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Iris Segmentation and Detection System for Human Identification

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***Abstract*— A biometric system of identification and authentication provides automatic detection of an individual based on certain unique features or characteristics possessed by that individual. Iris detection is a biometric identification method that uses pattern detection on the images of the iris of an individual. Iris detection is considered as one of the most accurate biometric methods available owing to the unique epigenetic patterns of the iris. In this project, we have developed a system that can recognize human iris patterns and an analysis of the results is done. A hybrid mechanism has been used for implementation of the system. Iris localization is done by amalgamating the Canny Edge Detection scheme and Sobel Operator. The iris images are then normalized so as to transform the iris region to have fixed dimensions in order to allow comparisons. Feature encoding has been used to extract the most discriminating features of the iris and is done using a modification of Gabor wavelets. And finally the biometric templates are compared using Hamming Distance which tells us whether the two iris images are same or not.**

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

I. INTRODUCTION

The word biometrics derived from “bio” that means life and “metric” that means measurement, in other words is the study of methods to uniquely recognize human behavior of each person. The study of automated identification, by use of physical or behavioral traits is called biometrics. The application of biometric is security. In today’s world, security has become very important. Iris Detection Security System is one of the most reliable leading technologies for user identification. The human iris has random texture and it is stable throughout the life, it can serve as a living passport or a living password that one need not remember but is always present.

Biometrics refers to the identification or authentication of an individual based on certain unique features or characteristics. Biometric identifiers are the distinctive and measurable features that is used to label and describe individuals. There are two categories of biometric identifiers namely physiological and behavioral characteristics. Iris, fingerprint, DNA, etc. belong to the former kind of biometric identifiers whereas typing rhythm, gait, voice, etc. belong to the latter.

A biometric system usually functions by first capturing a sample of the feature, such as capturing a digital color image of a face to be used in facial detection or a recording a digitized 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. The sample is then transformed into a biometric template using some sort of mathematical function. The biometric template is a normalized and efficient representation of the sample which can be used for comparisons. Biometric systems usually have two modes of operations. An enrolment mode is used for adding new templates into the database and the identification mode is used for comparing a template created for an individual, who wants to be verified, with all the existing templates in the database. A good biometrics is one which uses a feature that is highly unique. This reduces the chances of any two people having the same characteristics to the minimal. The feature should also be stable so that it does not change over the period of time.

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II. IRIS DETECTION

The iris is a thin circular anatomical structure in the eye. The iris’s function is to control the diameter and size of the pupils and hence it controls the amount of light that progresses to the retina. A front view of the iris is shown in Figure 1. To control the amount of light entering the eye, the muscles associated with the iris (sphincter and dilator) either expand or contract the centre aperture of the iris known as the pupil.

The iris consists of two layers: the pigmented front fibro vascular called as stroma and beneath it are the pigmented epithelial cells. The stroma is connected to the sphincter muscle which is responsible for the contraction of the pupil and also to the set of dilator muscles, responsible for the enlargement of the pupil which it does by pulling the iris radially. The iris is divided into two basic regions: “The Pupillary Zone”, whose edges form the boundary of the pupil and “The Ciliary Zone”, which constitutes the rest of the iris.

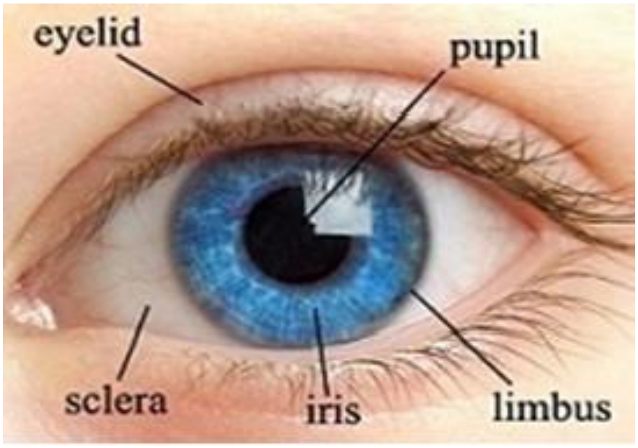

Figure 1: A Front View of the Human Iris

The iris is a well-protected organ that is externally visible and whose epigenetic patterns are very unique and remain stable throughout most of a person's life. Its high uniqueness and stability makes it a good biometrics that can be used for identifying individuals. These unique patterns can be extracted using image processing 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 sort 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. This biometric template is compared with all the other pre-existing templates in the database using certain matching algorithms in order to get the identification of the individual.

III. Literature Review

Iris detection technique is one of the biometric verification and identification techniques which also include fingerprint, facial, retinal and many other biological features [1]. They all present novel solutions for human being detection, authentication and security applications. The iris has been in use as biometric from few decades. However, the idea of automating iris detection is more recent. In 1987, Flom and Safir obtained a patent for an unimplemented conceptual design of an automated iris biometrics system [3] with the concept that no two irises are alike.

The pioneering work in the early history of iris biometrics is that of Daugman. Daugman's 1994 patent [2] and early publications became a standard reference model. Integro-differential operators are used to detect the center and diameter of the iris. The image is converted from Cartesian coordinates to polar coordinates and the rectangular representation of the region of the interest is generated. Feature extraction algorithm uses the 2D Gabor wavelets to generate the iris codes which are then matched using comparison method (Daugman, 2004). The algorithm gives the accuracy of more than 99.99%. Also the time required for the iris identification is less than 1 Sec.

Tan et.al. [4] Proposes several innovations, and then provide a comparison of different methods and algorithms of iris detection. The iris is localized in several steps which first find a good approximation for the pupil center and radius, and then apply the Canny operator and the Hough transform to locate the iris boundaries more precisely. The iris image is converted to dimensionless polar coordinates, similarly to Daugman, and then is processed using a variant of the Gabor filter. The dimension of the signature is reduced via an application of the Fisher linear discrimant. A careful statistical performance evaluation is provided for the authors' work, and for most of the well-known algorithms mentioned above [5].

Boles and Boashash [6] have given an algorithm that locates the pupil centre using an edge detection method, records grey level values on virtual concentric circles, and then constructs the zero-crossing representation on these virtual circles based on a one-dimensional dyadic wavelet transform. Corresponding virtual circles in different images are determined by rescaling the images to have a common iris diameter. The authors create two dissimilarity functions for the purposes of matching, one using every point of the representation and the other 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. The classification rate on using Gabor is 98.3% and accuracy with wavelet is 82.51%. Several interesting ideas are presented by Lim, et al., in [5]. Following a standard iris localization and conversion to polar coordinates relative to the center of the pupil, the authors propose alternative approaches to both feature extraction and matching.

For feature extraction they compare the use of the Gabor Transform and the Haar Wavelet Transform, and their results indicate that the Haar Transform is somewhat better. Using the Haar transform the iris patterns can be stored using only 87 bits, which compares well to the 2,048 required by Daugman's algorithm. The matching process uses an LVQ competitive learning neural network, which is optimized by a careful selection of initial weight vectors. Also, a new multi-dimensional algorithm for winner selection is proposed. Experimental results are given in [8] based on a database of images of irises from 200 people.

The pre-processing stage is standard. Edge detection is performed using the Canny method, and each iris image is then transformed to standardized polar coordinates relative to the center of the pupil as proposed by Du, et al.[3]. The feature extraction stage is quite different from those mentioned previously, and is simple to implement. The authors use a gray scale invariant called Local Texture Patterns (LTP) that compares the intensity of a single pixel to the average intensity over a small surrounding rectangle. The LTP is averaged in a specific way to produce the elements of a rotation invariant vector. Thus the method performs a loss projection from 2D to 1D. 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 based on the relative entropy of q with respect to p, otherwise known as the Kullback- Liebler distance. Another paper involving Du [8], in the context of hyperspectral imaging, provides evidence that the Du measure is more sensitive than either of the other two measures.

Even though iris detection has shown to be extremely accurate for user identification, there are still some issues remaining for practical use of this biometric [9]. For example, the fact that the human iris is about 1 cm in diameter makes it very difficult to be imaged at high resolution without sophisticated camera systems. Traditional systems require user cooperation and interaction to capture the iris images. By observing the position of their iris on the camera system while being captured, users adjust their eye positions in order to localize the iris contour accurately [10].

This step is crucial in iris detection since iris features cannot be used for detection unless the iris region is localized and segmented correctly. Many iris localization techniques exist and have been developed. Some of the classical methods for iris localization are Daugman'sintegro-differential operator [4], and Wildes' Houghtransform [11]. In order to compensate the variations in the pupil size and in the image capturing distances, the segmented iris region is mapped into a fixed length and dimensionless polar coordinate system [12]. In terms of feature extraction, iris detection approaches can be divided into three major categories: phase-based methods, zero-crossing methods, and texture analysis based methods.

IV. Proposed Methodology

The proposed Iris Detection System for authentication of driver in automobiles is based on image processing technique to ensure the uniqueness of driver. Image processing techniques can be employed to extract 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. When the driver is identified by iris detection system, their eye is first photographed, and then a template is 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 driver is identified, or no match is found.

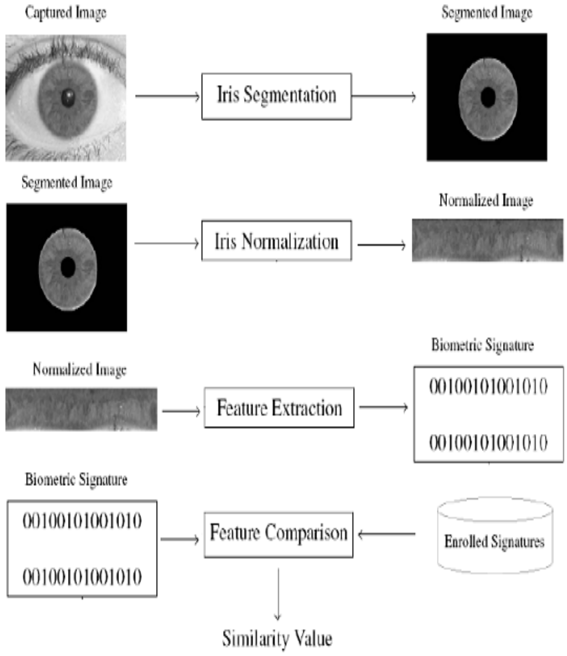

Figure 2: Main stages of the Iris Detection Systems.

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

Step 1: Image acquisition, the first phase, is one of the major challenges of automated iris detection since we need to capture a high-quality image of the iris while remaining non-invasive to the human operator.

Step 2: Iris localization takes place to detect the edge of the iris as well as that of the pupil; thus extracting the iris region.

Step 3: Normalization is used to be able to transform the iris region to have 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 4: The normalized iris region is unwrapped into a rectangular region.

Step 5: Finally, it is time to extract the most discriminating feature in the iris pattern so that a comparison between templates can be done. Therefore, the obtained iris region is encoded using wavelets to construct the iris code. As a result, a decision can be made in the matching step.

The proposed methodology for iris image detection is discussed. Figure 3 shows the system processes that used.

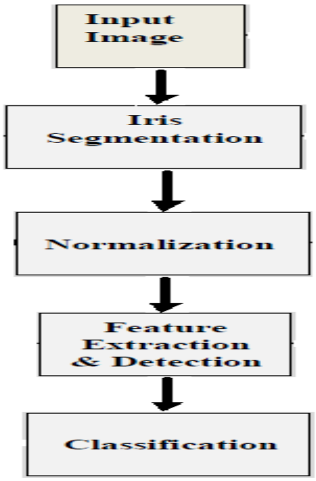

Figure 3: Flowchart of Methodology

a) Iris Image Acquisition

The iris image should be rich in iris texture as feature extraction stage depends upon the image quality, thus the image is acquired by 3CCD camera placed at a distance of approximately 9 cm from the user eye. The approximate distance between the user and the source of light is about 12 cm.

b) Pre-processing

CASIA Iris Image Database is probably the largest and the most widely used iris image database publicly available to iris detection researchers. It has been released to more than 2,900 users from 70 countries since 2006.

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. Images are 320x280 pixels gray scale taken by a digital optical sensor designed by NLPR (National Laboratory of Pattern Recognition – Chinese Academy of Sciences). There are 108 classes or irises in a total of 756 iris images.

The iris is surrounded by the various non-relevant regions such as the pupil, the sclera, the eyelids, and also noise caused by the eyelashes, the eyebrows, the reflections, and the surrounding skin. We need to remove this noise from the iris image to improve the iris detection accuracy.

c) Segmentation

The first part of iris detection is to isolate or localize the actual iris region from the digital eye image. The iris region can be thought of as two circles, one circle forming the iris/sclera boundary and the other forming the iris/pupil boundary. Eyelids and eyelashes are also present which usually cover the upper and lower parts of the iris region. Specular reflections can also occur inside the iris region which may corrupt the iris pattern. So the technique used must be able to exclude these noises and localize the circular iris region.

The degree to which the segmentation applied succeeds will greatly depend on the data set being used. Images where specular reflection occurs can hamper the process of segmentation. If the eyelids and eyelashes cover too much of the iris region then the segmentation process may not result in a success. The segmentation process is very critical as data that has been localized incorrectly will result in very poor detection rates. To speed iris segmentation, the iris has been roughly localized by a simple combination of Gaussian filtering, canny edge detection and hough transform. Hough transform is used to deduce the radius and center of the pupil and iris circles. Canny edge detection operator is used to detect the edges in the iris image which is the best edge operator available in MATLAB as shown in figure 4

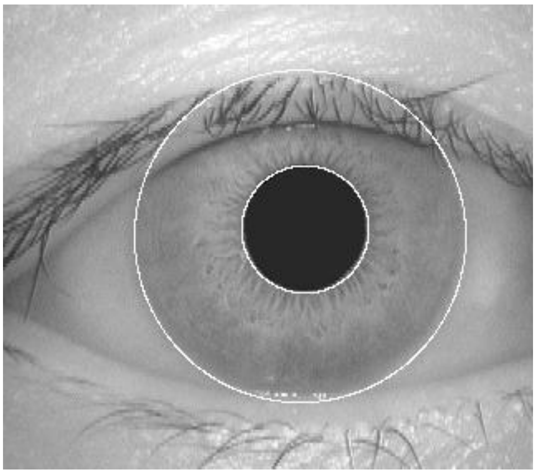

Figure 4: Segmented Eye Image

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 starts by a blur operation followed by the construction of a gradient map for each image pixel. A non-maximal suppression stage sets the value of 0 to all the pixels of the gradient map that have neighbors with higher gradient values. Further, the hysteresis process uses two predefined values to classify some pixels as edge or non-edge. Finally, edges are recursively extended to those pixels that are neighbors of other edges and with gradient amplitude higher than a lower threshold. The Canny edge detection receives the following arguments:

Upper threshold: This parameter is used in the hysteresis operation, sets the higher values of the gradient map to be considered as edge points.

Lower Threshold: This parameter is used in the hysteresis operation pixels with gradient values lower than this are considered 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: Similarly to the above parameter, it is the correspondent regarding the horizontal derivatives. It must be noted that, usually, the sum of the vertical 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.

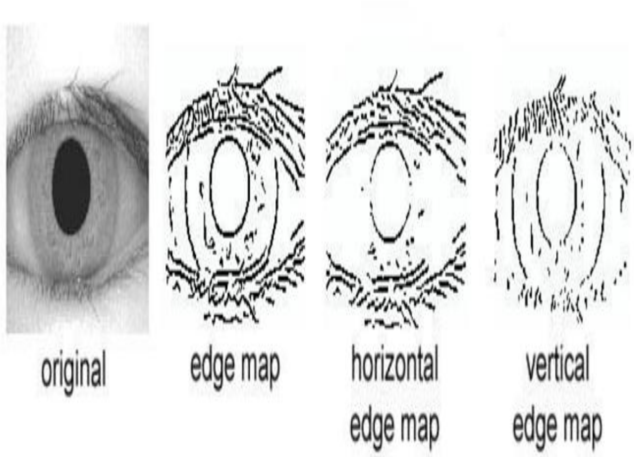

Figure 5: Application of canny edge detection on eye image

e) Sobel Operator

This technique performs 2D spatial gradient measurement on an image and also it emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input gray-scale image. In theory at least, the operator consists of a pair of 3x3 convolution masks as shown in figure. One mask is simply the other rotated by 90°. This is very similar to the Roberts cross operator. These masks are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one mask for each of the two perpendicular orientations. The masks can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation that is Gx and Gy. These can be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient.

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

Using this mask the approximate magnitude is given by:

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

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

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

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. Dimensional inconsistencies may arise in eye images mainly due to dilation of the pupil which causes the stretching of the iris. Pupil dilation usually occurs due to varying levels of illumination falling on the eye. The other causes of inconsistency are, varying imaging distance, camera rotation, head tilt, and rotation of the eye within the socket. The normalization process will produce iris regions having constant dimensions such that two images of the same iris taken at different conditions and time will have the same characteristics features at the same locations spatially.

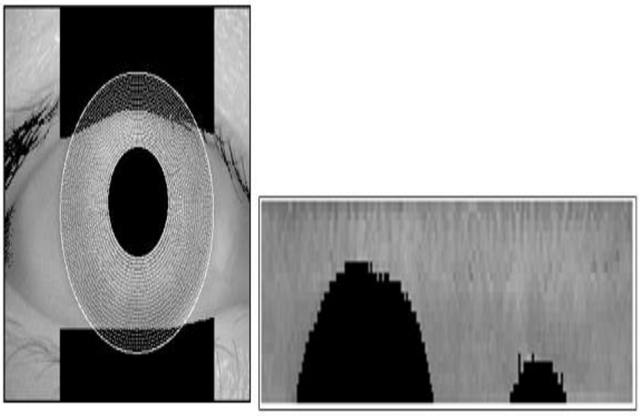

Figure 5: Iris Normalization

V. Result and Analysis

The automatic model implemented for the segmentation process proved to be quite successful. The images in the CASIA database had been specifically taken for research related to iris detection and hence the boundaries between the iris, the pupil and the sclera were quite distinctive. The segmentation technique when applied on the CASIA database had a success rate of 80%.

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 proportion of genuine or authentic attempts whose HD exceeds a given threshold. The rate at which a matching algorithm incorrectly fails to determine that a genuine sample matches an enrolled sample,

It is also known as Type-I error.

FRR can be calculated as:

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

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

Where ‘n’ is the total number of enrolments.

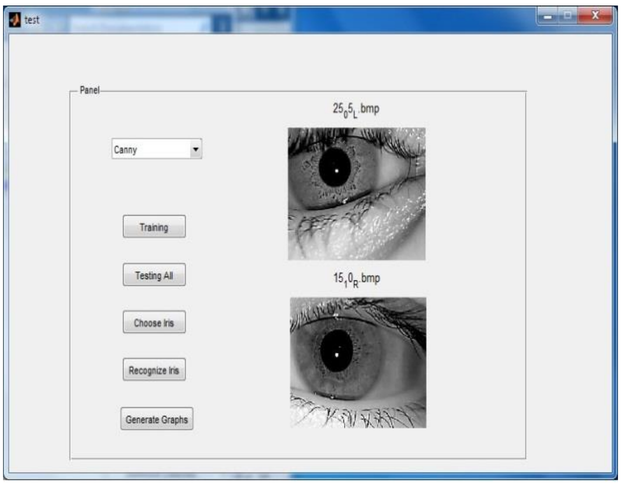

Figure 6: Canny Edge Detection of IRIS Detection

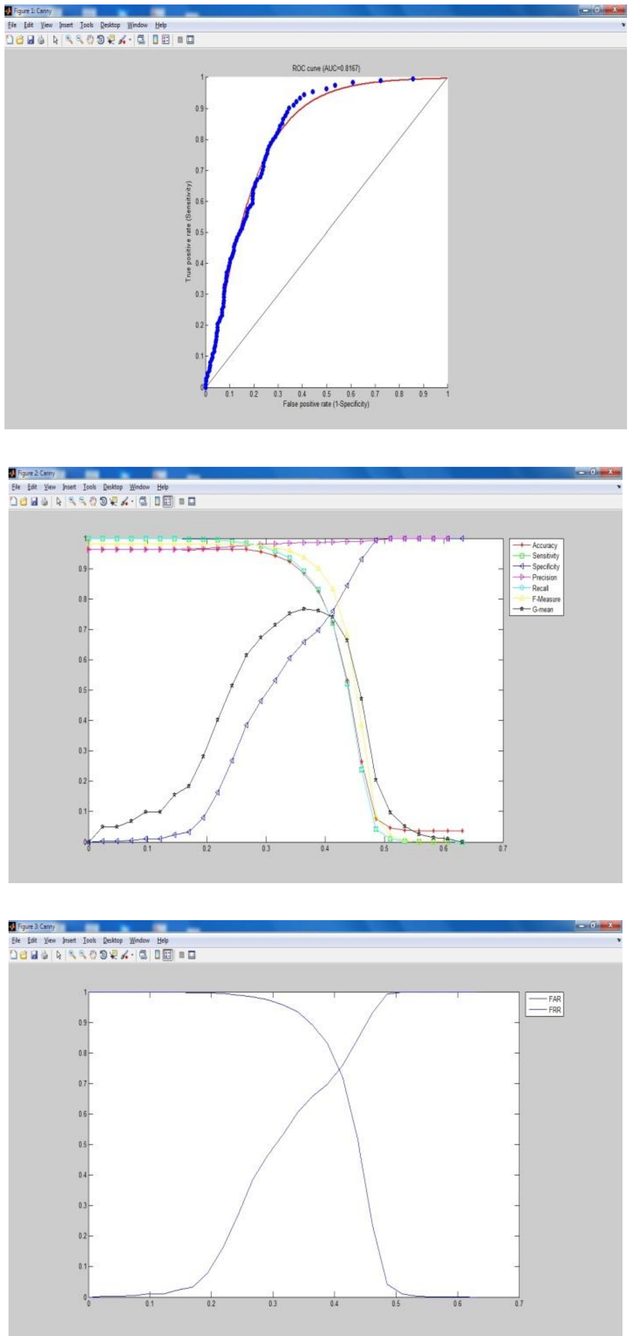

Figure 7: Canny Edge Detection Graphs of IRIS Detection

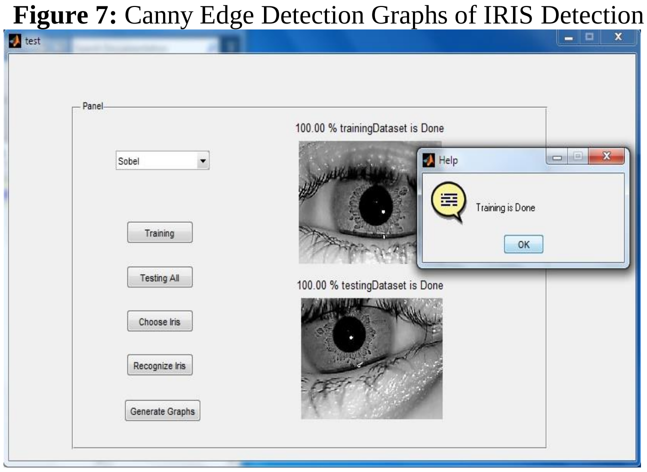

Figure 8: Sobel Operator Detection of IRIS Recognition

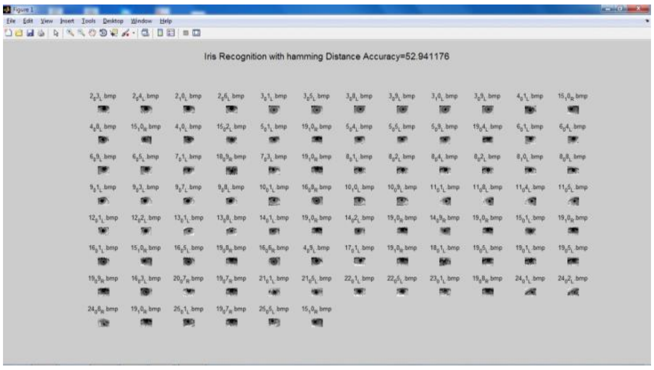

Figure 9: Iris Detection with Humming Distance

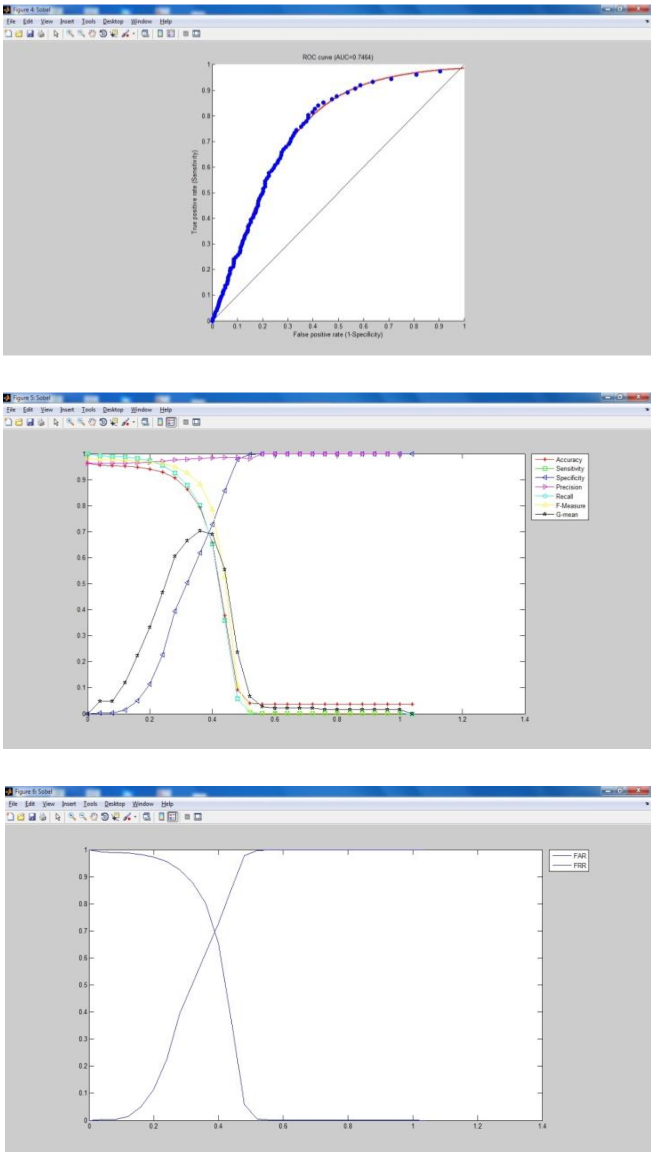

Figure 10: Sobel operator detector Graphs of IRIS Detection

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. The work again proved that iris detection is one of the most reliable methods available today the biometrics field. The accuracy achieved by the system was very good and can be increased by the use of more stable equipment and conditions in which the iris image is taken. The applications of the iris detection system are innumerable and have already been deployed at a large number of places that require security or access control.

References

[1] P. Sreekala., V. Jose, J. Joseph and S. Joseph, “The human iris structure and its application in security system of car”, IEEE International Conference on Engineering Education: Innovative Practices and Future Trends (AICERA), 2012.

[2] Libor Masek , “Recognition of Human Iris Patterns for Biometric Identification”, School of Computer Science and Software Engineering, University of Western Australia, 2003.

[3] Z. Zhou, Y. Du and C. Belcher, “Transforming traditional iris recognition systems to work on non-ideal situations”, IEEE Workshop on Computational Intelligence in Biometrics: Theory, Algorithms and Applications, 2009.

[4] Y. Zhu, T. Tan, and Y. Wang, ―Biometric personal identification based on iris patterns,‖ in Proc. Int. Conf. Pattern Recognition, vol. II, pp. 805–808, Nov, 2000.

[5] L. Ma, T, Yunhong Wang, and D. Zhang, “Personal identification based on iris texture analysis”, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.25, no.12, 2003

[6] W. Boles and B. Boashash, “A human identification technique using images of the iris and wavelet transform,” IEEE Trans. Signal Processing, 46(4):1185–1188 (1998).

[7] J. Zuo, N. Kalka, and N. Schmid, "A Robust Iris Segmentation Procedure for Unconstrained Subject Presentation," Proc. Biometric Consortium Conf., pp. 1-6, 2006.

[8] X. Liu, K.W. Bowyer, and P.J. Flynn, ―Experiments with an Improved Iris Segmentation Algorithm,‖ Proc. Fourth IEEE Workshop Automatic Identification Advanced Technologies, pp. 118-123, Oct. 2005.

[9] J.Canny, “A computational approach to edge detection,” IEEE Transactions on Pattern analysis and Machine Intelligence, 8: 679-698, November 1986.

[10] W. Boles and B. Boashash, “A human identification technique using images of the iris and wavelet transform,” IEEE Trans. Signal Processing, 46(4):1185–1188 (1998).

[11] L. Flom and A. Safir, U.S. Patent 4 641 394, 1987, Iris Recognition System.

[12] John Daugman, Iris recognition, 2006. http://www.cl.cam.ac.uk/_jgd1000/.

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