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Advanced IRIS Segmentation and Detection System for Human Identification

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***Abstract*—Iris recognition can be considered as one of the most reliable and accurate method of biometric technology, compared with other technologies like face, fingerprint and speech recognition. A biometric system is based on this fact that each and every individual has certain unique features which are characteristic to that individual and serve as basis for identification and authentication for automatic detection of an individual by the use of biometrics. Iris image detection is one of the biometric detection method which works on pattern detection which are present on the images of the iris of an individual. Iris pattern detection method is one of the most accurate biometric method for the reason that the iris pattern are absolutely exclusive to an individual and are unique in nature for each and every individual. This project pertains with the development of a system for human iris pattern recognition and analysis of the results which are delivered by the system. For the iris localization the Canny edge detection scheme and Sobel operator are amalgamated. As a next step the iris image are normalized in order to achieve transformation of iris region to have fixed dimensions to fulfill the requirements of comparisons. As a further step extraction of the most discriminating feature of the iris is obtained encoding and is done by using a modification of Gabor wavelets. By the use of Hamming distance, which gives information of two iris images being same or not. It is done by comparing biometric templates.**

***Index Terms*— Iris Detection, Bio-metric Identification, Pattern Recognition and Edge Detection, Edge, Canny, Sobel.**

I. INTRODUCTION

The biometrics word has been derived from "bio" means **life** and "metric" means **measurement**, in other words is the study of methods to recognize human behavior of each person. The study of automated identification, by use of physical or behavioral attribute is called biometrics. Security is the main application of biometric. In today's world, security has become very important. The iris pattern detection constituting the iris detection security system can be reckoned as most reliable technology for an individual's identification. The iris of human is random in texture and is stable structurally throughout the life hence it can serve as a living passport or living password for an individual which he does not have to carry or always remember. Biometrics means the metrics which pertains to human characteristics and forms a basis for realistic authentication for identification and access control.

Biometrics is the reference method for identification or for authentication of an individual on the basis of certain features which are unique in nature. In order to label and describe the individuals biometric identifiers are used which are sets of distinctive and measureable features. There are two types of biological identifiers, the one being physiological and the other behavioral characteristics. The iris, fingerprints, DNA etc. belong to physiological identifiers while the typing rhythm, voice, gait etc. belong to behavioral identifiers. The functioning of a biometric system begins with capturing a sample of the feature like a digital color image of the iris to be used in iris detection or a recording the sound signal to be used in voice recognition. The sample may then be refined so that the most discriminating features can be extracted and noises in the sample are reduced by means of filtering. By the use of some sort of mathematical function a sample is then converted into a biometric template. A biometric template represents a normalized and efficient representation of the sample taken and subsequently can be used for comparisons. There are two modes of operation with biometric systems. The first one is an enrollment mode by which new templates are added into the database and the other one is called identification mode which compares a created template of an individual, who wants to be verified with the templates present in the database. The parameter for being a good biometric is the use of feature which is highly unique. This minimizes the chance of any two different individuals to be matched as same. The feature should also be stable so that it does not change over the time span.

II. DETECTION OF IRIS

The iris is a thin circular anatomical structure in the eye. The iris functions by method of contraction and dilation to change the size of pupil so that the amount of light entering within the eye may be regulated as per requirement. For controlling the amount of light to be entered within the eye is regulated by changing the diameter of the pupil with the help of two sets of muscles for this purpose viz. sphincter and dilator muscles. By their contraction and expansion the pupillary size becomes small or large thus regulating the entry of light within the eye. The iris is a two layered structure. The front layer is made up of fibro vascular tissue called stroma and second layer is beneath it and made up of pigmented epithelial cells. The stroma is connected with sphincteric muscles responsible for the contraction of pupil and dilator muscles responsible for enlargement of pupil by pulling the iris in radial direction. The iris can be divided into two regions: the first one "The Pupillary Zone" which constitutes the boundary of pupil and "The Ciliary Zone" constituting the rest of iris.

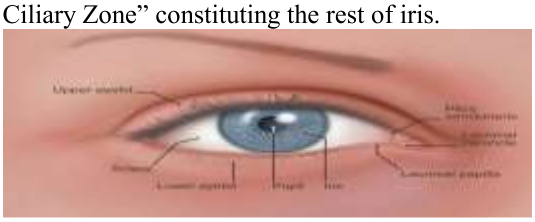

Figure 1: A Front View of the Human Iris

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The iris is the internal structure which is externally visible and is well protected by a transparent layer known as cornea and the epigenetic patterns of the iris are very unique and do not change throughout the lifespan of an individual. This parameter of its uniqueness and immunity against any structural change all throughout life of a person makes it a good biometrics that can be used for identifying individuals. These unique patterns can be extracted using techniques employed on a digitized image of the eye and then the results can be encoded into a biometric template which can later be stored in a database for future comparisons. The biometric template is usually created using some kind of mathematical operations. If an individual wants to be identified by the system, then first a digitized image of their eye is first produced, and then a biometric template is created for their iris region. The matching of biometric template is done against pre-existing biometric templates in the reservoir of the database of the system. By the use of certain matching algorithms paves the way for identification of an individual.

III. Literature Report

The iris pattern detection technique is a biometric way to verify and identify an individual. The other biometrics include retinal, facial, fingerprint biometrics which consider other biological features for an individual's identification. All these biometric technologies are destined to present novel solutions for the detection, authentication and to address security concerns of sensitive places.

The concept that no two irises are similar was achieved by conceptual design of an automated iris biometric system which was patented by Flom and Safir in 1987.

Daugman has done a pioneer work pertaining to iris biometric by giving a standard reference model through his early publications. The center and diameter of the iris is detected by the use of Integro-Differential operators. In the next step the image is converted from Cartesian coordinates to polar coordinates thereby generating a rectangular representation of the region of interest. With the help of 2D Gabor wavelets, by feature extracting algorithm, the iris codes are generated which are matched by using comparison method [Daugman 2004]. The accuracy of more than 99.99% is achieved by algorithm and the time taken for iris identification is less than 1 second. A comparison of different methods and iris detection algorithms was provided by Tan et. al.[4]. As the next step iris is localized by finding the pupillary center and radius and then to locate the iris boundary precisely by applying the Canny operator and Hough transform. Thus, image of the iris is converted into dimensionless polar coordinates and processing is done by using a variant of Gabor filter. By applying the Fischer linear discriminant the dimension of signature is reduced.

By the use of an algorithm, as given by Boles and Boashash[6], the center of the pupil is located by using the edge detection method. Gray level values on virtual concentric circles are recorded and then a zero crossing representation is constructed on these virtual circles based on a one dimensional dyadic wavelet transform. The corresponding virtual circles of different images are ascertained by rescaling the images to have a common iris diameter. Then two dissimilarity functions are created for the purpose of matching, one using every point of representation and the other one using only the zero crossing points. The algorithm has been tested successfully on a small database of iris images, with and without noise.

Zhu et. al. [7] used Gabor filters and 2D wavelet transform for feature extraction. For identification, weighted Euclidean distance classification has been used. This method is invariant to translation and rotation and tolerant to illumination. Gabor gives 98.3% classification rate and accuracy with wavelet is 82.51%. According to Lim, et al., after a standard iris localization and its conversion to polar coordinates with respect to center of the pupil the alternative approaches to both feature extraction and matching has been proposed.

The comparison by using Gabor transform and the Haar wavelet transform is used for feature extraction and the results indicate Haar transform is better. With the use of Haar transform only 85 bits are required to store iris pattern which is better than Daugman's algorithm which requires 2048 (2K) bits. The process of matching uses LVQ competitive learning nueral network which is optimized by selecting carefully the initial weight vectors. The results of the experiment are given in [8] which are based on the iris image database acquired from 200 people.

The stage of pre-processing is a standard stage. By using Canny edge detector method the edge detection is obtained and each image of the iris is transformed into standardized polar coordinates with respect to center of the pupil as proposed by Du, et al.[3]. The feature extraction stage is different from those which are mentioned earlier. And this is simple to implement. A gray scale invariant known as Local Texture Pattern (LTP) is used by authors, for comparing the intensity of a single pixel against the average intensity for a small surrounding rectangular area. By a specific way the LTP is averaged to obtain the elements of a rotational invariant vector. Thus by this method a loss projection from 2D to 1D is performed. This vector is then normalized so that its elements sum to one. The matching algorithm uses the "Du measure", which is the product of two measures, one based on the tangent of the angle between two vectors p and q, and the other one is based considering relative entropy of q with respect to p which is also known as Kullback – Liebler distance. A paper of Du[8] deals in context of hyperspectral imaging for providing the evidence that the Du measure is more sensitive as compared with either of the other two measures.

This step is crucial in iris detection since iris features cannot be used for detection unless for the iris region, localization and segmentation are performed correctly. There are different iris localization techniques. The iris localization methods as given by Daugman's integro-differential operator [4], and Wildes' Hough transform [12]. For the compensation due to variation in the pupillary size and in the image capturing distances the mapping of the segmented iris region is done into a fixed length and dimensionless polar coordinate system[13].

IV. Proposed Method

For biometric authentication of automobile driver, by iris detection system, is done by image processing technique. By image processing technique the extraction of unique iris pattern from a digitized image of the eye is obtained and it is encoded into a biometric template, which can be stored in a database. When the driver is identified by iris detection system, their eye is first snapped, and then a template is created for their iris region. This template is then compared with the other templates stored in a database to find the best matching template and the driver is identified, or no match is found.

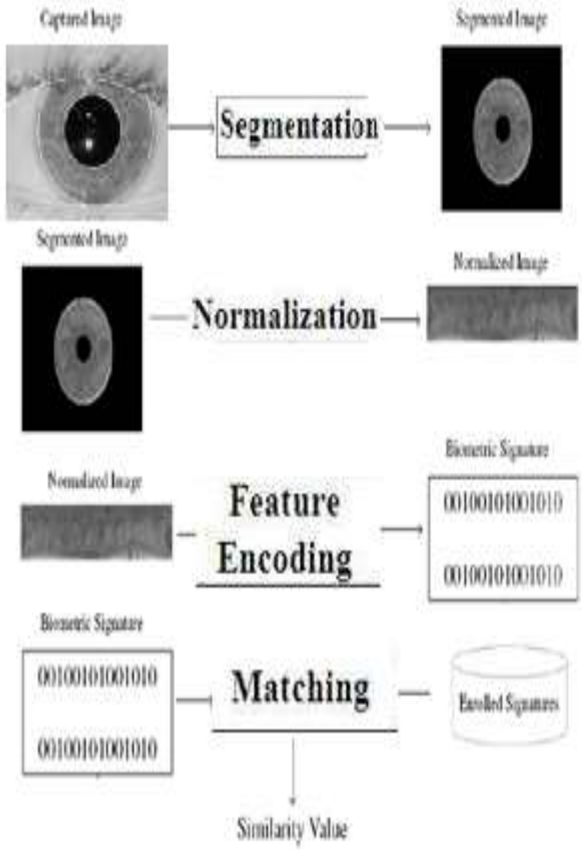

Figure 2: Stages of the Iris Detection Systems

Figure 2 summarizes the steps to be followed when doing iris detection.

Step (i): Iris Image acquisition, the first phase, is to acquire the image is one of the major challenging tasks of automated iris detection since we need to capture a high-quality image of the iris.

Step (ii): Iris localization is the process to detect the edge of the iris as well as that of the pupil; thus extracting the iris region.

Step (iii): Iris Normalization is used to be able to transform the iris region to fixed dimensions, and hence removing the dimensional inconsistencies between eye images due to the stretching of the iris caused by the pupil dilation from varying levels of illumination.

Step (iv): The normalized iris region is uncovered into a rectangular region.

Step (v): Finally, to extract the most discriminating feature in the iris pattern so that a comparison between templates can be done. Hence, the encoding of the obtained iris region is done by using wavelets to construct the iris code thereby making a decision in the matching step.

The iris image detection methodology is discussed and figure below shows system processes.

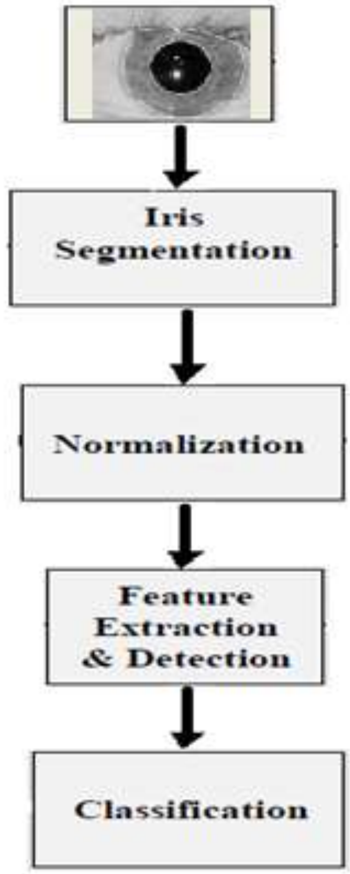

Figure 3: Methodology Flowchart

a) Stage of Iris Image Acquisition

The image taken of the iris must contain rich iris texture because image quality decides the qualitative success of extraction stage hence, a high quality of 3CCD camera is placed approximately 9cm away from the user's eye to capture a high quality image. The user's eye and the source of light are kept approximately 12cm apart.

b) Stage of Pre-processing

CASIA Iris Image Database is probably the biggest and the most widely used iris image database publicly available to iris scientists.
CASIA iris image database ver.1 is used in the proposed method which is collected by the institute of Automation, Chinese Academy of Sciences. It uses a special camera that operates in the infrared spectrum of light, not visible by the human eye. A digital optical scanner, which is designed by National Laboratory of Pattern Recognition (NLPR) which is a Chinese Science Academy, is used to take 320X280 pixels gray scale images. Out of a total of 756 iris images there are 108 classes which are available.
Certain non relevant regions like pupil, the sclera or eyelids or noise caused by eyelashes and adjacent skin surrounds the

iris. For accuracy of detection the noise from the iris images is required to be removed.

c) Segmentation stage

The first part of iris detection is to localize the actual iris region from the digital eye image. The iris region can be supposed to be made up of two circles – one circle constituting iris/sclera boundary and the iris/pupil boundary being formed by the other one. The upper and the lower part of the iris region are covered by eyelids and eyelashes. Inside the iris region specular reflections may be found which can lead to corrupt the iris pattern so the technique must be able to remove these noises and localize the circular iris region.

The data set which is used decides the extent of success of segmentation process. Images taken from the region with specular reflection affects the segmentation process. If the eyelids or eyelashes cover a substantial iris region then also the segmentation process may result in a failure. The segmentation process is of paramount importance because an incorrect localization of the data may cause very poor detection rates. The iris segmentation speed can be enhanced by the use of simple combination of Gaussian filtering, Canny edge detection and Hough transform so as to localize the iris. The radius and the center of the pupil and iris circles is deduced by Hough transform. Canny edge detection operator detects the edges in iris image and it is the best edge operator in MATLAB as shown in the figure below:

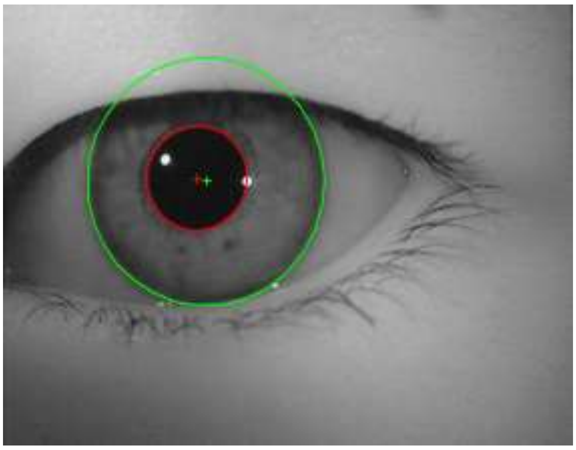

Figure 4: Segmented Image

d) Canny Edge Detection

There are many methods for edge detection, but one of the most optimal edge detection methods is "Canny edge detection". It receives a gray-scale image and outputs a binary map correspondent to the identified edges. It begins by a blur operation then followed by gradient map construction for each image pixel. A value of 0 for all the pixels of the gradient map that have neighbors with higher gradient values is set by a non-maximal suppression stage. The hysteresis process uses two values of pre-defined nature in order to classify some of the pixels as edge or non-edge. In the last edges are extended recursively to those pixels which are neighbor of other edges and have gradient amplitude higher than a lower threshold. Following arguments are obtained Canny edge detection:

Upper threshold value: It is a parameter utilized in hysteresis operation for setting the higher values within the gradient map in such a way that the higher values of the map are taken as non-edge points.

Lower Threshold value: This is also a hysteresis operation parameter where pixels with gradient values lower than this are reckoned as non=edge points.

Sigma of the Gaussian Kernel: This parameter defines the standard deviation of the bi-dimensional Gaussian kernel. Higher values increase the power of the blur operator and result in less number of detected edges.

Vertical Edges Weight: This is used to weight the vertical derivatives in the gradient map construction. It is usually in the [0, 1] interval and is multiplied by the vertical derivative value.

Horizontal Edges Weight: It is the correspondent with regard to horizontal derivatives. It is noteworthy that the sum of vertical weight values and horizontal weight values must be equal to 1.

Scaling Factor: This factor used to decrease the image size to decrease the number of edge point.

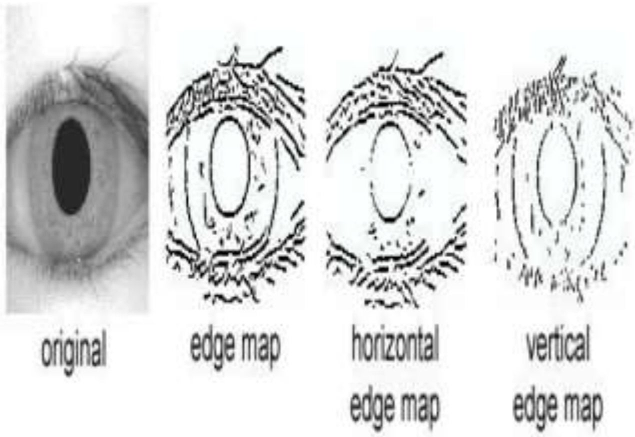

Figure 5: Application of canny edge detection on eye image

e) Sobel Operator

By this technique a 2D spatial gradient measurement of an image is performed. It also makes those regions prominent which are of high spatial frequency that correspond to edges. This operator is used in order to find out the approximate absolute gradient in an input gray scale image. Theoretically operator is comprised of 3X3 convolution masks in a pair as per figure. If one mask is rotated by 90 degrees it becomes the other mask. It has got high similarity with Robert's cross operator. These masks are so designed that there response is maximum for vertical edges and horizontal edges relative to pixel grid. One mask is designated for each of the two perpendicular orientations. There can be separate application of the masks for the input image, for producing separate measurements of gradient components in each orientation viz. Gx and Gy. The absolute magnitude of gradient at each point with respect to orientation of gradient are combined together, to obtain an expression as follows.

$$|G| = \sqrt{G_{x^2}} + \sqrt{G_{y^2}} \quad (1)$$

Using this mask the approximate magnitude is given by:

$$|G| = |H1-H4| + |H2-H3| \quad (2)$$

$$\frac{\partial y}{\partial x} = y(i,j) - y(i+1,j+1) \quad (3)$$

$$\frac{\partial y}{\partial x} = y(i+1,j) - y(i,j+1) \quad (4)$$

f) Normalization

On having successfully segmented the eye image, the next step is to transform the iris region of the eye image so that it has fixed dimensions in order to allow the feature extraction process to compare two images. The dilation of pupil is a cause of generation of dimensional inconsistencies in an eye image. The changing levels of illumination falling on the eye causes dilation of pupil. Other causes of consistency include changing distances for imaging, rotation of camera, tilting of head and rotation of the eye within the eye socket. By the process of normalization the iris region is projected to have constant dimensions in such a manner that the two images of the same iris taken at different conditions and time will possess characteristic features at the same locations which will be identical to each other.

V. Result and Analysis

The segmentation process has been successfully implemented by using the automatic model. The images contained in the database of CASIA are specially taken to carry out research related with iris detection therefore the demarcations between the pupil, iris and sclera is well marked. When this segmentation technique is applied on CASIA database, a success rate of 80% is achieved.

The False Reject Rate (FRR) measures the probability that an individual who has enrolled into the system is not identified by the system. It occurs when the system says that the sample does not match any of the entries in the gallery, but the sample in fact does belong to someone in the gallery.

The authenticity of a genuine attempt is evaluated according to the proportion of events where HD exceeds a given threshold. The rate of failure of the matching algorithm to determine the result by matching of an enrolled sample is classified as Type – I error.

FRR is calculated as under:

$$FRR(n)=\frac{\text{Number of rejected verification attempts for a qualified individual n}}{\text{Total number of verification attempts for that qualified individual n}}$$

$$FRR=\frac{1}{N}\sum_{n=1}^{N} FRR(n)$$

Where 'n' is the total number of enrolments.

Figure 6: Canny Edge Detection of IRIS Detection

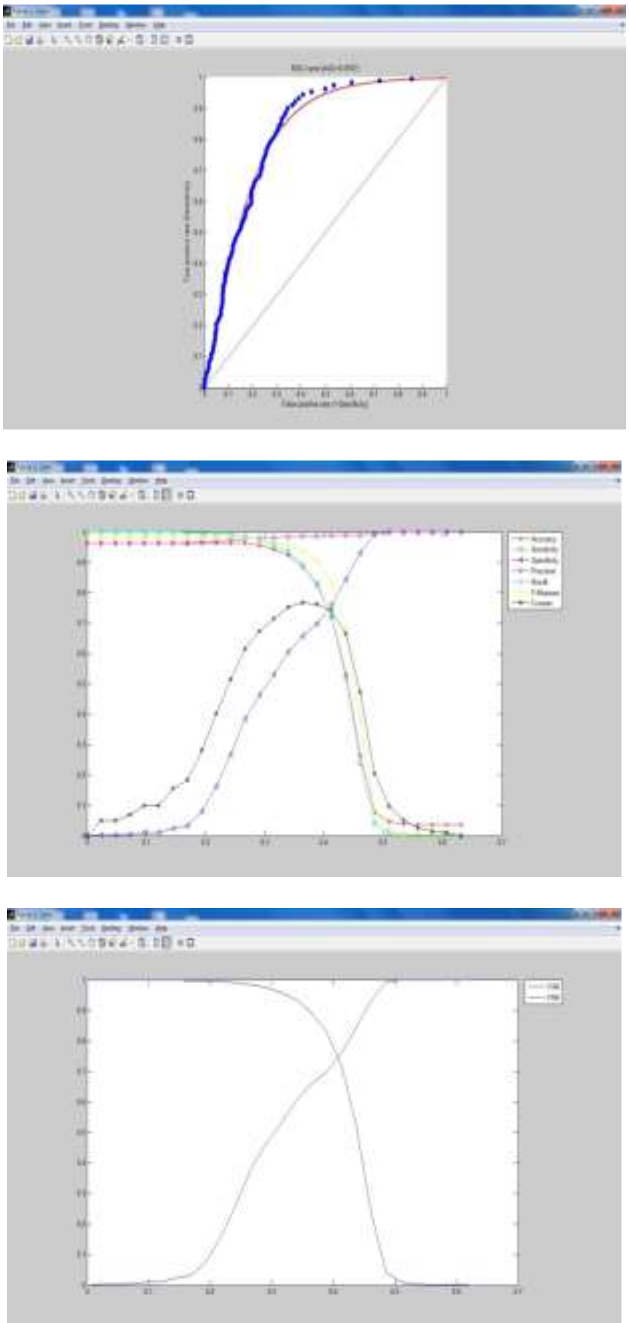

Figure 7: Canny Edge Detection Graphs of IRIS Detection

Figure 8: Sobel Operator Detection of IRIS Recognition

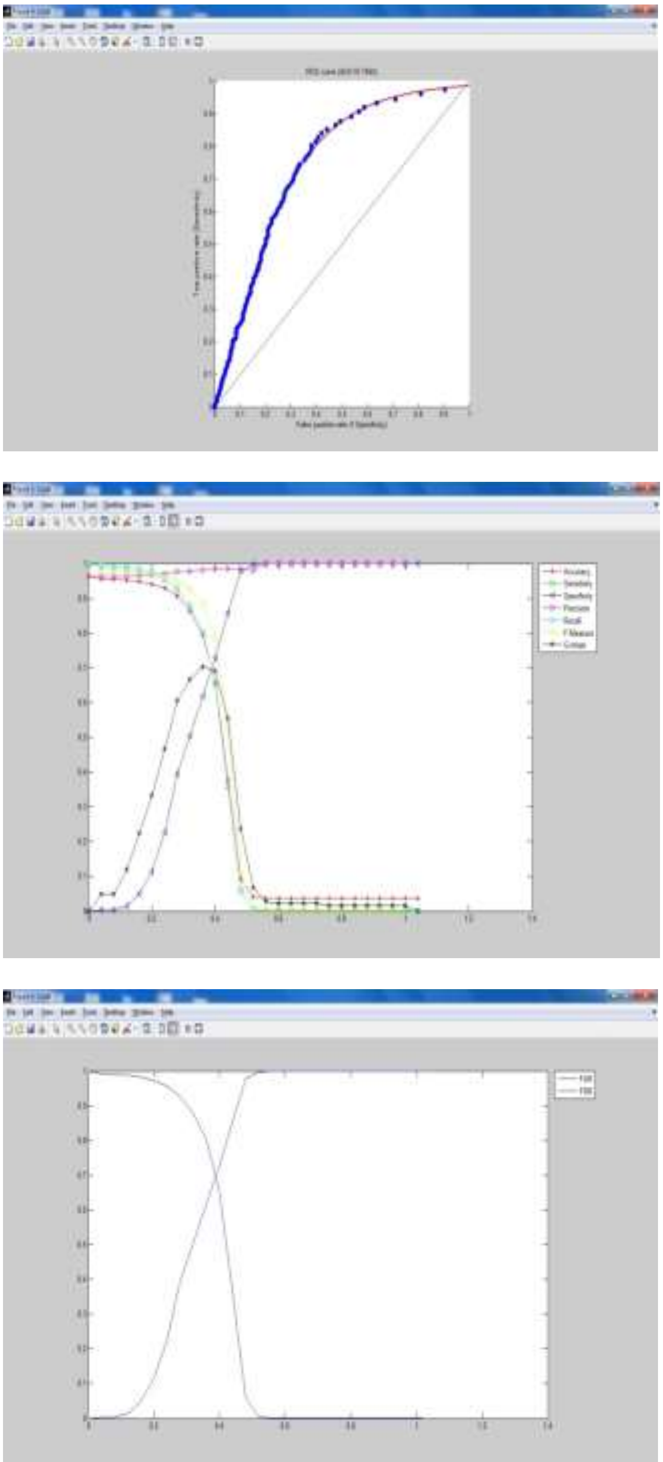

Figure 9: Sobel operator detector Graphs of IRIS Detection

Table 1: Comparison of Canny and Sobel Detection with different Parameter

	Accuracy	Sensitivity	Specificity	Precision	Recall	F-Measure	G-mean
Canny Detection	0.036696	0.000092	1	1	0.000092	0.00018399	0.0095919
Sobel Detection	0.036968	0.00027543	1	1	0.0002754	0.00055071	0.016596

VI. Conclusion

The iris detection system that was developed proved to be a highly accurate and efficient system that can be used for biometric identification.

On the basis of trials so far it has been proved beyond doubt that iris detection biometric method is the most reliable method for the identification of an individual. The accuracy can be enhanced if the iris image is taken by using the more stable equipment and the conditions in which the image of iris is taken. The iris image biometric technology is applied at many places and for multiple usages but its application is most widely accepted at the places where security challenges are important like airports, defense establishments or other sensitive zones so as to check the entry of an individual with feigned identity. From this paper we can conclude that which technique is best and we can use that for the better performance and accuracy.

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