Iris Recognition System Based On Morphological Bridged Canny Edge Detection and KNN Classifier

Shrishti Pardhi[1], Shahana Gajala Qureshi[2]

[1]M.Tech. (CSE), RIT College, Raipur
CSVTU University, Bhilai, Chhattisgarh, India

[2]Asst. Professor, Department of (CSE), RIT College, Raipur
CSVTU University, Bhilai, Chhattisgarh, India

Abstract: *A biometric system provides automatic identification of a character based on a unique feature or attribute possessed by the creature. Iris recognition is breakdown as the most unfailing and accurate biometric identification scheme offered. 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. Conversely, published results have usually been produced under favorable circumstances. So to build up generalized real time and efficient iris recognition system this work presents a number of serious modifications. This paper proposes a innovative iris recognition system which deals with, not merely the correction to the time constraint as well as deals with higher recognition efficiency requirement with a number of serious modifications in the conventional technique.*

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.

2. Brief about Iris Recognition

2.1 The 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 2.1. 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].
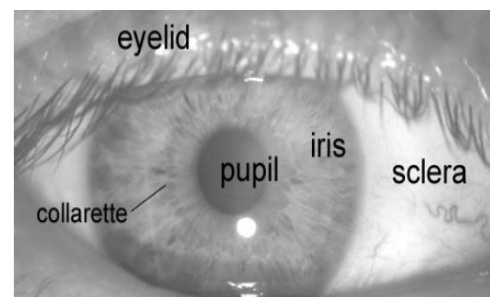

Figure 2-1: A front-on view of the human eye

The iris consists of a number of layers; the lowest is the epithelium layer, which contains dense pigmentation cells. The stromal layer lies above the epithelium layer, and contains blood vessels, pigment cells and the two iris muscles. The density of stromal pigmentation determines the color of the iris. The superficially visible surface of the multi-layered iris contains two zones, which frequently differ in color [3]. An outer ciliary zone and an inner pupillary zone, and these two zones are separated by the collarette, which appears as a zigzag pattern.

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 an 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].

2.2 Foundation of Iris Recognition

The iris is an externally visible, yet sheltered organ whose unique epigenetic pattern ruins stable throughout adult life. These characteristics build it very eye-catching for use as a biometric for identifying individuals. Image processing techniques can be working to take out 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.

When a subject needs to be identified by iris recognition system, their eye is first photographed, and then a template created for their iris region. This template is then compared with the other templates stored in a database until either a matching template is found and the subject is recognized, or no match is found and the subject remains unrecognized. Although prototype systems had been planned earlier, it was not until the early on nineties that Cambridge researcher, John Daugman, implemented a working automated iris recognition system [1][2].

The Daugman system is patented [5] and the rights are now owned by the company Iridian Technologies. Yet though the Daugman system is the most successful and most well known, lots of other systems have been developed. The most notable include the systems of Wildes et al. [7][4], Boles and Boashash [8], Lim et al. [9], and Noh et al. [10]. The algorithms by Lim et al. are used in the iris recognition system developed by the Evermedia and Senex companies. Also, the Noh et al. algorithm is used in the 'IRIS2000' system, sold by IriTech. These are, at a distance from the Daugman system, the only other known marketable implementations.

3. 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 (3-1) shows the complete proposed method with the help of flow chart.
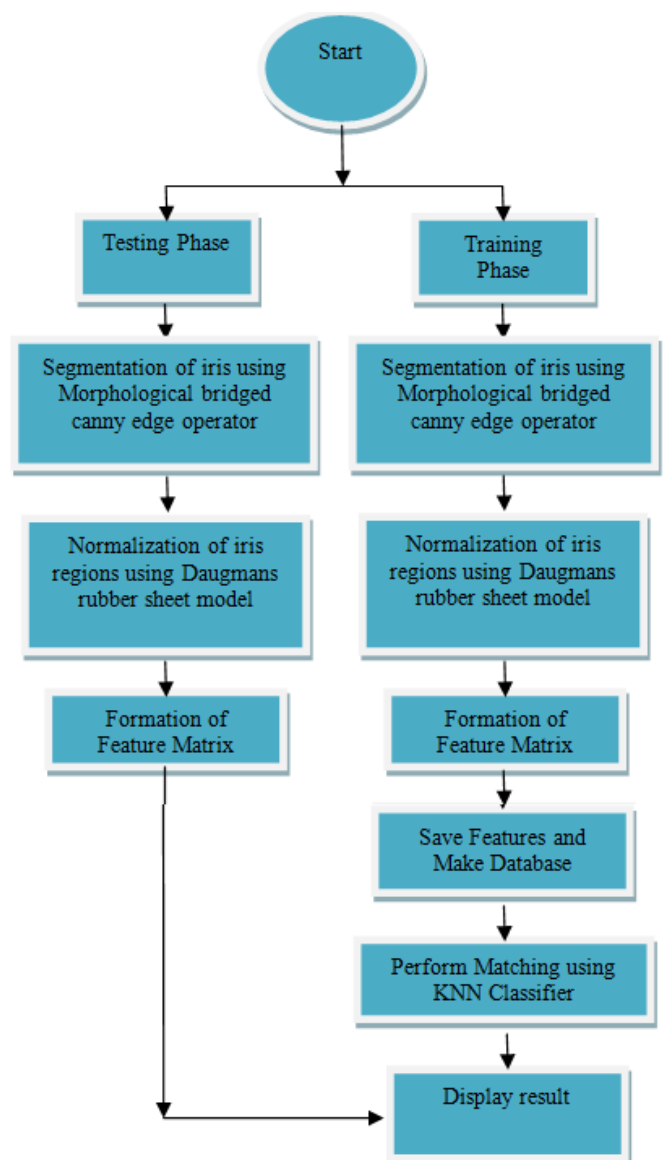

Figure 3-1: Proposed Methodology.

Paper ID: SUB155377

791

3.1 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
```

3.2 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.

3.2.1 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 $[0, 2\pi]$.
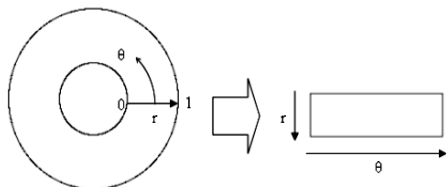

Figure 3-2: Daugman's Rubber Sheet Model

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

$$I\big(x(r,\theta), y(r,\theta)\big) \rightarrow I(r,\theta) \qquad (3.1)$$

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.

3.2.1.1 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 (3-3). 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

$$r' = \sqrt{\alpha}\beta \pm \sqrt{\alpha\beta^2 - \alpha - r_I^{\,2}} \qquad (3.2)$$

With

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

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.
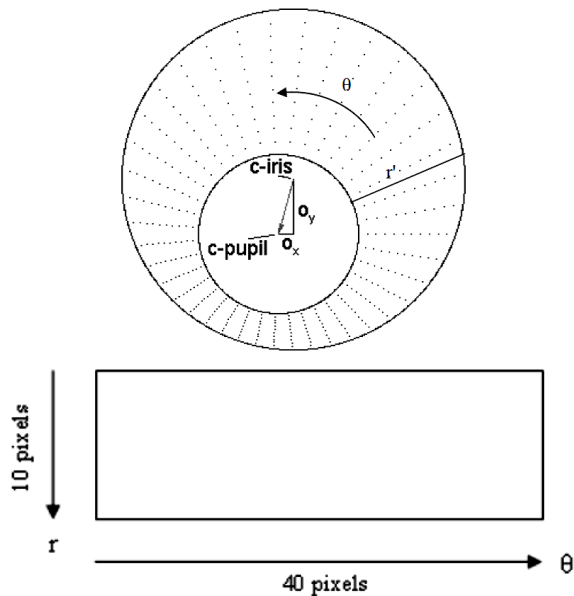
Paper ID: SUB155377

792

Figure 3-3 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.
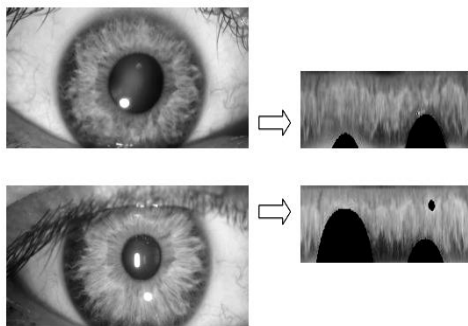

Figure 3-4: Illustration of the normalization process for two images of the same iris taken under varying conditions.

3.3 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.

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

3.4 K-Nearest Neighbor Classifier

In pattern recognition, the K-Nearest Neighbors algorithm (or k-NN for short) is a non-parametric method used for classification and regression. In both 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.

3.4.1 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,

Paper ID: SUB155377

793

regardless of their density in the original training data. KNN can then be applied to the SOM.

4. Expected Outcomes

Any sophisticated biometric system works on automatic identification of an individual based on a unique feature or characteristic possessed by the individual. In the current scenario iris recognition process has become an essential part of all the industrial and economical fields. The area is still challenging in terms of efficiency and real time processing facility. To fetch a new mile stone in this field this work proposes a modified approach to address both the problems simultaneously. So to develop generalized real time and efficient iris recognition system this work presents some serious modifications.

The situations during iris acquisition plays a crucial role in recognition process and it is often found that they are very much vague or imprecise; it is not possible to handle it properly with the help of conformist techniques. This project work basically 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 mining part for managing pupil illumination problem and iris matching part for providing high speed iris recognition.

Hence this paper proposed, 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 proposed modifications on predictable iris recognition system has been proposed in MATLAB 2012b and expected to make available higher recognition efficiency along with a good capability of real time processing.

References

[1] Libor Masek, "Recognition of Human Iris Patterns for Biometric Identification" Thesis submitted as partial fulfillment of the requirements for the Bachelor of Engineering degree of the School of Computer Science and Software Engineering, The University of Western Australia, 2003.
[2] John Daugman, "How Iris Recognition Works" Invited paper IEEE transactions on circuits and systems for video technology, vol. 14, no. 1, January 2004.
[3] John Daugman, "New Methods in Iris Recognition" IEEE transactions on systems, man, and cybernetics—part b: cybernetics, vol. 37, no. 5, October 2007.
[4] Pillai, Jaishanker K.; Puertas, Maria ; Chellappa, Rama "Cross-Sensor Iris Recognition through Kernel Learning " Pattern Analysis and Machine Intelligence, IEEE Transactions on Volume: 36, Issue: 1, Publication Year: 2014 , Page(s): 73 – 85.
[5] George, A.M.; Durai, C.A.D. "A survey on prominent iris recognition systems "Information Communication and Embedded Systems (ICICES), 2013 International Conference on Publication Year: 2013, Page(s): 191 – 195.
[6] Mesecan, I.; Eleyan, A.; Karlik, B. "Sift-based iris recognition using sub-segments" Technological Advances in Electrical, Electronics and Computer Engineering

(TAEECE), 2013 Publication Year: 2013, Page(s): 350 – 353.
[7] Jimenez Lopez, F.R.; Pardo Beainy, C.E. ; Umana Mendez, O.E. "Biometric iris recognition using Hough Transform " XVIII Symposium of Image, Signal Processing, and Artificial Vision (STSIVA), 2013 Publication Year: 2013 , Page(s): 1 – 6.
[8] Reid, D. ; Nixon, M. ; Stevenage, S. "Soft Biometrics; Human Identification using Comparative Descriptions" IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume: PP , Issue: 99 Publication Year: 2013 , Page(s): 1.
[9] Pillai, Jaishanker K. ; Puertas, Maria ; Chellappa, Rama "Cross-Sensor Iris Recognition through Kernel Learning" IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume: 36, Issue: 1, Publication Year: 2014 , Page(s): 73 – 85.
[10] Zafar, M.F.; Zaheer, Z.; Khurshid, J. "Novel iris segmentation and recognition system for human identification" 10th IEEE International Bhurban Conference on Applied Sciences and Technology (IBCAST), 2013, Publication Year: 2013, Page(s): 128 – 131.
[11] S. Sanderson, J. Erbetta. Authentication for secure environments based on iris scanning technology. IEE Colloquium on Visual Biometrics, 2000.
[12] R. Wildes, J. Asmuth, G. Green, S. Hsu, R. Kolczynski, J. Matey, S. McBride. A system for automated iris recognition. Proceedings IEEE Workshop on Applications of Computer Vision, Sarasota, FL, pp. 121-128, 1994.
[13] W. Boles, B. Boashash. A human identification technique using images of the iris and wavelet transform. IEEE Transactions on Signal Processing, Vol. 46, No. 4, 1998.
[14] S. Lim, K. Lee, O. Byeon, T. Kim. Efficient iris recognition through improvement of feature vector and classifier. ETRI Journal, Vol. 23, No. 2, Korea, 2001.
[15] Special issue on Biometrics, Proceedings of the IEEE, vol.85, no.9, Sept. 1997.
[16] P.W. Hallinan, "Recognizing Human Eyes", Geomtric Methods Comput. Vision, vol. 1570, pp.214-226, 1991.
[17] J.G. Daugman, "High Confidence Visual Recognition of Persons by a Test of Statistical Independence", IEEE Tans. Pattern Analysis and Machine Intelligence, vol.15, pp.1148-1161, Nov. 1993.
[18] R.P. Wildes, "Iris Recognition: An Emerging Biometric Technology", Proceedings of the IEEE, vol.85, pp.1348-1363, Sept. 1997.
[19] Y. Zhu, T. Tan, and Y. Wang, "Iris Image Acquisition System", Chinese Patent Application, No.99217063.X, 1999.
[20] T. Tan, "Texture Feature Extraction Via Visual Cortical Channel Modeling", Proc. 11th IAPR Inter. Conf. Pattern Recognition, vol.III, pp.607-610, 1992.
[21] A. Laine and J. Fan, "Texture Classification by Wavelet Packet Signatures", IEEE Trans. Pattern Anal. Machine Intell., vol.15, pp.1186-1191, 1993.
[22] W.W. Boles, and B. Boashah, "A Human Identification Technique Using Images of the Iris and Wavelet Transform", IEEE Trans. on Signal Processing, vol.46, pp. 1185-1188, April 1998.
[23] Y. Zhu, T. Tan, and Y. Wang, "Biometric Personal Identification System Based on Iris Pattern", Chinese Patent Application, No. 9911025.6, 1999