nearest neighbors.

K-NN is a type of instance-based learning, or lazy learning, where the function is only approximated locally and all computation is deferred until classification. The k-NN algorithm is among the simplest of all machine learning algorithms. Both for classification and regression, it can be useful to weight the contributions of the neighbors, so that the nearer neighbors contribute more to the average than the more distant ones. For example, a common weighting scheme consists in giving each neighbor a weight of 1/d, where d is the distance to the neighbor.

The neighbors are taken from a set of objects for which the class (for k-NN classification) or the object property value (for k-NN regression) is known. This can be thought of as the training set for the algorithm, though no explicit training step is required.

2.4.1 Algorithm of K-Nearest Neighbor Classifier

The training examples are vectors in a multidimensional feature space, each with a class label. The training phase of the algorithm consists only of storing the feature vectors and class labels of the training samples.
In the classification phase, k is a user-defined constant, and an unlabeled vector (a query or test point) is classified by assigning the label which is most frequent among the k training samples nearest to that query point.

A commonly used distance metric for continuous variables is Euclidean distance. For discrete variables, such as for text classification, another metric can be used, such as the overlap metric (or Hamming distance). Often, the classification accuracy of KNN can be improved significantly if the distance metric is learned with specialized algorithms such as Large Margin Nearest Neighbor or Neighborhood components analysis.

A drawback of the basic "majority voting" classification occurs when the class distribution is skewed. That is, examples of a more frequent class tend to dominate the prediction of the new example, because they tend to be common among the k nearest neighbors due to their large number. One way to overcome this problem is to weight the classification, taking into account the distance from the test point to each of its k nearest neighbors. The class (or value, in regression problems) of each of the k nearest points is multiplied by a weight proportional to the inverse of the distance from that point to the test point. Another way to overcome skew is by abstraction in data representation. For example in a self-organizing map (SOM), each node is a representative (a center) of a cluster of similar points, regardless of their density in the original training data. KNN can then be applied to the SOM.

3. Results and Discussions

The Real time iris recognition system has been successfully implemented in the MATLAB 2012(b). This section shows the results obtained from this work. To perform fair judgments the efficiency of the proposed work, images from CASIA Iris image database have been utilized for database preparation and testing.

3.1 Real time recognition efficiency

In this subsection we will show the total time requirement for the iris recognition as well as different time required for different subsections. Table 1 shows the time requirement for different subsections.

Table 1: Real time recognition of proposed iris recognition system.

S.no.	Subsections	Time Required
1	Iris image loading	0.0045 sec
2	Iris segmentation	0.1932 sec
3	Iris Recognition	0.5863 sec
	Total time requirement	**0.8254 sec**

Table 1 indicates that the average total time required for the developed technique for iris recognition is 0.8254 sec, which is very less as compare to the available iris recognition techniques.

3.2 Efficiency of Developed Iris Recognition system

This section shows the recognition efficiency of developed technique with the help of table 2. For the recognition efficiency calculation 32 images from CASIA iris image database have been used.

Table 2

S. No.	Iris Image Name	Recognition	Recognition Result of Proposed Method	
			True Recognition	False Recognition
1	1.bmp	Recognized	Yes	No
2	2.bmp	Recognized	Yes	No
3	3.bmp	Recognized	Yes	No
4	4.bmp	Recognized	Yes	No
5	5.bmp	Recognized	Yes	No
6	6.bmp	Recognized	Yes	No
7	7.bmp	Recognized	Yes	No
8	8.bmp	Recognized	Yes	No
9	9.bmp	Recognized	Yes	No
10	10.bmp	Recognized	Yes	No
11	11.bmp	Recognized	Yes	No
12	12.bmp	Recognized	Yes	No
13	13.bmp	Recognized	Yes	No
14	14.bmp	Recognized	Yes	No
15	15.bmp	Recognized	Yes	No
16	16.bmp	Recognized	Yes	No
17	17.bmp	Recognized	Yes	No
18	18.bmp	Recognized	Yes	No
19	19.bmp	Recognized	Yes	No
20	20.bmp	Recognized	Yes	No
21	21.bmp	Recognized	Yes	No
22	22.bmp	Recognized	Yes	No
23	23.bmp	Recognized	Yes	No
24	24.bmp	Recognized	Yes	No
25	25.bmp	Recognized	Yes	No
26	26.bmp	Recognized	Yes	No
27	27.bmp	Recognized	Yes	No
28	28.bmp	Recognized	Yes	No
29	29.bmp	Recognized	Yes	No
30	30.bmp	Recognized	Yes	No
31	31.bmp	Recognized	Yes	No
32	32.bmp	Recognized	Yes	No

Table 2, clearly indicates that all the 32 images have been successfully recognized by the developed real time iris recognition technique. The same recognition efficiency is reflected in the plot of figure (3-1). Hence the technique developed in this paper provides very high iris image recognition efficiency approximately 100% while the recognition efficiency.

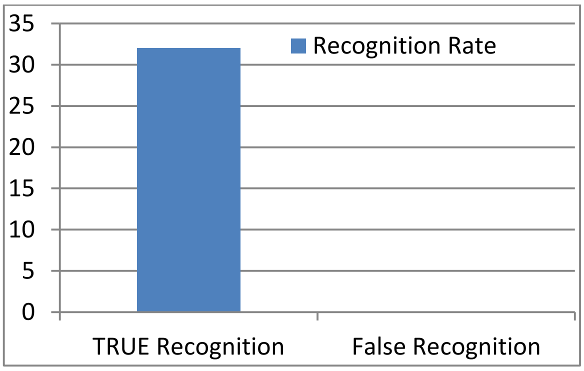


Figure (3-1) Recognition Efficiency of developed system.

4. Conclusions

This paper, putted, three serious modificationsin available conventional iris recognition method for real time and efficient iris recognition. Mean wise modification proposed are in the pupil segmentation part, Feature extraction part for handling pupil illumination problem and iris matching part for providing high speed and efficient iris recognition.

For the efficient pupil detection a morphological bridged canny edge detection technique has been used, for feature part, rubber sheet model of iris was exclusively used as feature. This modification reduces the feature space complexity as well as saves the time consumption for feature extraction. The third and most crucial modification implemented, is in the feature classification part, after feature space formation using rubber sheet model, K- Nearest Neighbor classifier is used to achieve highest iris recognition efficiency.

Hence this paper forwarded, not only the correction to the time requirement as well as dealt with higher recognition efficiency requirement with some serious modifications in the conventional technique.

The obtained result indicates the higher iris image recognition efficiency approximately 100 percent, of the developed system along with the real time recognition efficiency. Moreover the average recognition time for an iris image is found as 0.8254 sec, which is very less as compare to sate of the art techniques.

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