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Design a Secure Voting System Using Smart Card and Iris Recognition

Md. Mahiuddin
Department of Computer Science and Engineering
International Islamic University Chittagong (IIUC)
Chittagong, Bangladesh
mmuict@gmail.com

***Abstract*— Bangladesh is one of the countries in which introduced voting system in parliamentary and assembly polls. But in every election, the election commission is facing a lot of troubles and various types of problems throughout the election. The most familiar issue faced by the election commission is improper confirmation with respect to the arrangement of casting the votes, duplication or illegal casting of votes. In this paper, a secure and new voting system is developed to improve the existing voting system using smartcard and iris recognition. Iris is one of the most secure biometric of person identification. The main goal of this article is to avoid the duplication of casting votes.**

***Keywords*— Iris, Smartcard, Voting system.**

I. Introduction

Voting system is a government selection process in every democratic nation. Democracy is meant to allow people to vote freely and voting is the right of every people of a democratic nation. The democratic government depends on the results of the election.

Today's world is the era of internet and computer technology. The uses of computer, internet and electronics are increasing day by day. The security system is also upgrading day by day. It should be necessary to upgrade the traditional voting system and also security. The main objective of this article is to develop a new idea about voting system and also ensure the security of it.

To ensure the security of voting system, we use iris recognition in proposed system. Iris recognition is used because it is highly unique, stable, cannot be duplicated and easily captured.

Different types of voting system have been used around the world. Paper ballot voting system is an old and unsecure voting system where it is possible to cast multiple votes from the same voter. It runs to cast the vote with a ballot paper and a stamp (Shown in Fig.1).

In electronic voting system (EVM), the process of election data is recorded, stored and preceded as digital information [1]. Electronic voting device is used as casting as well as counting of votes. The block diagram of EVM is depicted in Fig. 2. Design of EVM based on solar power is reported in [2]. Implementation and formal analysis of electronic voting protocol using AVISPA is presented elaborately in [3]. Supeno Djanali *et al.* proposed a method to secure voting data based on SHA256, digital signature, and RSA asymmetric encryption [4]. A Low cost, low error rate and efficient android based e-voting system is developed for the election of EEPIS BEM president [5].

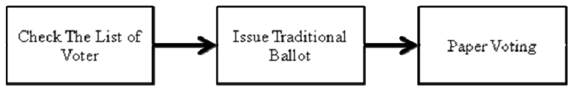


Fig. 1. Traditional Paper Voting System

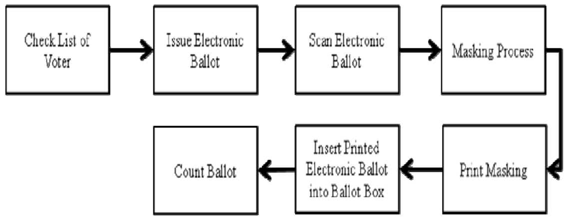


Fig. 2. Electronic voting system

Security is the main concern of existing voting systems. Sometimes an unauthorized person gives vote. Some politicians try to follow illegal method to win the election. In paper ballot and EVM systems needed more manpower. These existing systems are much more time consuming and also slow. In proposed system, we use Irish pattern and smart card. Hence the proposed voting system is more secure than existing system.

Smart card is a card in which a microprocessor and a memory chip are attached used for processing and storing information respectively. Secure exchange between the reader and the card is performed in the card more easily. Smart card has the capacity of store and access data. It also provides an immediate exchange of necessary information. We can store a person's iris data and personal information in smart card.

In the proposed voting system, the voter identity card is replaced by smart card in which all the details of the person are updated. Only the specified person can poll using their smart card. Here the smart card reader reads the smart card and the details of that person is displayed, and then it asks for verification which is iris recognition. If the iris pattern matches then the person can poll. The person is allowed to poll once using by smart card. After voting, if the person tries to use smart card again, the smart card reader will access the cards but it will show the message that the person has already voted.

A. *Hough Transformation*

We use the Circular Hough Transform algorithm to segment the image. In our proposed system, we find the iris and pupil boundaries from an eye image using Circular Hough Transformation algorithm. It is also used to localize the iris where the pupil boundary and iris boundary are present. Any lines and circles can be identified from an image using Circular Hough transformation algorithm.

A circle equation with radius r and center (a, b) is described as follows.

$$(x-a)^2+(y-b)^2=r^2$$

A circle can also be expressed by the equations as follows.

$$x=a+r\sin(\theta)$$

$$y=b+r\sin(\theta)$$

Here use the Hough transform to find the triple parameters of (a, b, r) to determine the point (x_i, y_i) [6].

B. Daugman's Integro-differential Operator

The pupil region and circular iris are detected by Integro-differential operator in Daugman Iris detection implementation. The eyelids and eyelashes can also be detected by it. The equation of integro-differential operator is as follows [7].

$$\max_{(r,x_p,y_0)}\left|G_\sigma(r)*\frac{\partial}{\partial_r}\oint_{r,x_0,y_0}\frac{I(x,y)}{2\pi r}ds\right|$$

Where, $I(x,y)$ represents the image of eye, radius described by r, $G_\sigma(r)$ denotes the Gaussian smoothing function, contour of the circle given by (r, x_0, y_0) is s.

C. Normalization

Normalization is performed using the rubber sheet model proposed by Daugman. In this technique, every point in the segmented iris region is converted into Cartesian coordinates (x,y) to polar coordinates (r,θ).

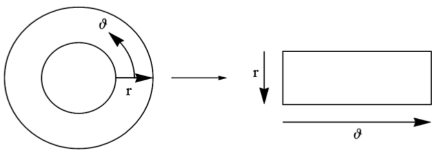


Fig. 3. Dougman's rubber sheet model.

The transformation is described by the following equation.

$$I(x(r,\theta),y(r,\theta))\rightarrow I(r,\theta)$$

Here,

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

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

Where, $I(x,y)$ represent the region of iris, Cartesian coordinates is described by (x,y), corresponding normalized polar coordinates can be represented by (r,θ), and the coordinates of the iris boundaries and the pupil in the θ direction are represented by (x_l, y_l) and (x_p, y_p) respectively [8].

D. Wavelet encoding

The data in the iris region can be decomposed by wavelets into components and it appears in different resolution. The wavelets are localized in both frequency and time [9].

E. Gabor Filters

Gabor filter can provide optimum combined representation of a signal in space and spatial frequency. It is created from a Gaussian kernel function modulated by a sine/cosine wave. The localization in frequency of a sine wave is perfect, but it is not localized in space at all. When a sine wave is multiplied by Gaussian function, it provides localization in space with some loss of frequency localization. It provides localization in both frequency and space. Gabor filter has a real part and an imaginary part. The real part is achieved from a cosine modulated by a Gaussian function and the imaginary part is achieved from modulating a sine wave with a Gaussian function [10].

Daugman's phase quantization and demodulation method can be represented as follows.

$$h\{\mathrm{Re},lm\}=\mathrm{sgn}_{\{\mathrm{Re},lm\}}\int_\rho\int_\phi\{l(\rho,\phi)e^{-i\omega(\theta_0-\phi)}.e^{-(r_0-\rho)^2/a^2}.e^{-(\theta_0-\phi)^2/\beta^2}\rho d\rho d\phi\}$$

Here, $I(\rho,\phi)$ is the normalized image of iris, α and β are 2D wavelet size parameters, (r,θ) represents the polar coordinates and ω is wavelet frequency.

F. Log-Gabor Filter

The relationship between the number of samples and the frequency and space resolution is disproportional since more samples give the higher frequency information and lower space resolution. The quality of a filter depends on obtaining the maximum frequency information given a set of time resolution [11]. From this perspective, Gabor filter is a good filter because it provides excellent localization on space resolution and frequency information. However, at certain bandwidth, a Gabor filter contains non-zero DC component which means that the response of the filter is depending on the signal mean value. On the other hand, non-zero DC component can be acquired for any bandwidth by using Log-Gabor filter.

The frequency response of a Log-Gabor filter is given as follows.

$$G(f)=\exp\left(\frac{-\left(\log\left(f/f_0\right)\right)^2}{2\left(\log\left(\sigma/f_0\right)\right)^2}\right)$$

Where, f_0 is the center frequency, σ represents the filter bandwidth and f is the original frequency.

G. Hamming distance

Hamming distance (HD) measures the number of different bits in two strings of the same length. In another way, it measures the number of bit shifting is required to match two strings. It is also used to count the error rate in matching.

If hamming distance is 0 between two templates, it represents a perfect match. If hamming distance is 0.5 between two templates then the two templates is independent. A threshold is set to decide the two templates are from the same person or different persons [11].

The benefit of Hamming distance is fast matching speed because the templates are in binary format.

Let there are two patterns and N is the total number of bits present in both patterns. HD is counted by doing exclusive-OR (XOR) of the bits of two patterns. So, the equation for Hamming Distance is expressed as follows.

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j$$

Evaluation of Hamming distance is performed with bits that generated from the actual iris region.

II. Proposed Voting System

Our proposed voting system is depicted in Fig. 4. Firstly, we check the iris database from the smart card. On that time, the voting record of a voter is also checked. If the voting record shows the voter gives vote then he/she cannot allow for voting. If the voting record shows that the voter cannot give vote then capture the voter iris image by using iris scanner camera. Match the captured iris image and smart card iris image database using hamming distance. If the iris image is not matched to the smart card database then stop the process. On the other hand, if the iris image is matched to the smart card database then allow the voter to give a vote and update the voting record of the voter.

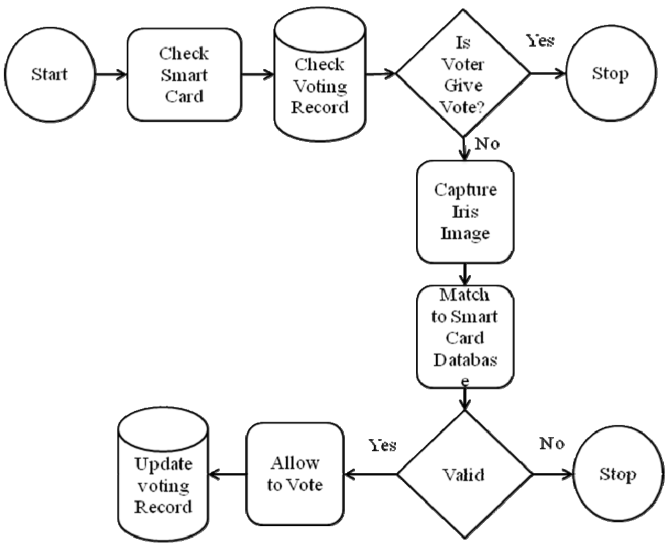


Fig. 4. Block diagram of proposed voting system.

The chances of voting illegal voting will be reduced. If one person takes other person smart card then after scanning the eyes the details of the voters come in front of the officer or poll worker. The officer or poll worker will match that voter smart card details from the database. If it doesn't match then the officer or poll worker will get to know that the person is a real person or fake person. In this way, we can find the illegal voter and exclude the voter.

If one person gives votes in one place the database will get updated globally that this person has given the vote. If the voter will go some other place than after scanning the eye it will be shown that this person has already given the vote. As a result, the person is not allowed to vote. By this way, we can eliminate the chances of registering the person in more than one place.

There is no need to mark voter's forefinger by the inedible ink. The database will be updated when a person gives the vote. It is more secure than the traditional ballot paper voting system.

Our proposed system is very much time effective and fast. Require less man power than ballot paper voting system and electrical voting system.

A. *Iris recognition*

Iris recognition system consists of five stages, such as, image acquisition, segmentation, normalization, feature extraction and matching.

Firstly, an iris image is collected from open source database, CASIA database. In segmentation process, we use circular Hough transform and canny edge detector. In normalization, we use Doughman rubber sheet model. In feature extraction process, we use 1D log Gabor wavelet. And lastly, for matching, we use hamming distance.

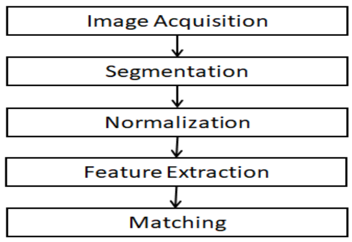


Fig. 5. Steps of iris recognition systems.

B. *Image Acquisition*

Iris image cannot be acquired by the normal camera because it is small in size. The detail of iris cannot visible in normal camera. There are also light reflection is present when capturing iris image by normal camera. So, it is difficult to acquire good images.

We are using "CASIA (Institute of Automation, Chinese Academy of Sciences) Iris Image Database version 4.0" and some iris image taken by mobile for image acquisition.

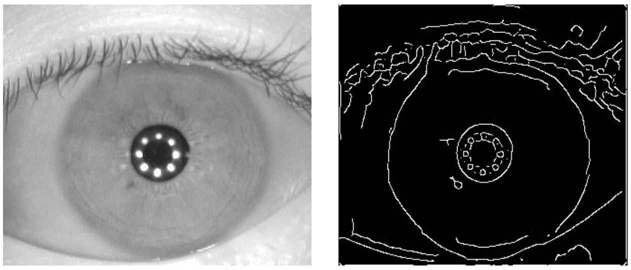
C. *Segmentation*

For segmentation, Hough transform is better than Integro-Differential Operator. The errors of segmentation by Hough Transform technique show that the segmentation is lower than Integro-Differential Operator [12]. So, we use Hough transform for segmentation.

The edge detection technique is used before Hough transform is applied. For this reason, we choose the 'canny edge' to extract the image. We find all the edges in the iris image. In this method, the inner and outer boundary of an iris is detected (shown in fig. 6).

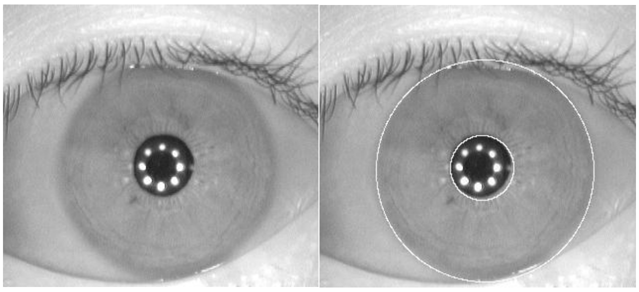
We use Canny edge detector because it is better than other edge detector like Sobel edge detector for iris detection [13].After finding edge detection point, at each edge point draw a circle with center at the point with the needed radius. In segmentation process, the circle is drawn in the parameter space. So, our x axis is the a-value and the y axis is the b value and the z axis is the radius (r).

In this way, the inner and outer boundary of iris can be detected by circular Hough transform. The result of segmented iris image is shown in Fig. 7.



Original image After canny edge detector

Fig. 6. Original image and segented Image



Original image After canny edge detector

Fig. 7. Implementation of Hough transformation

D. Iris normalization

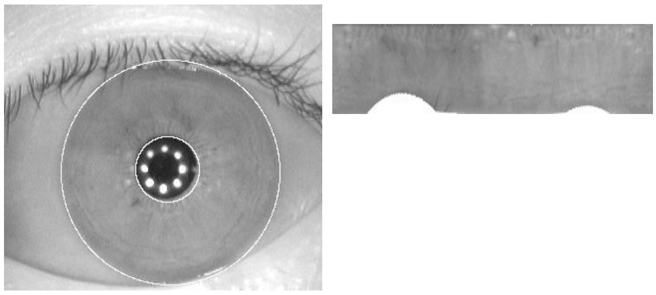
For normalization, we use Doughman's rubber sheet model. In this technique, every point in the segmented iris region is converted into Cartesian coordinates to polar coordinates. The result of normalization iris image is given in Fig. 8.

E. Feature extraction

A template representing iris pattern information is created using a 1D log-Gabor wavelet in the feature extraction.

Feature extraction is implemented by the normalized iris pattern is convoluted with 1D Log-Gabor wavelet. First 2D normalized iris pattern is broken up into a number of 1D signal and then Gabor filter is used to those 1D signals. The rows of the 2D normalized pattern are taken as the 1D signal. Each row corresponds to a circular ring on the iris region [14] (Depicted in Fig. 9).

The encoding process produces a bitwise template containing a number of bits of information, and a corresponding noise mask which corresponds to corrupt areas within the iris pattern, and marks bits in the template as corrupt. The result is given Fig. 9.



Original image Normalized Image

Fig. 8. Segmented iris image to normalized iris image

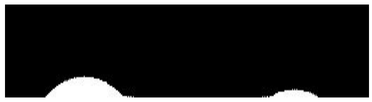


Fig. 9. Binary Mask normalized image

F. Matching

For matching, we use the hamming distance. Hamming distance of two templates is calculated by shifting one template left and right bit-wise and a number of Hamming distance values are calculated from successive shifts. Illustration of one shifting process is shown in Fig. 10. One shift is defined as one shift left, and one shift right of a reference template.

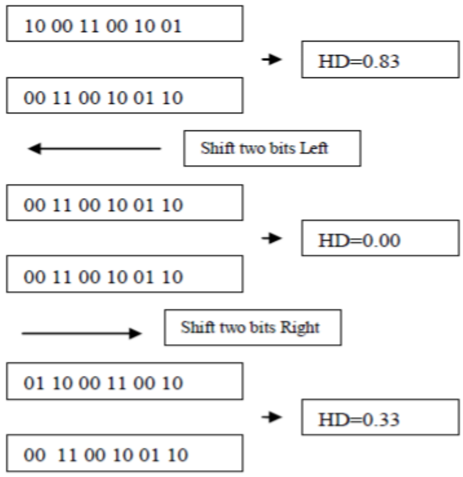


Fig. 10. Shifting process

III. Results and Discussions

A. Segmented result

The CASIA database image is successfully segmented accurately but some of iris image cannot be segmented properly. The result is shown in Table I.

Every image of the database has different segmentation value. The segmentation value of the iris image based on their circle iris and circle pupil is achieved by using Hough transform. The average of the circle pupil and circle iris of CASIA database is given in Table II.

B. *Matching Result*

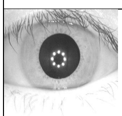
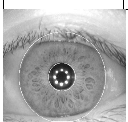
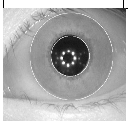
In this paper, we use ideal iris for experiment. So, iris pattern is important for iris recognition. In our experiment, some image is perfectly identified and some images are not identified. Some same iris image is not identified perfectly. The details result is described in Table III.

We use 200 images of 100 person of CASIA iris database which is ideal iris image. In CASIA iris image, there is no light reflection, and iris and pupil is visible. The detail of iris is completely visible. So, the segmentation of iris image of CASIA iris database is perfectly done. The iris boundary (iris-sclera) and pupil boundary (pupil-iris) is perfectly segmented.

TABLE I. SEGMENTATION RESULT OF EYE IMAGE

Number of Persons	Eye Position	Number of eye images	Number of segmented eye	Error in Segmentation
1	L	10	10	0
	R	10	10	0
2	L	10	10	0
	R	10	10	0
3	L	01	10	0
	R	07	10	0
4	L	10	10	0
	R	10	10	0
5	L	06	02	4
	R	01	01	0
6	L	01	10	0
	R	08	10	0
7	L	09	10	0
	R	10	10	0
8	L	07	07	0
	R	07	07	2
9	L	01	10	0
	R	05	10	0
10	L	10	10	0
	R	10	10	0

TABLE II. AVERAGE SEGMENTATION VALUE OF IRIS IMAGE

Iris Image	CASIA database Image							
	Central iris			*Central pupil*			*Average of central iris*	*Average of central pupil*
	115	158	110	118	156	57	127.6666667	110.3333333
	170	155	113	167	154	35	146	118.6666667
	125	168	110	127	163	48	185	133.3333333

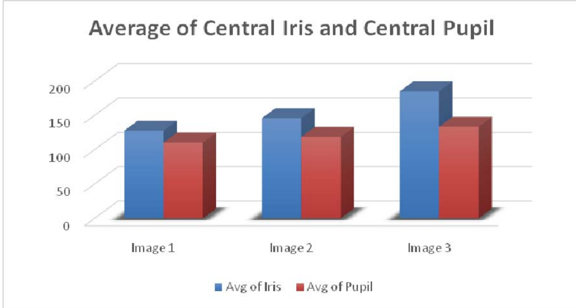
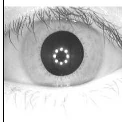
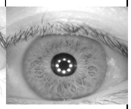
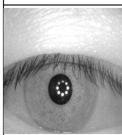
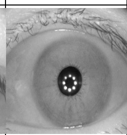
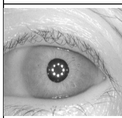
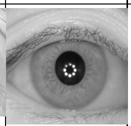
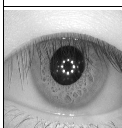
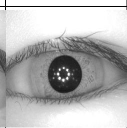
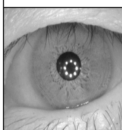
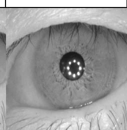
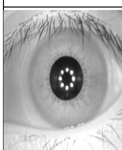
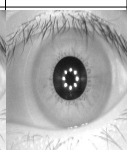


Fig. 11. Average of central pupil and Average of central iris

TABLE III. MATCHING RESULT OF INPUT IMAGE

Image 1	Image 2	Hamming distance	Successfully recognized	Error in matching
		0.4085	Different iris	0
		0.3729	Different iris	0
		0.4853	Different iris	0
		0.4003	Different iris	0
		0	Same iris	0
		0	Same iris	0

C. *Limitations*

We are using 20 non-ideal iris images. The image is captured by us by using smart phone. The pupil and iris are not properly identified. There is light reflection of our database. The details of iris and pupil of our database is not completely visible. So, the iris image of our database is not perfectly segmented.

IV. CONCLUSION

With the increasing the population day by day, the improvement of voting system is necessary. Undoubtedly the proposed voting system is techniques are especially good. We have used iris recognition and smart card for improving this system. Many bio metric methods are available but iris recognition has high accuracy rate. Using the smart card, it is likely to poll from any polling booth rather than the particular polling booth. The iris pattern of the person is obviously unique. It reduces the polling time which is most important. It totally rules out the chance of invalid vote.

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