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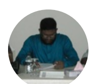
2 AUTHORS:

Shuvra Chakraborty
University of Dhaka



Ali Md. Haider
BRAC University

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Iris Texture Recognition with DCT Compression for Small Scale System

Shuvra Chakraborty and Md.Haider Ali

Abstract — Person identification based on iris recognition is a popular biometric for its universality, uniqueness and permanence. By far, it is a prominent, matured and well developed biometric technique that provides positive identification with a high degree of confidence. Here, we have implemented both iris based identification and verification. Iris segmentation has been proposed with conventional Hough transform with lots of improvements in speed. Eyelash detection process has been integrated with eyelid detection to make the image preprocessing step faster. An automated segmentation integrity checking has been proposed to detect the failure of proper iris segmentation. A correction to the segmentation failure also has been proposed. If the correction process fails the automated integrity checking again then improperly segmented images are not enrolled for further feature extraction.A DCT(50%) column wise feature extraction based method has been proposed for iris recognition which requires less memory due to the energy compaction property of DCT. Matching is performed using Euclidian distance between feature vectors by shifting to get the best alignment with minimum matching score. In order to evaluate the performance of the iris recognition system, the popular CASIA-I iris image database with 756 grey scale images are used and with ideal template storing , it gives a satisfactory accuracy rate of about 92% and precision rate above 98%.

Index Terms— Edge and feature detection, Feature evaluation and selection, Image processing software, Texture.

1 Introduction

In present days, where everything is being digitalized day by day, accurate identification of a person is a major issue of security in every sector of our society. Accurate identification or verification of a person can identify crime and fraud, save critical resources from malicious actions.

Any human physiological and/or behavioral characteristic can be referred as"Biometric" if it satisfies the conditions of Universality, Distinctiveness, Permanence and Collectability. However, in a practical biometric system that employs biometrical condition for personal recognition, there are a number of other issues that to be considered, they are performance, acceptability and circumvention. A practical biometric system should meet the specified criteria of recognition accuracy, speed, and resource requirements, should be harmless and acceptable to the users.The applications of biometrics can be divided into different fields like Commercial, Government, Forensic applications. Commercial applications includes computer network login, electronic data security, e-commerce, Internet access,ATM, credit card etc. Government applications include national ID card, driver's license, social security card and so on. Border control and passport control are also part of government application in biometrics. In forensic application field there are corpse identification, criminal investigation, terrorist identification, parenthood determination etc. Biometric systems are being increasingly deployed in large-scale civilian applications for accurate person identification. Thus, biometric systems can be used to enhance user convenience as well as improve security.

A number of different biometric characteristics exist to identify or verify a person. The applicability of a specific biometric technique depends on the requirements of the application context and no single technique can out perform all biometrics for all application environments. No one is optimal but may be superior then others according to application domain. For example, it is well known that both the fingerprint-based and iris-based techniques are more accurate than the voice-based technique in criminal detection. Efforts to devise reliable mechanical means for biometric personal identification have a long and colorful history. However, the idea of using iris patterns for personal identification was originally proposed in 1936 by ophthalmologist Frank Burch, MD. In the 1980's the idea appeared in James Bond movies, but it remained science fiction. It was not until 1987, two American ophthalmologists, Leonard Flom and Aran Safir patented Burch's concept but they were unable to develop such a process. So, zigzag patterns of the iris had a long way to go then! At last John Daugman develops actual algorithms for iris recognition in 1994. This provides the framework basis for all current iris recognition systems. 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 few years. Formation of the unique patterns of the iris is completely random and independent of any genetic factors. The only characteristic that is dependent on genetics is the pigmentation of the iris means its color. Due to the epigenetic nature of iris

- *Shuvra Chakraborty is with Department of Computer science and Engineering, University of Dhaka, Dhaka-1000, Bangladesh.*
- *Md. Haider Ali is with the Department of of Computer science and Engineering, University of Dhaka, Dhaka-1000, Bangladesh.*

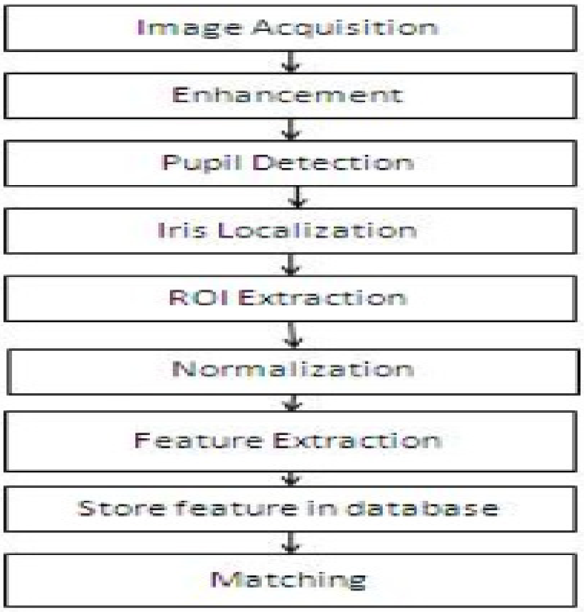


Fig.1. Steps of feature extraction from iris image

patterns, the two eyes of an individual contain completely independent iris patterns and even identical twins possess uncorrelated iris patterns[4].

2 PROPOSED SYSTEM ARCHITECHTURE

The steps of feature extraction from an iris image are shown in Fig. 1.
In Enhancement step, the iris image is filtered to remove noise and other spurious effect. Several type of filters are available for this purpose like median filter, low pass filter etc. In segmentation step, the ROI (Region Of Interest) is extracted from iris image to extract feature from it. Generally, these steps include the process of pupil and iris localization. Normalization step is obvious for iris recognition purpose as we need the iris vectors having same dimension for proper comparison purpose. The diameter of pupil may expand or shrink due to lighting effect and other reasons. So the region of interest may not have the same radius always. An explicit normalization method is required here. Feature extraction may include different approaches to generate iriscode for further comparisons.Matching performance for individuals often depends on this step. Determination of the location of pupil in an iris image is the first step of feature extraction.

2.1 Image Acquisition

For image acquisition purpose, we have used the well known iris image database CASIA version I. This database consists of iris images of size 280X320. Here, 108 different person's images are gathered and the images of left and right eye are classified separately for research purpose. Each person's image folder contains about 7 images, four for left and right eyes respectively. So, we have a total 756(108X7) greyscale images in CASIA-I database.

2.2 Enhancement

As we know, image enhancement is one of the important preprocessing steps to remove spurious effect, Here, iris image enhancement, Gaussian filter is used. We have used contrast stretching for a special purpose. Contrast stretching is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains. It differs from well known histogram equalization as it can only apply a linear scaling function to all image pixels. But contrast stretching is used here to "stretch" the intensity level of pupil to find it easily.

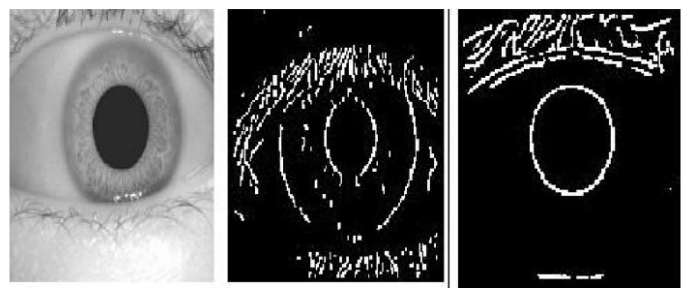


Fig.2. (a) Iris image (b) Vertical edge map (c) Horizontal edge map [left eye, left to right]

2.3 Iris and pupil localization

The first step of iris localization is edge map detection. For this purpose, famous algorithm Canny Edge Detection is used. To localize iris boundary, a vertical edge map is created. Canny edge detector smoothes image to eliminate noise. It then finds the image 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 further reduced by hysteresis. Hysteresis is used to track along the 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 nonedge). If the magnitude is above the high threshold, it is made an edge. And if the magnitude is between the two thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a gradient above T2. To find out pupil boundary we use only the iris part for efficiency and a horizontal edge map is created for that purpose. The result of the vertical and horizontal edge map creation is shown in Fig. 2.
For iris image localization, Conventional Hough Circle detection algorithm is used with some improvements. A question can arise that why do we have chosen Hough transform? This is because of localizing iris in the presence of eyelid, eyelash and noises and provides good re-

sults. More than that, it does not assume anything about the position of iris in the acquired eyeball. So, for most cases it can localize the iris. Though it is computationally expensive as it requires searching for a range of radius, we used Hough transform for accuracy. The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and iris regions. Original Hough transform with canny edge detection algorithm is quite time consuming if applied without any modification. Some improvements applied here are listed below:

- From our observation on CASIA image data set, we have found that the average iris radius ranges from 89-152 pixels. So, we don't need to search for all possible radius values. Similarly, to find out pupil region, Hough circle detection is per formed using a radius range 29 to 71 pixels.

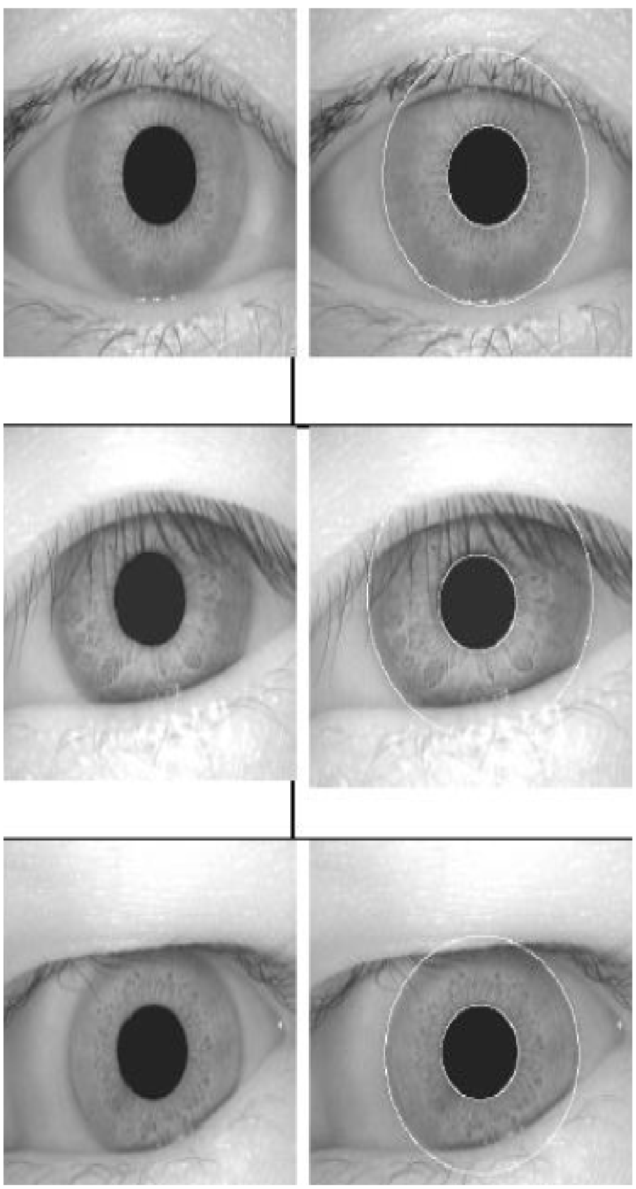


Fig.3. Iris image and corresponding segmented image. (a)-(b),(c)-(d),(e)-(f)[Left to Right] and [Top to Bottom].

- The darkest region for an iris image can be the eye lashes, eye brows and pupil region. Generally the darkest pixel intensity subtracted by some threshold T is taken as the intensity value of the pupil. That means, the darkest pixel may be not the pupil intensity but for sure it is very near to that value. So, we search for the region of largest cluster of pixels with the range darkest value to [darkest value-T]. If it fails then the searching time can be a bottleneck but it is found that it works 99% time. But pupil region forms the largest cluster of darkest pixels in the iris images. So, to minimize searching area for iris, this method works effectively.
- After finding the searching region, a scaling factor is used to resize the image. When image is resized, other factors are also resized using the scaling factor such as if image is resized with factor F, radius R, r of iris and pupil will be resized as

$$R = R \times F$$
$$R = r \times F$$

The result of iris localization is shown in Fig.3.

2.4 Eyelid and Eyelash Detection

For eyelid detection, the conventional method of parabolic version of Hough transform with canny edge

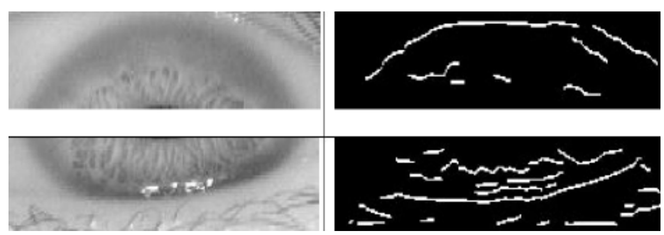


Fig. 4. (a) Iris image (b) Vertical edge map (c) Horizontal edge map[left to right]

map detection in horizontal gradient for both the top and bottom eyelids is used. Radon transform can be used to perform this task with some compromises in information but we prefer to use parabolic version of Hough transform as we have used DCT compression later which may loss some information. This process is illustrated in Fig. 4.

We have decided to avoid the eyelash detection part from the pre-processing step. The reason behind is, it is noted before that parabolic version of Hough transform is used to detect the eyelids is computationally expensive in nature. But after that the process of eyelash detection which needs methods like 1-D Gabor method is effective but applying it globally may remove the important zigzag information in iris region. So, we avoid this step by sacrificing some information to reduce computational complexity a little.

2.5 Segmentation integrity and Correction

The iris recognition system is highly dependent on the iris segmentation process. So, if the process fails, a wrong estimation of region of interest will be established and the whole process will fail. We have proposed a new method to check the integrity of iris segmentation before proceeding further. After iris and pupil finding, we have the center coordinates and radius of iris and pupil. Now, we imagine a virtual circle just inside the limbic boundary of iris. That means we estimate a radius R with a value between iris and pupil radius and the radius value is very close to iris radius value.

R=iris radius - T

Where T is set to 7 pixel here. Now, we start checking the

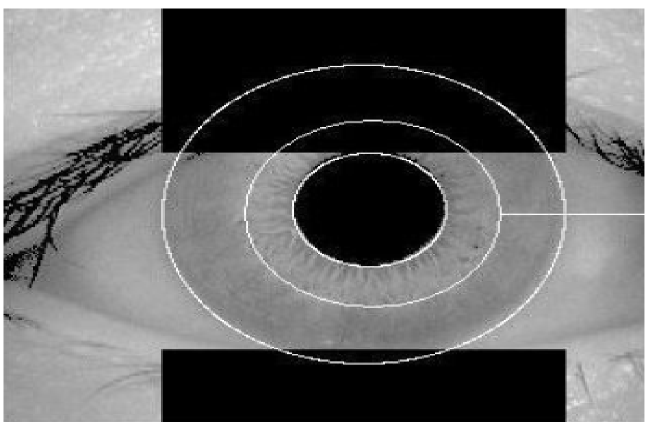


Fig.5. A virtual circle inside limbic boundary.

intensity of the pixels through the radius line. For sure, we are going to have a large intensity change at limbic boundary point when go through and if the intensity changes between neighboring pixels in greater than a threshold, we can say that we are crossing the limbic boundary point, L(x,y). So, outside this point the radius is no more a part of region of interest. If Euclidian Distance(iris center,L) is very close to the iris radius value, we can say segmentation is OK and can proceed further. Otherwise we have to start a correction process. Now, a question may arise from where shall we start tracking as shown in fig.5 by an axis line?

Here, we have decided to start tracking from a point about in the halfway between the occluded top and bottom region as shown in fig. 5 by two black rectangles. The decision has been chosen on the basis that if we choose a point in such way, we can avoid the interference of eyelashes easily.

From the observation of our experiment in CASIA database, we have found that the segmentation process fails only when the intensity difference between the point of limbic boundary point and sclera is not big enough and this causes the canny edge detection to fail. For some iris images we can get rid of such a situation by histogram equalization but then we have found that contrast strteching is muss essential as compared to it's histogram equa-

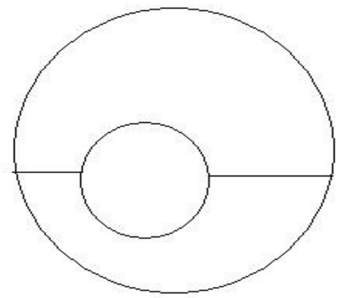


Fig. 6: Basic idea of Normalization

lization counterpart.

For closed eye detection, we propose that an iris image has actually two types of intensity values, one strong dark range for eyelashes and a light intensity range for skin values. From the gray level distribution of intensity values, a threshold has been used to detect closed eyes since for any eyes which is not closed, the intensity variation is much more different. But, though we can apply it for fully closed eyes, this may cause a problem in detection when eye are almost closed but not fully.

2.6 Normalization

Normalization process is an obvious step before feature encoding. Without normalizing an iris image it can't proceed forward as the size of the pupil can shrink or expand due to various reasons. So, the region of interest changes in size and it is not like always two concentric circles, one inside another.

As shown in fig. 6, if we go through the radial line at the right side and left side, the radius size varies completely. The same iris image can be of different size in different times but we need a fixed dimension to compare the ROI of the images to each other. To remedy this problem, the idea of traditional Daugman's rubber sheet model has been used. But we have used it with a normal geometric equation in (1) to estimate the points as below:

$$\frac{m1 . x1 + m2 . x2}{m1 + m2} \qquad (1)$$

Where, m1: m2 are the ratios to subdivide the points between pupil to limbic boundary. So, the solution brings out a fixed number of points from each radial line and here, we have used 30 as the fixed number points through each radial line. Moreover, from the segmentation step, we can see that eyelid occluded region is also discarded. But to make the normalized version, we need to fill up the

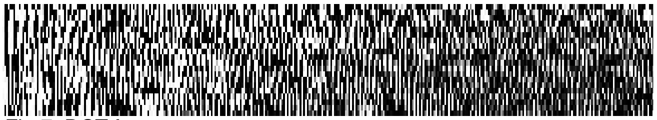


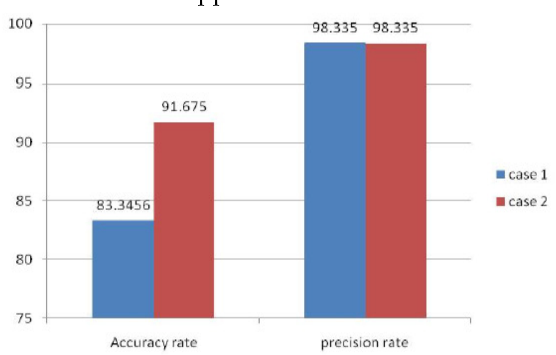
Fig.7. DCT feature vector

point's intensity values in the occluded region. Here, we have filled those entries using the average of the intensity values of other pixels in the image.

2.7 Feature Extraction

Here, we propose to use 1-D DCT (Discrete Cosine Transform) for feature extraction. But we decided to make the feature extraction method is a little bit tricky. Given a normalized image, we apply 1-D DCT in a column wise order, not in a row wise order (Generally it is used in row wise order). We think problem can happen in row wise order because the iris boundary is circular but not a circle actually. So, naturally some information loss occurs at the boundary line of the iris segmentation. But if we use column wise order, than we are actually tracking information through the radial line. This helps to protect the information integrity.

After 1-D DCT in a column wise order, now, we get the values in same order as normalized image vector array. According to the DCT properties in chapter 2, we know that discarding the lower portion of the DCT values effect the image quality with a little compromise. So, we have decided to discard upper half information from the normalized array. This can cause some information loss to occur but It can minimize the memory requirement also. Fig.7 shows the normalized and corresponding DCT values of an iris image vector.



(a)

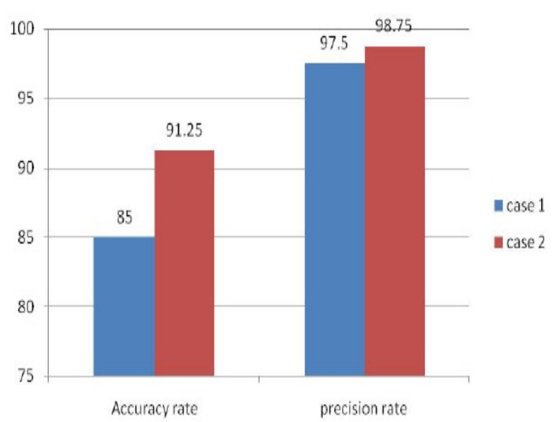


Fig.8. (a) Precision and accuracy rate for case 1 and 2(left eye) (b) Precision and accuracy rate for case 1 and 2(right eye).

2.8 Matching

Given two normalized Feature vectors Im1 and Im2 of fixed size M X N where M=15 and N=360, we compare their matching score by the Euclidian Distance method. If the distance score less than or equal to 837 then it is considered as a match, other wise non-match. Matching is done by rotating the feature vector and the minimum score is taken as result. This makes the matching process rotation independent. Here, minimum score corresponds to the best alignment of the two iris vectors being matched.

3 EXPERIMENTS AND DICSUSSION

For performance evaluation, we have considered different cases. Firstly, we trained our system with random template [case 1] for both eyes and then compare the result of the system trained with ideal template [case 2]. The Fig. 8 below shows a comparative study of precision and accuracy rate of both cases, respectively.

For both eyes, a significant change of accuracy occurs when ideal template is selected in case as compared to case 1. But, what is the reason behind that we don't have more accurate result in accuracy rate? Actually the answer depends on both the quality of training and other iris images to be matched.

Let, we have a very good quality of training image but if in the image to be checked, most of the iris region are occluded by eyelid and eyelashes. So, though the training image quality is very good, but the occluded region can make a big difference in matching score and the image can be considered as a non-match. We can try out best to match the regions perfectly but the occluded part region difference can't be estimated either. So, those iris images who suffer from the problem of accuracy, actually suffers from the problem of occluded region actually. To evaluate the performance of the iris not only precision and accuracy rate but also false rejection and acceptance are impor tant. So, overall performance should be evaluated under by taking all these things into concern. FA and FR decrease in ideal case as compared to random case due to choice of ideal template as shown in Fig. 9. Performance against imposter attack is also considered and a good response is found.

So, we can say the system is reliable as precision rate and FA, FR are satisfactory because giving access to unauthorized person can be more harmful when compared to rejecting authorized person due to the low quality of the image.

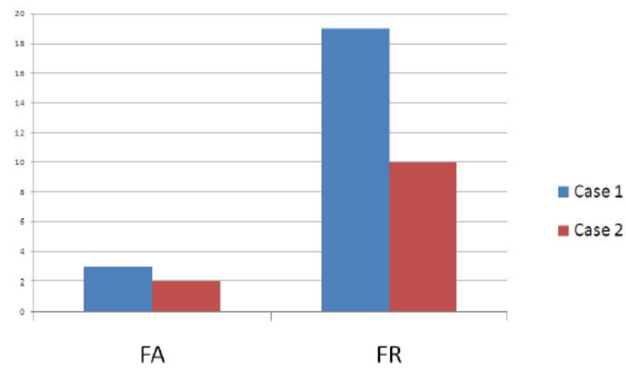


Fig.9. Comparison study of FA and FR in case 1 and 2.

A special thing should be noted, threshold value has been chosen by observing the difference scores of two iris vectors in the database. So, if database changes, threshold value is needed to be adjusted to get a better performance and from our observation, we can say if threshold value is relaxed a little bit performance may degrade sharply. Our iris system is not only reliable but also memory efficient. According to our work, normalized feature vectors are stored in 15 rows and 360 columns. So the total size is 15 X 360= 5400 only for each image. Since they are just DCT values (according to gray level intensity), so memory requirement per image entry is constant. Rotation independency of iris vectors has been also achieved here by shifting DCT values while matching. The proposed segmentation process works OK for 674 images among 756 images in the CASIA iris database. The automated correction process checks for segemantion integrity and using the correction process, it recovers additional 44 images. So, the system works OK for a total of 718 images.

4 Conclusion

Identification of humans is a goal as ancient as humanity itself. As technology and services have been developed in the modern world, human activities and transactions have proliferated in which rapid and reliable personal identification is required. The proposed Iris recognition system consists of several subsections likes iris and pupil localization, Unrolling the iris region, Feature extraction and Encoding iris vectors and matching. We have proposed to use approximation of the pupil location by the maximum cluster of the darkest pixels in the image with scaling to reduce searching area of Hough transform to reduce detection time effectively as compared to traditional mathods. A fixed range for iris and pupil radius has been proposed for CASIA image database to improve Hough circle search again. Since the segmentation step is the basis of all the steps, we have proposed to check the segmentation integrity of enhanced contrast stretched image before proceeding further. To detect the failure of segmentation method, we have proposed to assume a virtual circle inside the limbic boundary of the iris and if the process fails here, contrast strtching is used to enhance image and Hough is reapplied on the image. A special thing to note here that though contrast stretching fails a very few times when applied here but the idea of applying contrast stretching improves the case for this very few images too. But still it fails, then our system don't operate on the image further.

We have already discussed about the steps taken to eyelid and eyelash detection. Some expensive steps are compromised with some information in the iris region. We have not used threshold to detect eyelash to preserve the original zigzag pattern in the iris. So the proposed iris unrolling system is effective and robust with it's segmentation integrity check idea. In normalization step the conventional Daugman's Rubber sheet model is used. Here, we have used the idea of simple ratio based geometric equation to extract iris feature code. In feature encoding step,We have proposed to apply 1D-DCT(50%) feature encoding method in column wise direction to improve performance and as it is known DCT energy compaction property helps to reduce the size of the feature vector to half. We have proposed it to use here for memory efficiency with compensation of the information as little as possible. Section 3 shows that the proposed system gives a satisfactory level of accuracy about 92% and precision rate above 98%.

The primary focus was to implement an automated iris recognition system which is fast, fair accuracy and memory efficient, a main requirement of small scale systems. As every system has some limitations, some of them are described below. Some information loss occurs when detecting eyelids as we cover the eyelid region by a black rectangle to avoid the effect of eyelashes also. Eyelash detection step is avoided to reduce processing time by sacrificing some information. So, the eyelashes outside the occluded black region are not removed here and it may become a part of the iris feature. If the segmentation integrity method fails then we discard the image completely.

Though circular and parabolic Hough transform is used with several time improvements methods, it takes the 60% time of total process. Segmentation integrity checking method takes some extra times also. Computationally expensive Hough transforms increases reliability and thus limits of circle radius search need a practical limit. So, if image size is big enough, Hough can be bottleneck to the system.

A very few images fails to overcome the integrity check and discarded. For example, 37 numbered person's folder in CASIA fails in this step. Future works will be dedicated to obtain features that are rotation independent. Hough method is computationally expensive. So, a new and fast segmentation technique without compromising the robustness of Hough can be a special concern. We have used DCT(50%) strategy but other model of DCT can be applied to minimize the size of the iris vectors. A future research can be conducted in that direction effectively. In today's digital world, where almost everyone have a mobile phone with a digital camera, Iris recognition can be used as effective technology for person identification easily. But in a under developed country, the costly iris pattern recognition limits us from having the social security in a cost effective way. If our system can contribute a little bit towards this purpose, then our effort will be successful.

Among different methodologies of iris matching, the original Hough transform based iris verification method needs a rather high computational power, which makes the method less applicable for real time applications. But the proposed system does the faster template matching using some improvements in Hough using canny edge detection. DCT based iris recognition has made it memory efficient from most of it's counterparts but when the reliablility factor is crusial, we want to propose it for for small scale recognition system. Though the correction method works well while image quality is low, but the proposed method works well for poor images with contrast stretching of the image. The system can be easily implemented using less hardware requirements and low memory specification. Thus it can be a framework to the small scale systems easily. Future works will be dedicated to overcome the limitations as stated before.

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Shuvra Chakraborty received her BSc. and Msc. degree in Computer Science and Engineering from University of Dhaka Bangadesh.She is working as lecturer in the department of Computer Science and Engineering, University of Dhaka, Bangladesh Since 2011.

Md. Haider Ali. received his BSc.and MSc. degree in Applied Physics and Electronics from University of Dhaka Bangadesh.He received Doctor of Engineering in Electronics and Information Engineering (2001) from Visual Computing Laboratory, Department of Electronics and Toyohashi City 441–8580, Japan. He is currently working as Professor in the department of Computer Science and Engineering, University of Dhaka, Bangladesh.