An Improved Algorithm for the Detection of Diabetes using Iris Images

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<u>Submitted by:</u>

Mohit Ahuja

Roll No: 801461017

<u>Under the guidance of:</u>

Dr. Kulbir Singh

Professor, ECED Thapar University

ELECTRONICS AND COMMUNICATION ENGINEERING DEPARTMENT

THAPAR UNIVERSITY

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DECLARATION

I hereby declare that the work which is being presented in the thesis entitled **"An Improved Algorithm for the Detection of Diabetes using Iris Images"** for the award of degree of Master of Engineering in Electronics and Communication Engineering Department (ECED), Thapar University, Patiala, is an authentic record of my work carried out under the supervision of Dr. Kulbir Singh, Professor, ECED, and refers other's work which are listed in the reference section.

The results presented in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.

Date: 14/07/2016

Mohit Ahuja

Roll No. 801461017

It is certified that the above statement made by the candidate is correct to the best of my knowledge and contents of the thesis have reached the requisite standard.

Date: 14/7/2016

Dr. Kulbir Singh
Professor, ECED
Thapar University, Patiala

Countersigned by:

Dr. Sanjay Sharma
Professor and Head ECED
Thapar University, Patiala

Date:

Dr. S.S Bhatia
Dean of Academic Affairs
Thapar University, Patiala

Date:

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Mohit Ahuja

801461017

ABSTRACT

With the advancement in computer technology, the computer vision system has found its way in various applications like object recognition, industrial defect inspection, and biometrics. It links to various fields using image processing. Iridology is also based on this method, in which the evaluation our internal organ is done by looking at an image of the iris. Iridology is based on the iris recognition process, in which the extraction of the iris code is done by using basic iris recognition steps after this image registration is done, and i.e. comparison of iris image with the iris chart. For this process, a number of methods have been introduced, which make iris recognition method acceptable. Therefore, it is really a scientific knowledge that can be used as a pre-diagnostic tool in several cases.

In this work, a high-end research is going in a particular direction for the detection of Diabetes. The work is basically carried out in five steps, namely; iris image acquisition, image pre-processing which includes (iris localization/segmentation, iris normalization, and image enhancement). In proposed work image localization, segmentation, and enhancement of iris is based on Circular Hough Transform. Iris normalization is carried after the extraction region of interest and the segmented iris is then normalized based on Daugman's Rubber sheet model. The novelty of the work lies in the facts that only Region of Interest is normalized rather than the methods where whole iris image was first normalized and then Region of Interest was extracted and also for the detection of diabetes both left and right eye images are used while in previous work only left eye images are considered. Also, the features are extracted from the iris images, by employing Discrete Cosine Transform (DCT) rather than Discrete Wavelet Transform (DWT). Finally, Support Vector Machine (SVM) is used for the classification.

For good performance of Iris Recognition scheme, segmentation and normalization play an important role. The discussed method is tested on a database of 59 images containing 47 of diabetic patients and 12 being healthy. A comparative study with existing ones was carried out and simulation results demonstrate that an improved accuracy of 5.72% has been obtained with proposed technique.

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ABBREVIATIONS AND ACRONYMS

DCT	Discrete Cosine Transform
DWT	Discrete Wavelet Transform
FAR	False Acceptance Rate
FRR	False Rejection Rate
FV	Feature Vector
FWT	Fast Wavelet Transform
MFCC	Mel Frequency Cepstral Coefficient
HT	Hough Transform
ROI	Region of Interest
ANN	Artificial Neural Network
DT	Decision Tree
SVM	Support Vector Machine
ROC	Receiver Operating Characteristic

Chapter 1

Introduction

1.1 Preamble

In today's world, the computer is used everywhere in all fields. In engineering sciences, the idea of computer vision is for constructing artificial setup that acquires useful information from images. The image data can be taken from various sources such as different views from different cameras, video sequences, or data from a medical scanner which has multi dimensions [1]. Computer vision can be considered as small and miscellaneous. Although previous work exists, it was not until the late 1970s that a new intensive work of the field taking place when computers are able to take and process a large number of datasets such as images.

Nowadays, computer vision has become very useful and is commonly used in many industries as it combines with image processing and machine vision.

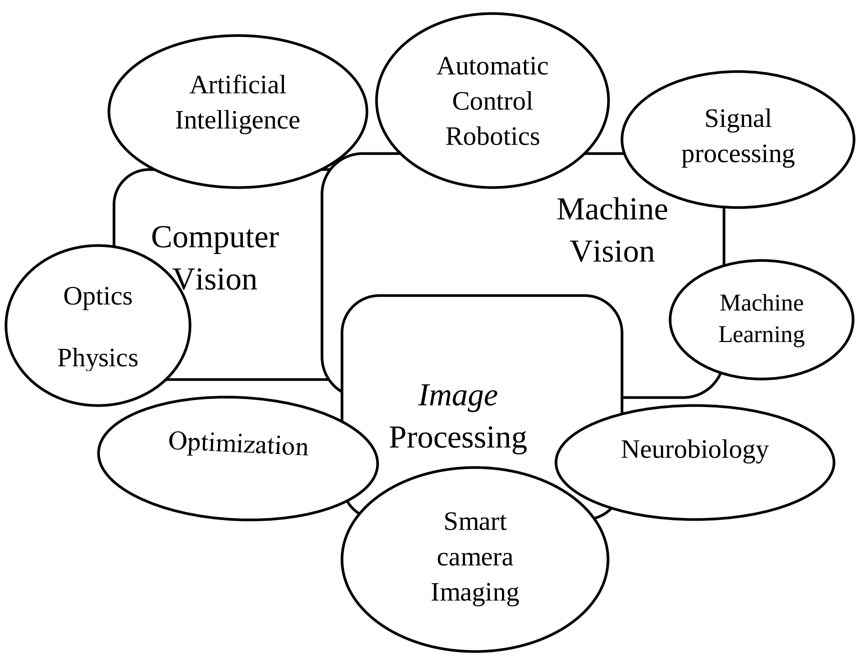


Figure 1.1: Relationship between computer vision, image processing and machine vision with various other fields [2]

Figure 1.1 shows the relationship between computer vision, image processing, and machine vision. Image processing field is closely linked to computer vision and image analysis is carried with the help of computer vision. In the image analysis, a two-dimensional (2-D) image is transformed from the one form to the another form with the help of image processing tools such as image enhancement, noise reduction, edge detection operator and pixel-wise operation.

In a similar way, computer vision also focuses on the three-dimensional (3-D) scene projected onto several images, in which it constructs its structure or any other useful information about the 3D scene from several images. Nowadays, the typical problem in computer vision is object identification; in which with the help of image processing, and machine vision determination of various object shapes are carried out such that whether or not the image data comprises some particular object, feature, or action. The job of object identification is normally done by a computer quite effectively without the help of humans, but it is not satisfactory for the random objects in random situations. The present methods to deal with this task are good for particular objects, such as simple symmetrical things like human faces, handwritten characters for the specific situations described by in terms of well-defined background, and posture of the body comparative to the camera. The various types of the recognition problem are specified in the literature:

- **Recognition:** In this method, various types of predefined objects or object classes can be recognized, with the help of objects 2D positions in the image or 3D views in the sight.
- **Identification:** In identification process, a specific case of an object is recognized such as identification of a particular individual's face, iris or fingerprint. It can also be used for the identification of a particular vehicle.
- **Detection:** The process of detection is very useful in the current scenario in which the image data is scanned for the definite condition. Various things are identified like detection of probable abnormal cells or tissues in images of medical science. The method of detection based on fast computations is used for detection of area or region of interest in many cases, which is further analyzed for the correct interpretation.

1.2 Overview of Iridology

Iridology is a way by which the health condition of any individual can be examined by the analysis of color patterns and other characteristics of the iris [3]. In Iridology, the study of different signs is done for the examination of the health of the body and investigates how they are reflected in the human eye [4]. Naturopathic practitioners analyze the iris for symptoms of genetic and functional weakness for the whole body.

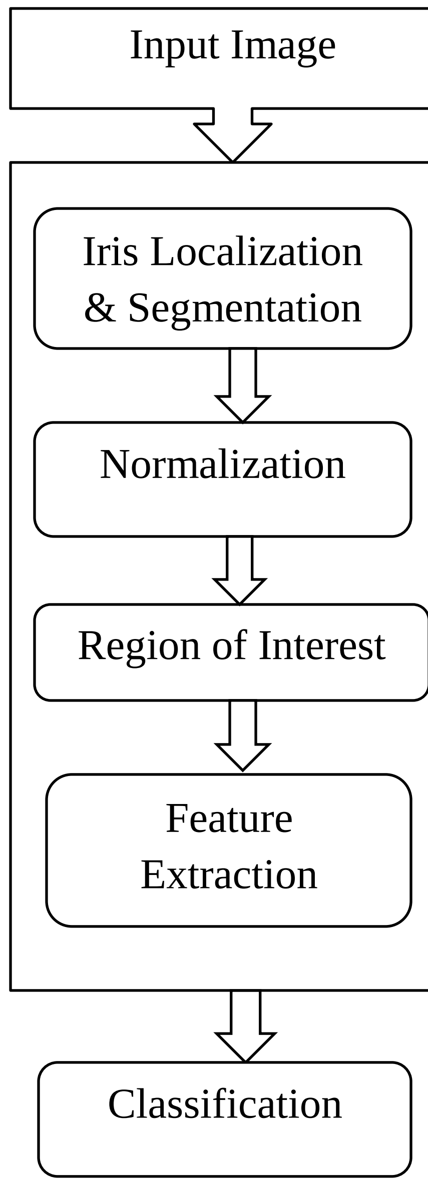


Fig 1.2 Block diagram of Iridology scheme

The iridology system starts with image acquisition. At this stage, the image is acquired using a webcam or scanner that is connected to a computer. Since this project is done in offline mode, the output of the image acquisition is saved into memory. The image is then converted into a grayscale image and consequently, image manipulation is carried out to perform dilation for the center of iris detection purpose. After the detection of the center of iris next step is performed, the image then will undergo a pre-processing state, and ultimately analyzed to display the result.

1.3 Iris Chart

Iridology has improved significantly since the 1800's. At that time Dr. Bernard Jensen gave [6] one of the best comprehensive iris charts which demonstrate the place of the body organs in the iris. Whenever there are variations in the body tissues then change in the iris is appears through the nerve fibers in the iris by representing a reflex physiology that looks like specific tissue variations and positions. In iridology, the experimental facts are collected through the way of numerous symbols, signs, irregular shades in the iris [7]. These signs and symbols create identified important and sustained inflammatory conditions, local damages, destruction of muscles, numerous medicine toxins and alterations in the structure of body organs. Therefore, a method is made to examine the experimental features from iris image and to collect the valuable facts with the help of iridology chart.

This chart was developed by Dr. Bernard Jensen with the research of 50 years [8]. Every tissue is recognized and those of main significance are outlined so that they can found easily. The complete chart is properly organized so that every organ can be found in the chart in a particular location as found in a normal body.

The complete chart is divided into six circles. The innermost two circles denote the bowel the next circle after this represents the heart, blood vessels, and organs. The fourth circle specifies the muscles and bones. Fifth describes the bones membranes [9]. Whereas the outmost circle indicates the lymphatic's and skin.

Within one or more circles, certain particular organs are situated in one or both eyes, For example, the pancreas organ is located in both left and right images in between 7 to 8 o'clock [10].

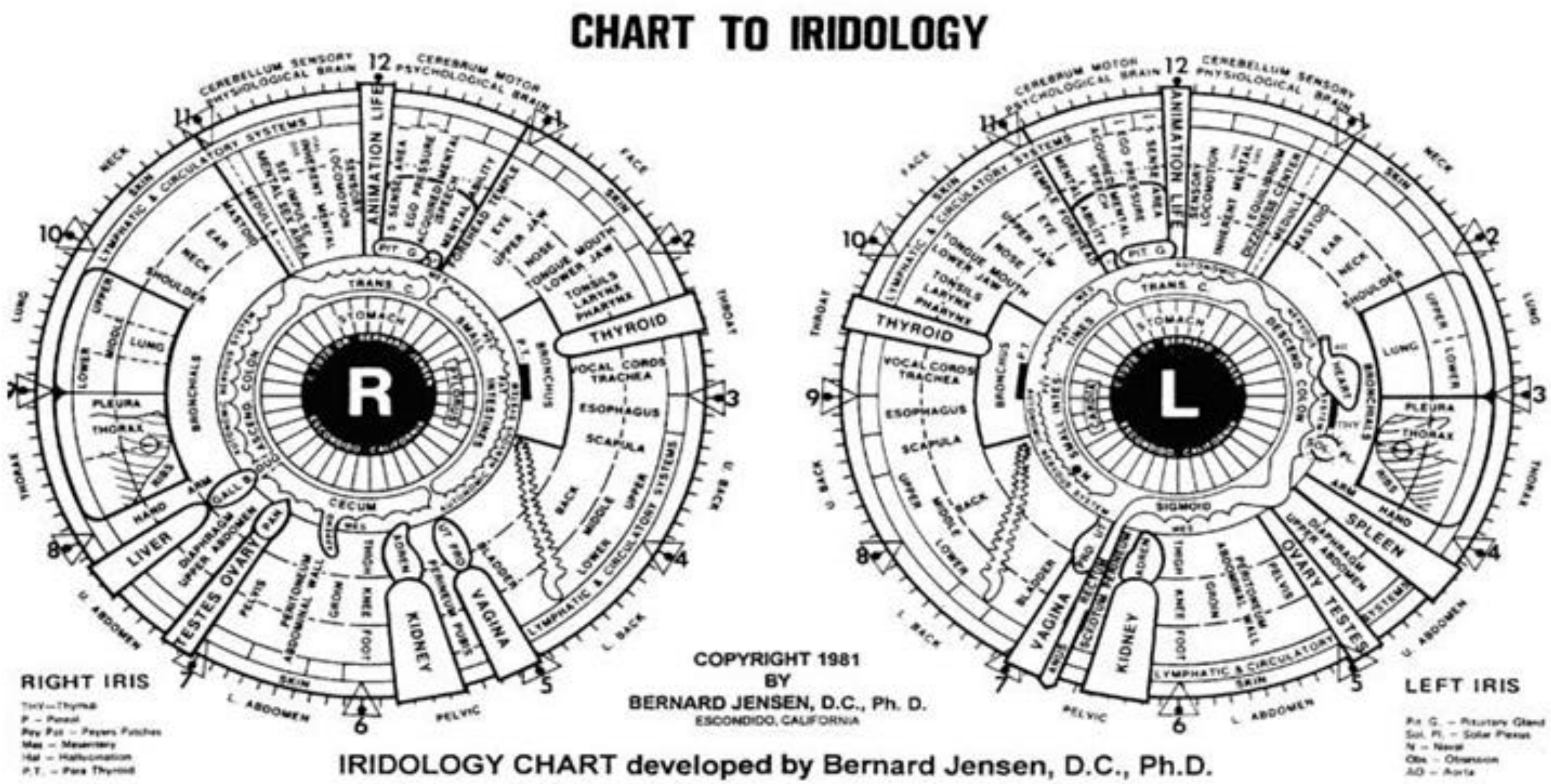


Figure 1.3 : iridology chart [11]

Furthermore, [12] one thing must be to keep in mind that an iridology chart is a reflection of a human body and that no matter how similar we look but we all are unique. In the very first step, it is very necessary to study the iris to find out different marks because there may be some chances that few people might born with their internal organs with little shift in the body. Also, there are few chances that some people born without certain organs, therefore, a different type of defects present in the body. Due to this, there may be a shift in the iris chart for that particular person a bit. For example, the position of the kidney in the iris can be any place from 6 to 7 o'clock region [13].

1.4 Thesis Layout

This thesis consists of 5 chapters which are discussed briefly here. The first chapter gives an introduction to the thesis and the overview of image processing and iridology concept.

Chapter 2 Literature Review: In this chapter an overview of iris anatomy is explained along with different techniques that are used in its steps of the iridology scheme such as iris segmentation, iris normalization, and feature extraction then at last classification techniques are discussed in this chapter that related to the thesis An Improved Algorithm for the Detection of Diabetes using Iris Images.

Chapter 3 Diabetes detection using DCT: This chapter discusses the proposed methodology which is used for the Detection of Diabetes using DCT coefficients. The development of iris extraction algorithm and iris analysis method is discussed in this chapter. Each process and implementation is presented in detail through block diagrams and flow charts.

Chapter 4 Results and Discussions: The various experimental outcomes of each stage are discussed in this chapter. After that discussion of several issues that affect the correctness and reliability of the results are explained.

Chapter 5 Conclusion and Future work: This chapter coveres the conclusion for processing and experimental results that are obtained in the previous chapter and also the future work in the field of iridology is also suggested in this chapter.

Chapter 2

Literature Review

2.1 Introduction

In a human body, the eye is a light responsive body part which consists of three translucent zones. The outmost zone is a fibrous tunic, and contains a front curve and an extended sclera. The intermediate zone is called vascular tunic zone, which consists of the iris, and pupil. Retina is the third inmost zone [14]. Figure 2.1 shows the structure of the human eye.

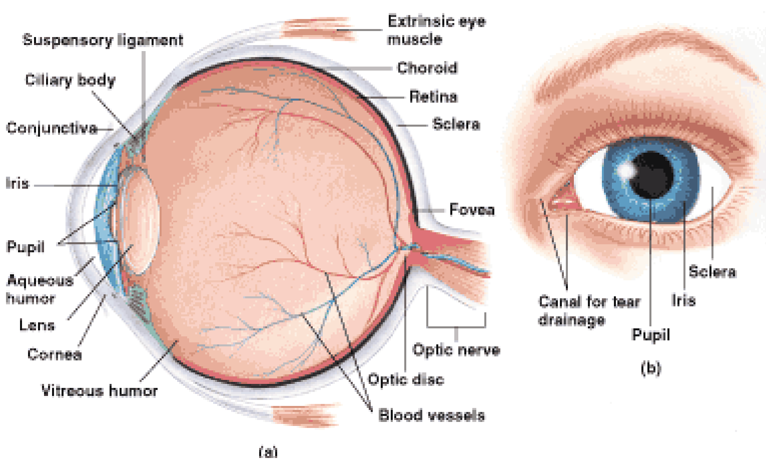


Figure 2.1: Anatomy of human eye [15]

The iris of the eye retains a complete and composite arrangement hence it is treated as the specific area of the eye. In the biometrics for the human identification, the iris can be used due to its complex structure [16]. In this chapter, a brief description of the iris is given alongwith the functioning and processing of Iridology with the methods which are required for its functioning.

In the human body, the iris is the only interior portion which can be seen from outside of the body near the pupil to the human eye [14]. It is a tiny, rounded shape and is nearly same as the diaphragm of the optical system of the body. It consists of various combinations of muscle cells, nerve endings, blood vessels; all of these messily create color patterns. Therefore, the color of the iris is seen as green, brown, blue, gray or hazel etc. and hence, it varies from one person to another. In this structure, the arrangement of cells, blood vessels, etc. is considered to be rich in details and form a particular pattern for every person [17]. The structure of iris is shown in Figure 2.2 which shows the complex organization of iris.

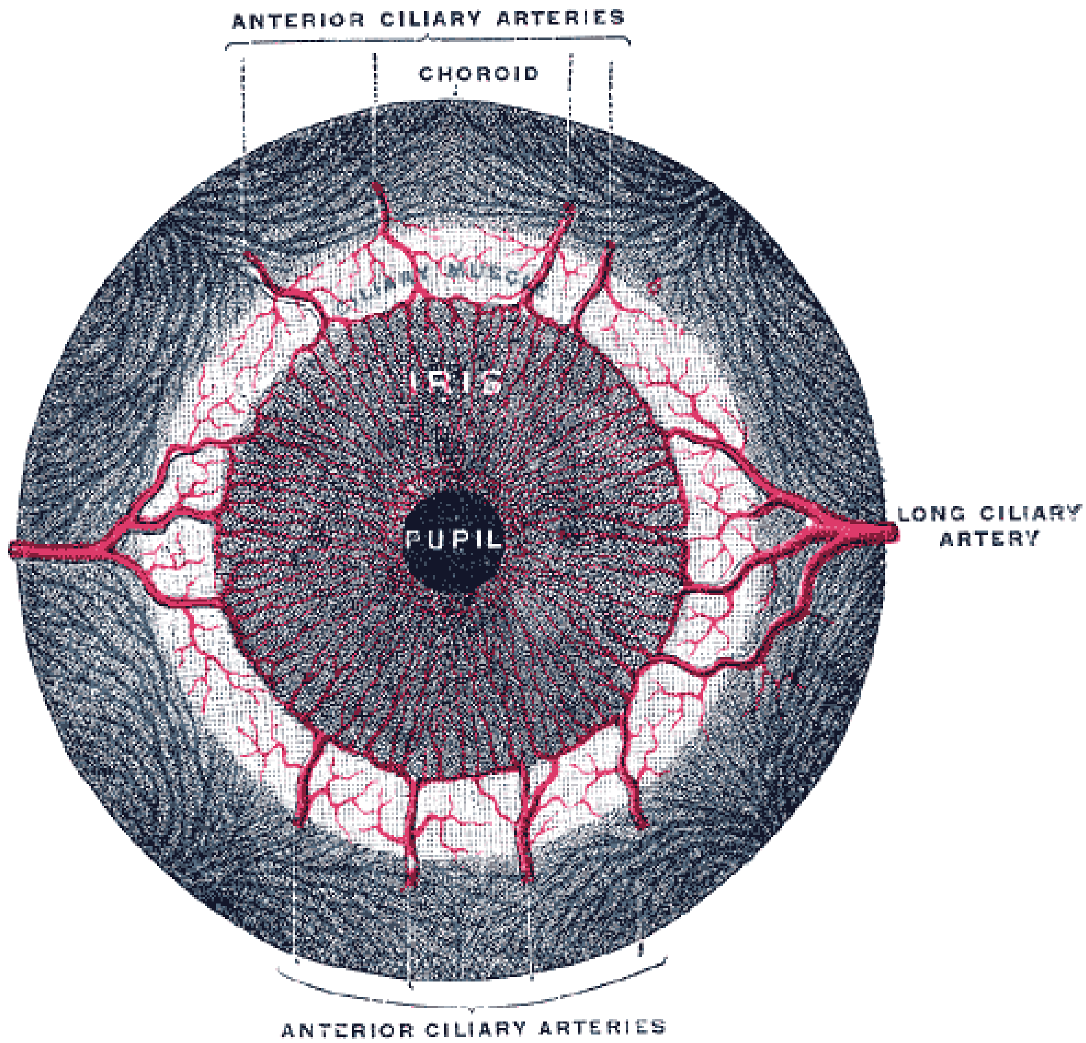


Figure 2.2: Anatomy of iris [18]

If all other body organs patterns are compared, then iris patterns are enormously complex [19-22]. The study shows that the uniqueness of iris have one in about 10^{31} persons and also for the same person, both the left and right iris differs with great value [6].

2.2 Image Acquisition

Image acquisition is one of the most sensitive steps at the beginning of the process. In the image, acquisition environment must remain constant all the time, else the results will become unreliable. The iris is not ever completely centered in the image. Sometimes in this step, we acquire the only portion of the iris or sometimes we get the lid in the image and sometimes not [23]. This is due to the fact that we cannot lock the eye in front of the camera. The light reflection points are a bit annoying. However, light reflections produce white spots in the image and it can be removed easily. As a result, the part of the image which comes to the white spots is not usable for diagnosis anymore. Therefore to solve this problem setting of the light reflection must be adjusted into the pupil and it would be much more desirable. But due to the movement of eyes balls it is nearly difficult task except the viewer is waiting for the time, were the light reflection perfectly located inside the pupil [24].

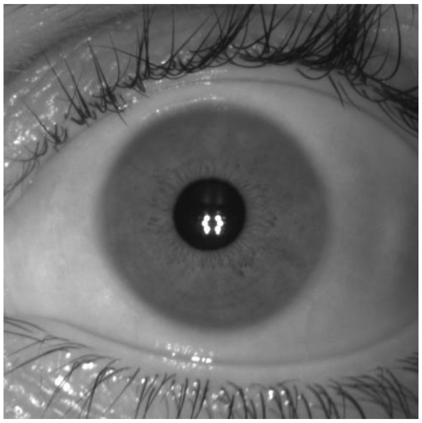


Figure 2.3: Left eye image acquisition

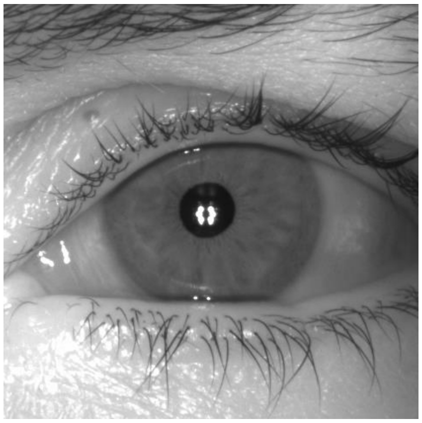


Figure 2.4: Right eye image acquisition

2.3 Image Localization

In this step for the proper detection of iris, the acquired image must be preprocessed to convert it into a suitable form. Iris is a circular portion in between the pupil which is an inner boundary and the sclera which is outer boundary [25]. Iris localization is done in two phases, in first phase detection of the pupil is done, which is the black rounded part bounded by iris nerves. Now the center point of the pupil is used to detect the outer radius of iris patterns. The main phases involved are inner detection and the outer iris localization [26].

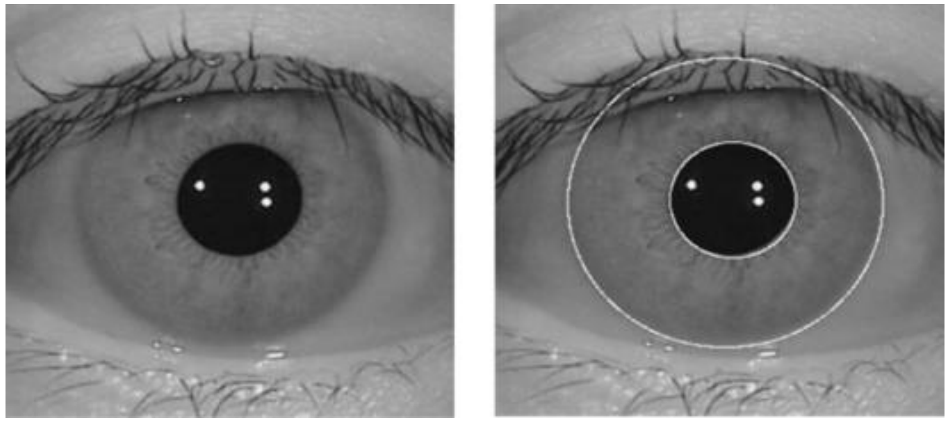


Figure 2.5: Iris localized image

2.4 Image Segmentation

Image segmentation is a very important step in the whole process because results mainly depend on upon this step. Segmentation of the iris image is a tough job due to the complex structure of iris image and also iris and pupil boundaries do not have perfect circles in several cases [27]. Figure 2.6 shows the extracted image of iris from the complete eye. Numerous approaches have been presented for the job of segmentation which is explained in following subsections.

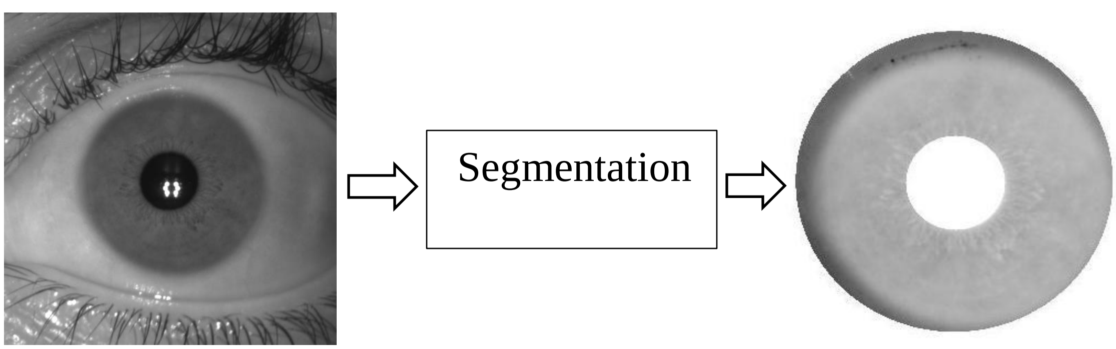


Figure 2.6: Iris segmented image

2.4.1 DAUGMAN'S INTEGRO-DIFFERENTIAL METHOD

In the year 1993, Daugman gave one of the best significant techniques to implement the iris recognition system [28]. He suggested a technique which is based on the Integro-differential operator used for detection of the circular pupil and the iris boundaries of the eye image.

$$max_{r,x_0,y_0} \left| c * \frac{\delta}{\delta_r} \oint_{r,x_0,y_0} \frac{P(x,y)}{2\pi r} ds \right. \quad (2.1)$$

where, $P(x,y)$ is the area under the image which is under consideration.

$G_\sigma(r)$ represents the Gaussian kernel.

r is the radius.

σ is known as the superlative convolution scale.

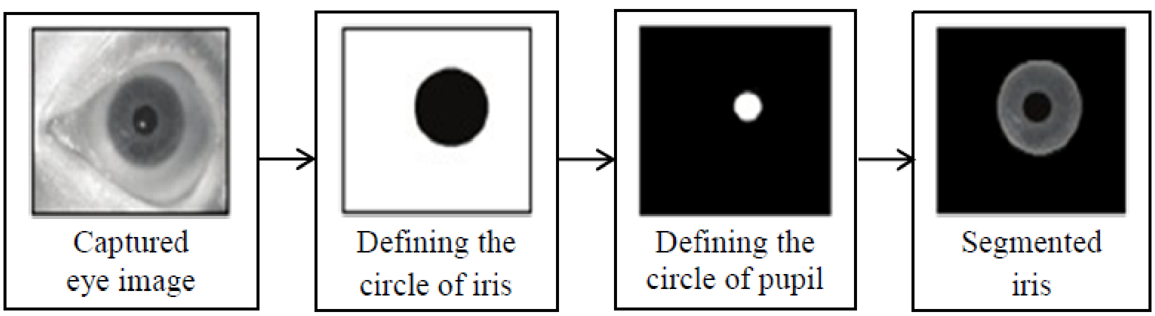


Figure 2.7: Process of iris segmentation using Daugman's Integro-differential technique [29]

Equation 2.1 represents the Integro-differential operator which is an annular edge detector that finds the parameters for an annular boundary for the automatic localization of the iris region [7]. Figure 2.7 shows diagrammatically processing of iris segmentation using it.

2.4.2 HOUGH TRANSFORM

Hough Transform is a computer based process which can be used to detect the existing lines and circular shapes in an image [30]. It can also be used for the detection of radius and center coordinates of the pupil and iris sections. In 1997 Wildes [20] proposed an automatic segmentation procedure based on the circular Hough Transform. In this, he used gradient-based binary edge map construction for the segmenting iris after which Hough Transform is applied. In first step process, the captured eye image is converted for the detection of the circle of iris and pupil boundary. Pictorial depiction of processing of the operator is shown in Figure 2.8. To perform the operation of segmentation the thresholding of image intensity gradient is done by using following equations [10].

$$| \nabla \mathrm{H}(i,j) * P(i,j)| \tag{2.2}$$

where, $\nabla = ({}^{\partial}/_{\partial i}, {}^{\partial}/_{\partial j})$

$$H(i,j) = \frac{1}{2\pi\sigma^2} e^{\frac{(i-io)^2+(j-jo)^2}{2\sigma^2}} \tag{2.3}$$

Then, on the edge a point (i_x, j_y) Hough Transform is applied and (i_c, j_c) is assumed center of the circle and radius r and σ is standard deviation.

$$H(i_c, j_c, r) = \sum_{y=i}^{n} a\big(i_x, j_y, i_c, j_c, r\big) \tag{2.4}$$

where,

$$a\big(i_y, j_y, i_c, j_j, r\big) = \begin{cases} 1, if\ b\big(i_y, j_y, i_c, j_c, r\big) = 0 \\ 0,\ otherwise \end{cases} \tag{2.5}$$

$$b\big(i_y, j_y, i_c, j_c, r\big) = (i_{y-}i_c)^2 + (j_y - j_c)^2 - r^2 \tag{2.6}$$

a and b represents the pixels intensity values, the boundary points which are set over the circle results '0' value of b-function while the value of a come to be '1', signifies the local pattern of curve. The major advantage of this method is that Hough Transform is based on automatic detection of the objects i.e. in this process there is no need to define the contour or boundaries of the object as compared to the Discrete Active Contour method in which boundaries of the objects must be defined manually at the starting of the process.

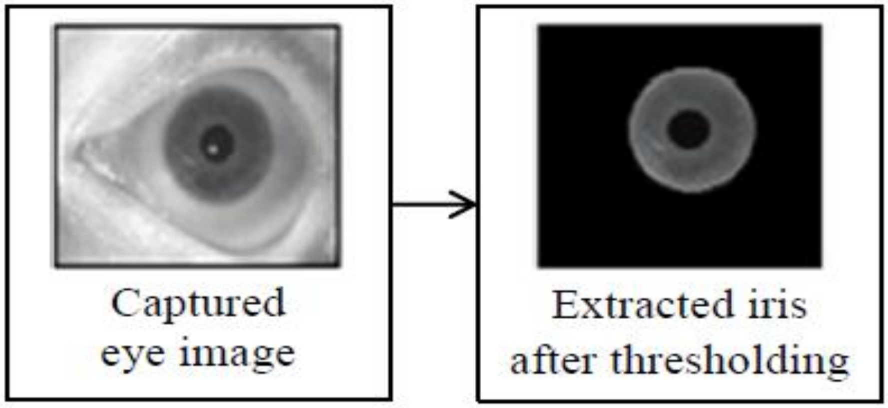


Figure 2.8: Process of iris segmentation with Hough Transform [27]

2.4.3 Discrete Active Contour method

Li *et al*. [31] proposed the discrete active circular contour method without re-initialization, which is later used by Singh *et al.* [32], for iris recognition method to localize the iris images perfectly. In this technique detection of pupil and iris boundaries are done based on the two types of energies which are known as internal and external energies but in this process, initial contour for every eye must be defined manually. It is the major problem of his technique.

Figure 2.9 shows the process of the iris segmentation with the help of discrete circular active contour method as discussed above.

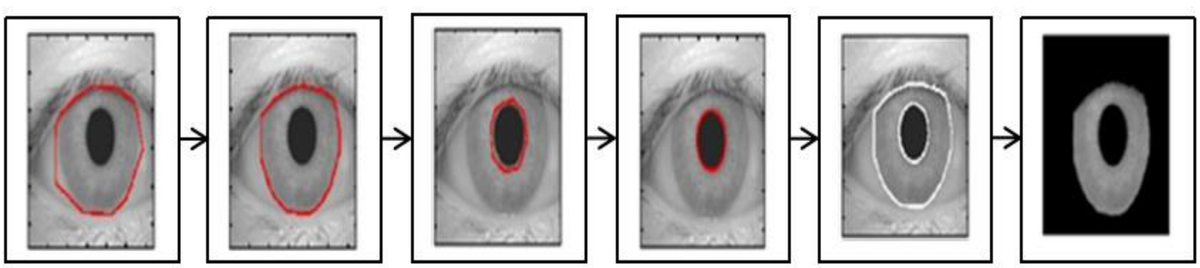


Figure 2.9: Processing of iris segmentation with discrete circular active contour method without re-initialization [32]

2.4.4 Canny Edge Detection and K-means Algorithm

In 2013, Jayachandra *et al*. [33] presented canny edge detection and K-means algorithm for images to decrease the noise data and for the detection the edges, canny edge detection technique emphases on pupil edge detection in iris recognition system. These images are stored in the database after the detection of edges, and then K-means process is used to identify an image from the stored data that retains nearby pupil boundary for the specified input image [34].

2.4.5 Comparison between the Segmentation techniques

Table 2.1 compares the accuracy of different segmenting techniques to study the significant performance of segmentation methods. On the basis of this contrast, a segmentation technique is adopted for the task of the segmentation process.

Table 2.1: Comparison among segmentation techniques [32], [34]

S.no	Segmentation methods	No. of samples	Accuracy (%)
1.	Hough Transform	756	83
2.	K-means algorithm	756	84
3.	Daugman's Integro-Differential	756	87
4.	Active Contour method	756	100 (approx.)

2.5 Region of Interest

The region of Interest is the area of iris which is considered for the further analysis in the process because, as stated above, various tissues of the human body lies in the various region of the iris [35]. Therefore, to find the condition of pancreas organ the region of interest for is different, and for the kidney related problems area of interest is different. This is because these organs lie in different iris locations [13]. The area of interest is extracted out after the normalization of the iris. Hence, for the different disease recognition different area of interest is segmented.

2.6 Image Normalization

This step is applied after the segmentation process in which iris part is extracted out from the complete eye image. This step is carried out to fix the dimension inconsistencies of iris region for the purpose of comparisons. In the process of image acquisition, different images of the iris may have dissimilar dimensions due to various reasons like change in the pupil size which are further influenced by the factors like illumination, distance, and the angle at which the image is taken [36]. These changes in the dimensions of iris increase the complexity in the recognition job. Hence, for the better results by getting good accuracy, normalization of iris images is carried out to ease the process. To solve this problem, numerous normalization approaches have been presented till date. In 1993, Daugman's proposed a method for the normalization of iris which is known as Rubber sheet model for iris normalization.

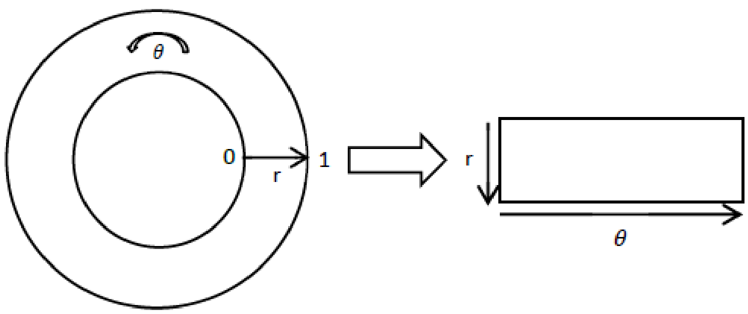


Figure 2.10: Daughman Rubber Sheet Model [58]

In this process, iris images which are in the Cartesian coordinate (i, j) before the normalization are converted to fixed length polar coordinate (r, θ) by using following equations [37], [7].

$$P(i(r,\theta), j(r,\theta) \rightarrow P(r,\theta) \quad (2.7)$$

$$i(r,\theta) = (1-r)i_p(\theta) + ri_l(\theta) \quad (2.8)$$

$$j(r,\theta) = (1-r)j_p(\theta) + rj_l(\theta) \quad (2.9)$$

In the year 1997 Wildes [20] introduced another method which is able to deform the iris images. In this technique, every point of the iris image is transformed in accordance with a function which is known as a mapping function. In the newly attained image intensity values are made to be close to corresponding points in the selected database image.

Virtual circles is another method which was given by Boles *et al*. in 1998 [38] for the purpose of iris normalization. In the first phase of this process, every image is scaled to a reference circular zone, which is determined by the ratio of the radius of inner and outer boundaries of the iris. Then in the second phase, these images are non-linearly unwrap to the annular zone to a fix-sized rectangle block linearly for subsequence processing [39]. This is completely different from the other techniques since the normalization is not done until two iris areas match. Now after this process, two iris images have same dimensions. Therefore, feature extraction is done from iris region by different methods. To extract the identical features from all images the coefficients from each iris image normalization resolution is selected.

2.7 Feature Extraction

Iris has very complex structure and it contains a lot of nerves and blood vessels. Whenever, there is a change in the condition of an organ or condition of health of the individual, and then these changes appear in the iris in the form of different changes like rings, lines, and change in color of the iris, radii Solaris, and pigmentations. All these changes appear in the iris texture. There are many algorithms for feature extraction which are discussed below.

2.7.1 Gabor Filter

2-D Gabor filter calculates both real and imaginary parts of the signal and generates a unique feature iris code and after which it stored. 2D-Gabor filter is a combination of elliptical Gaussian and a complex plane wave. Khan *et al.* [40] proposed a scheme to generate unique feature information using 1-D Gabor filter from the iris images. 1-D Gabor filter also generates a real and imaginary feature coefficients matrix and calculate the specific features from the iris in the form of coefficients and then store them. 1-D Gabor filter can be represented by the subsequent equation [41].

$$G(x,y) = e^{-\pi(\frac{(x-x_0)^2}{\alpha^2}+\frac{(y-y_0)^2}{\beta^2})} e^{-2\pi i[w(x-x_0)cos\theta+w(y-y_0)sin\theta]} \quad (2.10)$$

where, (x_0, y_o) is the center of the receptive field in the spatial domain.

α and β represents the standard deviations for the elliptical Gaussian along with x and y −axes respectively.

w is the central frequency.

θ represents the alignment of the Gabor filter.

2.7.2 Log-Gabor Filter

Log-Gabor filter is simply a mending of simple Gabor filter. As in Gabor filter, a dc component will be there if bandwidth is greater than 1 octave. So to overcome this problem Log-Gabor filter was implemented and hence for better results, it is used in feature extraction process. Here, in Log-Gabor filter, the frequency response is Gaussian on log frequency axis and described by the following equation [42].

$$G(f) = \exp\{-\left[\log\frac{w}{w_0}\right]^2 /2[\log\frac{k}{w_0}]^2\} \quad (2.11)$$

The Log-Gabor Filter can be constructed with arbitrary bandwidth and has the advantage of symmetry on the log frequency scale a modification of basic Gabor filters known as Log-Gabor function, which provides varies advantage over basic Gabor filter. Log-Gabor filter represented by Yao *et al.* [43], is strictly band pass filter. Iris feature extraction appears to be more suitable due to this property regardless of the background brightness.

2.7.3 Discrete Wavelet Transform

Discrete Wavelet Transform is another method to calculate the features. Panganiban *et al.* [44], proposed wavelet transform method, to calculate the features from the normalized iris images. DWT decomposed the input signal into M levels, where the maximum value of M can be four. DWT decomposes the image into 4 sub-images and from this sub-image encode the iris code because useful information is contained in the low-frequency components only.

Basically, the Fast Wavelet Transform (FWT) is a mathematical process which is aimed to transform an input signal from time domain to the sequence of coefficients i.e. generate a feature vector matrix by using the orthogonal basis of many small finite signals or wavelets. Hence unique code of features is generated by extracting low-frequency information. In 2014, Oluwakemi *et al.* [45] proposed that this wavelet transform can be used for the multidimensional signals such as different types of waves or images etc. This transform converts the time domain variable to the special domain. Therefore in different types of systems, these transformed are applied to generate a particular iris code, which is further used in the matching process.

2-D DWT approximates an input image into four sub-sampled images, namely, (LL), horizontal (HL), vertical (LH), and diagonal (HH) which is shown Figure 2.10.

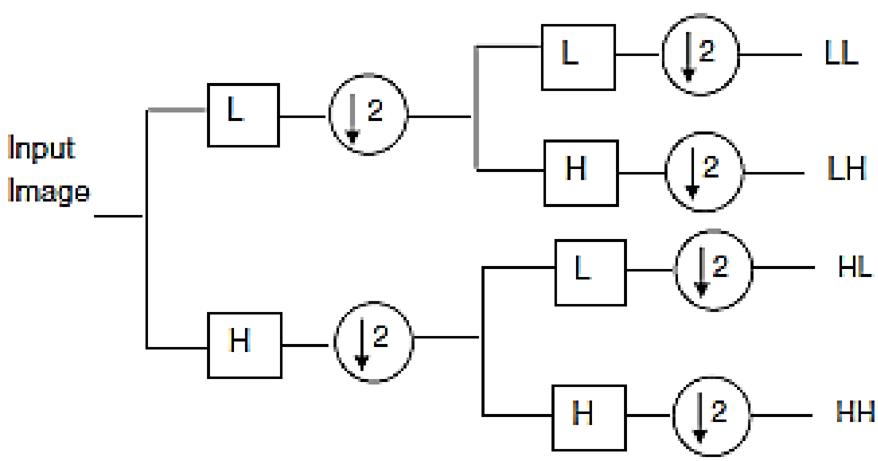


Figure 2.11: Single level decomposition of an image [10]

In the complete process, the input iris image of size $M \times M$ split into four sub band images in which every single size of image is $M = 2 \times M = 2$ which represents the different components frequency information. Figure 2.11 demonstrate the block diagram of single level decomposition of an image. Different sub-bands like; LL sub-band, is achieved by low-pass filtering in both the rows and columns which describes the rough description of an input image and HH sub-band, is achieved by the high-pass filtering in both the rows and columns which describe the high frequency components along the diagonals. The remaining two HL and LH sub-band images are obtained by the different filtering in different directions i.e. low-pass filtering in vertical direction and high pass filtering in the horizontal direction and vice versa. LH sub-band image consist the vertical information corresponds to horizontal boundaries. However HL sub-band signifies the horizontal information from the vertical boundaries. With this transformation, one can approximate the image more than once. DWT consists of two of the decompositions which are known as the pyramidal and packet decomposition. In the pyramidal decomposition, only LL sub-band image can be decomposed. In the whole process at every level of approximation, different sub-band can be further decomposed. In the packet decomposition, the decomposition of all sub-bands can be done which is not restricted to LL sub-band merely. Different types of researcher's use the different level of decomposition by using several types of wavelets in field of image processing [46], [47].

2.7.4 Discrete Cosine Transform

In the year 2014 Nichal *et al.* [48] presented a method for the extraction of features from the iris images based on Discrete Cosine Transform (DCT). After generating the feature vector coefficients from the normalized iris image it is applied to the coding and matching in the process. Another researcher Abhiram *et al*. [49] also used the DCT to calculate the features from the normalized iris images to focus the important features in the upper left corner of feature vector matrix and generated the mandatory feature coefficients. The DCT for a 2-D image is given by following equation [50],

$$C_{kl} = \alpha_k \alpha_l \sum_{p=0}^{M-1} . \sum_{q=0}^{N-1} P_{pq} \cos\frac{\pi(2p+1)k}{2M} \cos\frac{\pi(2q+1)l}{2N} \tag{2.12}$$

where,

$$\alpha_k = \frac{1}{\sqrt{M}}\ if\ k = 0 \qquad \alpha_k = \sqrt{\frac{2}{M}}\ \ if\ 1 \le k \le M-1$$

$$\alpha_l = \frac{1}{\sqrt{N}}\ if\ l = 0 \qquad \alpha_l = \sqrt{\frac{2}{N}}\ if\ 1 \le l \le N-1$$

where, α_l, α_k are known as the DCT coefficients of 2-D the normalized image.

In the year 2014, Nisar *et al.* [51] proposed a different method for the in feature calculation in which features are calculated in two phases known as training phase and testing phase. In the first step, a 2-D signal is transformed to the 1-D signal after which and feature calculation is carried with Mel Frequency Cepstral Coefficient (MFCC). The main aim of using two phases is that in matching process sample features are matched which were stored in the database during the training process [51].

2.8 Classification

There are various tasks in the field of computer vision but object classification is a major important task. In the field of image classification, the job of the classifier is to define the class of testing image into one of a number of predefined classes. This task is very easy for the humans but it is very difficult for the machines. Therefore for this problem there are many classification methods are introduced in the field of image classification. There are numerous reasons like, accessibility of high quality and low priced camera, high capacity computers, which increased the interest in object classification algorithms [52]. The whole process consists simple camera which captured the images of the interested area which are further analyzed. It also comprises image devices like image sensors and various steps of image processing like detection, extraction, and classification. For the classification, the system contains a stored database which comprises predefined shapes that are matched with the identified object to categorizing it into the appropriate class. In the domains like biometric, manufacturing graphic examination, video observation, biomedical imaging the image classification is a main and interesting task.

2.8.1 Artificial Neural Network

Artificial Neural Network is artificial intelligence which reproduces some functions of the individual mind. This system has a typical tendency for storing observed information. There are sequences of layers are present in the ANN and each layer be made up of a set of neurons. All neurons of each layer are associated with weighted connections to every neuron of the previous and next layers. ANN uses the nonparametric method, therefore, the number of inputs and network organization controlled the performance and accurateness of this network hence is known as non-parametric classifier [53]. It is also able of performing the functions like OR, AND, and NOT, therefore, ANN is a universal useful approximator with random accuracy.

ANN is a self-adaptive data-driven system which powerfully controls the noisy inputs. The computation degree is high hence it is very complex and semantically poor. The time taken by ANN for the training is very high. The problem of overfitting is also present there and it is very difficult to choose the type network architecture for ANN.

2.8.2 Decision Tree

Decision Tree (DT) computes the class membership of input data by frequently dividing a dataset into uniform subsets. DT follows the hierarchical order and it authorizes the acceptance and rejection of class labels at each intermediate phase. The whole process is done in three parts. In first part subdivision the nodes are done and in second part terminal nodes are find. In the last step, class label is allocated of to the terminal nodes. DT use non-parametric approach, therefore, can control the nonparametric training data and does not need a wide design and training [54]. DT provides a set of instructions which are very easy to understand and also offers hierarchical links among input variables to prediction class group. DT is very easy and simple to construct therefore it is very less complex and computational effectiveness is good. Due to the usage of hyperplane assessment borders which is parallel to the feature axes may perhaps limit their use in which classes are clearly distinct. When these different outcomes values are correlated or the values are undecided then, in that case, DT becomes complex and calculations become is very high.

2.8.3 Support Vector Machine

Support Vector Machine is another classifier in which hyperplane or set of hyperplanes are created in a high or infinite dimensional space, that is further used for classification process [55]. In SVM functional margin is very large, therefore good separation is attained by the hyperplane that has the largest margin, to the nearby training data point of any class. Hence, greater is the margin there is very less possibility of generalization error of the SVM classifier. SVM also uses nonparametric method along with binary classifier approach. It is very effective because it can handle a number of input data very effectively as compared to other classifiers. The hyperplane selection and kernel parameter play a major role in the performance and accuracy of SVM. In this classifier, the different gains values can be achieved by using different threshold. SVM can also capable of performing nonlinear transformation hence it offers good simplification ability. The problem of overfitting is eliminated in SVM as compared to ANN and it is less complex as well. Therefore very less computational complexity is there. In this the resulting transparency is low and training time is large.

2.9 Database

A database which is used in this algorithm is taken from the A. Bansal [10] which was previously used in the method taken as reference for this scheme. A database of iris images of healthy persons and those suffering from diabetes has been created.

Figure 2.12: ISCAN-2 iris scanner [56]

Iris images for experimental work have been acquired using ISCAN-2 dual iris scanner of Crossmatch Technologies, Inc [10]. Front view of I-SCAN-2 is shown in Figure 2.11, while Table 2.2 depicts the distribution of the dataset.

In this research total, 59 images of the iris are used in which 47 images are of diabetic persons which have 27 left eye images and 20 right eye iris images and on the other hand there are 12 images are from healthy persons which have both 6 left and right eye iris images. This database is used in the complete process of proposed scheme. In the training phase, a total of 32 images are used for the training of the SVM classifier which has 20 images from the diabetic persons and 12 from the healthy persons.

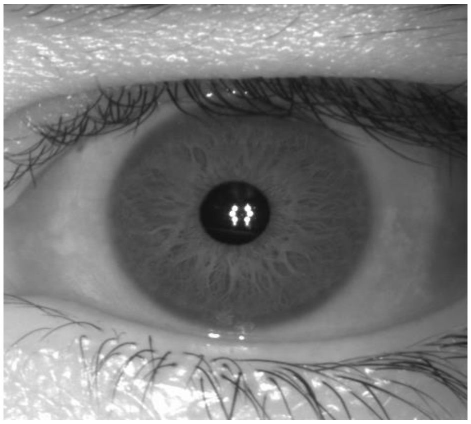


Figure 2.13: Left eye image of a healthy person

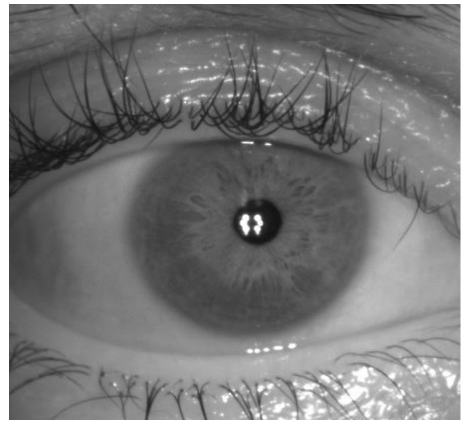


Figure 2.14: Right eye image of a healthy person

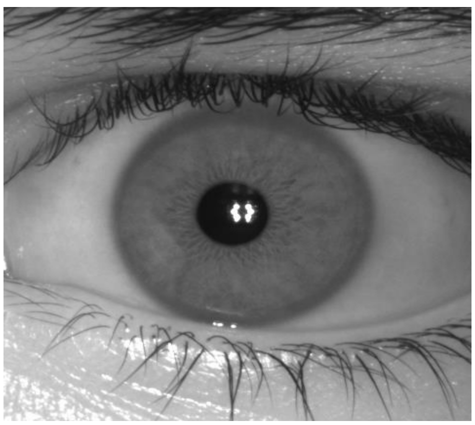


Figure 2.15: Left eye image of a diabetic person

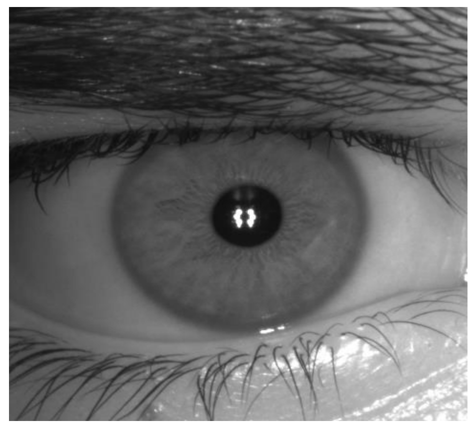


Figure 2.16: Right eye image of diabetic person

Table 2.2: Distribution of Dataset

S.no	Distribution of dataset	Number of images
1.	Healthy	12
2.	Diabetic	47
3.	Left eye images	35
4.	Right eye images	24

Image acquisition is the first step in this process and it is very important for image segmentation in which the only iris is extracted from the whole iris. The job of iris image acquirement is quite tough due to numerous reasons like; iris are quite small in size, typically merely round 12 mm in diameter and there are regular activities of the eyeball due to light-sensitive pupil [24].

2.10 Gaps in study

Today, people are in need of preventive health care and less complex methods of analyzing their condition. Thus, Iridology bio-scanning method can provide people a painless, economical and non-invasive method of assessing health status.

The previous methods discussed in this chapter, generally, focus on the detection of disease by analyzing only the left eye. There may be some anomalies in this approach, as the left eye cannot be always suitable for analysis due to various reasons. Thus, there is a need to extend the approach to both eyes.

2.11 Objectives

The main objectives of this dissertation are to achieve the following objectives:

- Develop an improved algorithm to analyze the presence of diabetes in person using iris image processing.
- To implement the proposed algorithm on both left and right eyes images of the database.
- Comparison of the proposed algorithm with existing methods based on the parameters like the overall accuracy of the method, FAR, and FRR.

2.12 Chapter Summary

The basic fundamentals and origin of the Iridology scheme with the various techniques and different methodologies which are requisite for processing of this scheme are discussed in this chapter. The database which was required to perform the training and testing in this process is discussed in brief for correct processing and also for the better understanding of this database some images from the database are also presented in this chapter. The details which are discussed in this chapter to achieve the thesis objectives are taken as a reference for the designing of new methodology which is explained in the next chapter.

Chapter 3

Diabetes Detection using DCT

3.1 Implemented Technique

In this chapter, the study of the iris images is carried out for the determination of diabetes through DCT coefficients along with support vector machine. An earlier employed method based on DWT [10] is considered as a reference to develop the proposed algorithm. In place of DWT in the block, diagram DCT is used for the extraction of features as shown in Figure 3.1. In the proposed scheme both left and right eye images are considered for the determination of diabetes and only ROI is normalized instead of the complete iris.

3.2 Overview of the proposed method

An algorithm purposed for detection of diabetes as shown in Figure 3.1 consists of following steps:

- **Input Iris image:** In this scheme database which was used in the previous method [10] is used. A database of iris images of healthy people and those suffering from diabetes was created using ISCAN-2 dual iris scanner of Crossmatch Technologies [56]. In the previous method only left eye images are considered but in this work both left and right eye images are considered.
- **Iris pre-processing:** In the pre-processing stage, three steps are carried out. The first step in this is iris localization in which pupil and iris boundaries are detected. After the proper localization of iris from the complete eye image, iris segmentation is done in which iris part is segmented from the image which is further used in the process. Now region of Interest is extracted from the complete iris because according to iris chart different organs of human body are lies in the different part of the iris.
- **Iris Normalization:** Iris normalization is next step after the extraction of ROI. In this process different dimensional inconsistencies are removed which are arises due to various problems that are occurring at the time of image acquisition.

- **Feature extraction:** Now from the normalized image Features are extracted using DCT then five feature vectors are generated which are further used in the classification process.
- **Classification:** It is the last step in the process in which classification is carried out using SVM classifier. There are two phases of the classification process, training, and testing phases.

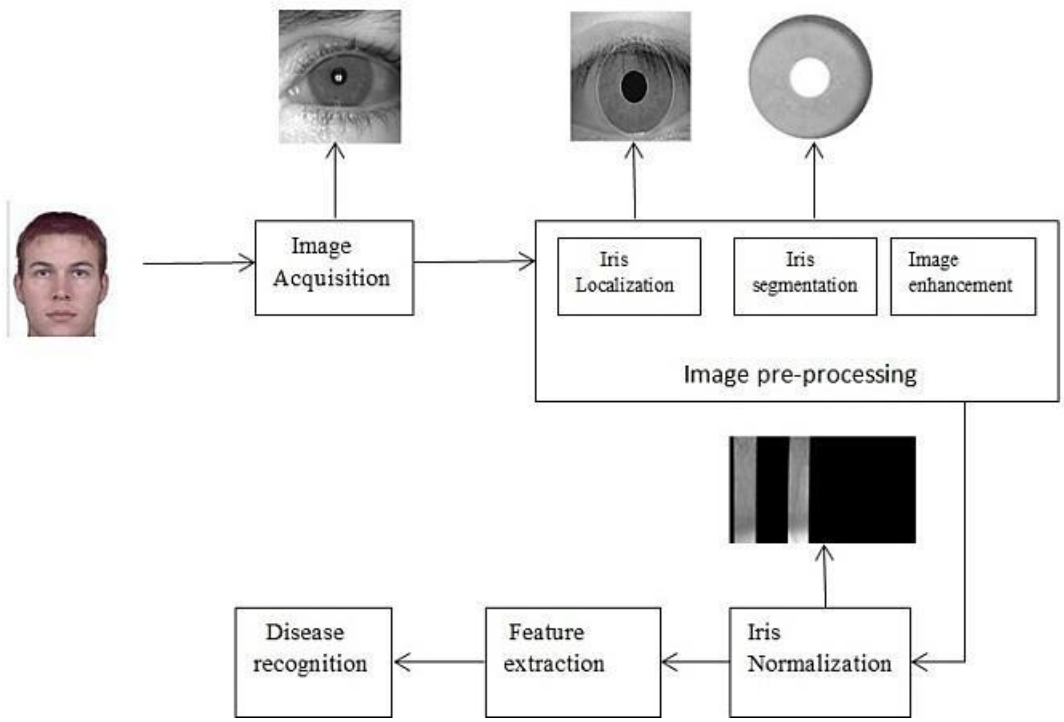


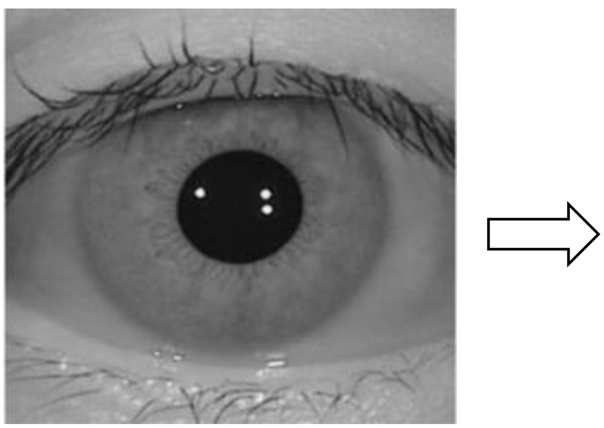
Figure 3.1: Overview of the proposed scheme

3.3 Image pre-processing

Image pre-processing is a way by which we remove the unwanted distortion and enhance some of the features in the image, which is further important in processing. Thus, by using pre-processing steps image is converted to the appropriate form for the extraction of features. In this work, in image pre-processing, the three steps are done namely, iris localization, iris segmentation i.e. segmented region of interest.

3.3.1 Iris Localization

Iris localization is the first step in the iris pre-processing in which two circular boundaries are detected. The first boundary is between iris and sclera and the second boundary is between iris and pupil. These two boundaries are detected by using the Hough transform. In this process first, we apply edge detection operator for the detection of edges of the input image. For this purpose canny edge detection operator is applied with a threshold value of 0.2. After the detection of edges of the iris images now center coordinates of pupil and radius of iris image are detected using Circular Hough transform [30]. Figure 3.2 shows the original image of the database while Figure 3.3 shows the iris localized image after using Hough Transform.



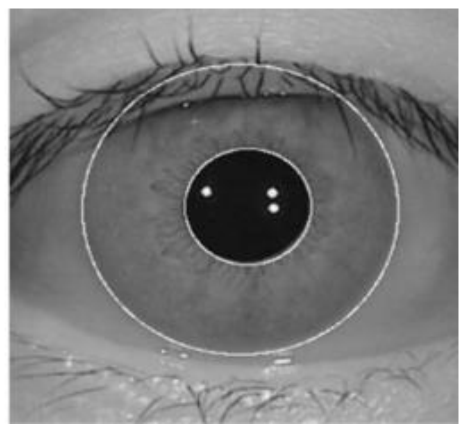


Figure 3.2: Original iris image

Figure 3.3: Image after iris localization

3.3.2 Iris Segmentation

Iris segmentation is a major step in this process. In this step, only iris part is extracted out from the complete eye image. This step is applied after the successful localization of the iris image and iris region is extracted out by using simple image manipulation methods. In this step firstly pupil part is detected are whose pixels values are stored in the accumulator and now this image is subtracted from the original image then resultant image is obtained which have a complete image without the pupil part. After which again the same process is repeated for the sclera part. On the basis of the intensity gradient, the part which lies in the sclera region is detected. After which these pixels values are stored in the accumulator. Now the image which has an area without pupil is used from this the image which has only sclera part is subtracted then we obtained the iris part only.

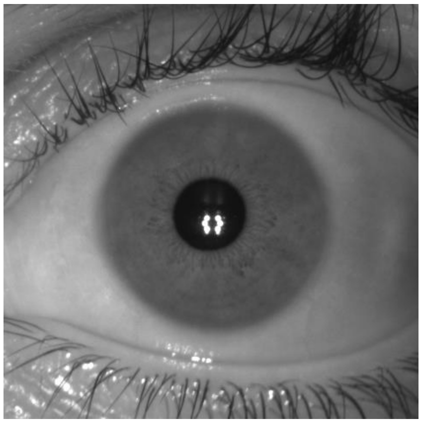


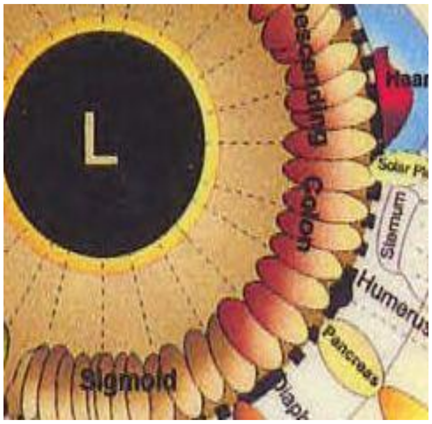
Figure 3.4: Original Image

Figure 3.5: Segmented iris part

Figure 3.4 shows the original image before the segmentation and Figure 3.5 shows the image after the segmentation. As shown above, in this only iris part is present remaining unwanted part is removed successfully. This part is further processed for the remaining process and care must be taken in this step for the proper iris segmentation because remaining part must be carefully removed for the better results.

3.3.3 Region of Interest

Jensen B. [11] shows an iridology chart which represents iris-like, a chart of the body. Iridology chart splits iris into distinct parts and each distinct part signifies the different body organ. Whenever there is any change in any part of the body organ, it is reflected in that particular part. Then these changes can be analyzed by using a different part of the iris in which changes are occurring. Now, it is very important for analysis that we have to know about that in which part of iris the pancreas is present.



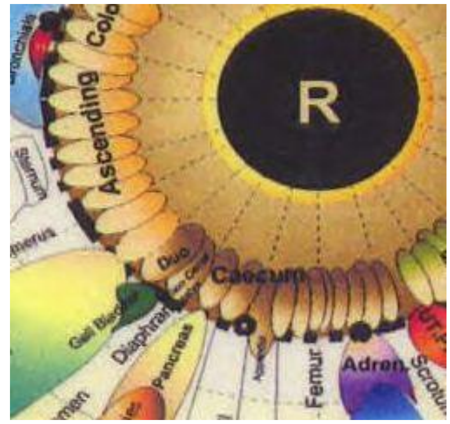


Figure 3.6: Left eye iris chart

Figure 3.7: Right eye iris chart

The pancreas is separated into three parts namely; head, body, and tail. Iridology charts in Figure 3.6 and Figure 3.7 demonstrate the head of the pancreas in the right eye between 7 and 8 o'clock, body and tail lies in left eye within 7 to 8 o'clock, and 4 to 5 o'clock respectively.

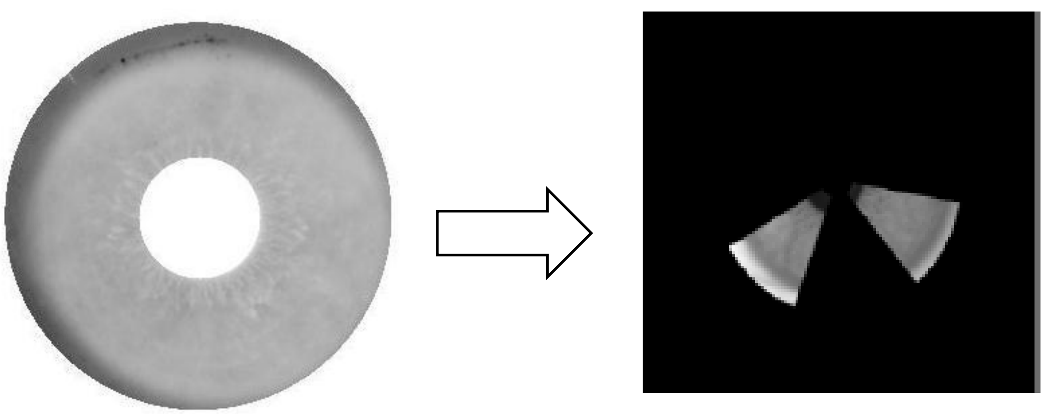


Figure 3.8: Segmentation of region of interest for database image

In previous work [10] only left eye is considered for the detection of diabetes using DWT and only area between 7 to 8 o'clock are extracted but in this scheme, both the regions are extracted from both left and right eye as shown in Figure 3.8 also ROI is extracted before the iris normalization while in previous work first iris normalization is carried out then ROI is extracted. But in this case only, ROI is normalized instead of the whole iris.

3.4 Iris Normalization

In this step for the for comparison purpose, the iris region which is extorted out from the complete eye is converted to the fixed size image to achieve good detection. Illumination variations result in a change of pupil size, which ultimately causes elastic deformations in iris texture. This elastic deformation causes a problem in pattern matching. Therefore to attain good accuracy in the process, it is essential to remove the causes of deformation. To achieve this goal J. G. Daugman [57] proposed a model which is known as Rubber sheet model to normalize the iris. This method removes the effect of pupil dilation by transforming an image from Cartesian coordinates to polar coordinates with fixed dimensions.

After performing segmentation using Hough Transform and Region of Interest extraction, iris normalization is carried out. It is very important step because due to this step, the various images of the same iris give same characteristic features for dissimilar conditions. In this algorithm, only ROI is normalized instead of the whole iris while in the previous work, complete iris image is normalized then ROI is extracted out. Figure 3.9 shows the results after the normalization process.

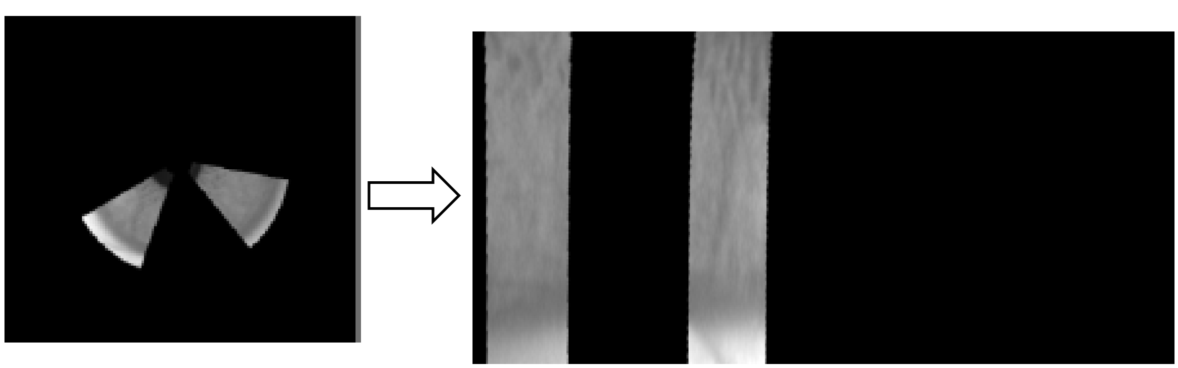


Fig 3.9 Normalized Region of Interest image

3.5 DCT based Feature extraction

There are many algorithms for feature extraction like DWT [10], Gabor filters [40, 59] and modified Gabor filter [43]. In this work, DCT has been applied to determine the important features from normalized ROI. The DCT signifies an image as a summation of sinusoids of different magnitude and frequencies [60].

Elementary frequency components of a signal are decomposed by DCT and 2-D DCT deliberates the important energy information of matrix in a few coefficients in upper left corner of the resultant DCT matrix which is further carried as FV matrix.

3.6 SVM classification

After finding the coefficients through DCT now to show the effect of these DCT coefficients on the accuracy of this scheme a feature vector is formed using the distinct combinations. Now these feature vectors are used for categorizing the images into diabetic or healthy with SVM classifier the results obtained from the extraction of DCT coefficients using five different combinations of feature vectors namely; mean (f1), variance (f2), standard deviation (f3), skewness (f4) and kurtosis (f5). These coefficients are passed to Supporting Vector Machine for classification in the proposed scheme. SVM is a pattern matching classifier. These classes are classified using the concept of risk minimization.

The development of SVM as a classifier is carried out in two phases. In a first phase, determination of optimal hyperplane is carried out that will differentiate the two classes also a mapping of non-linearly separable classification into a linearly separable classification is carried out in the second phase [61-62].

In first phase training of SVM classifier is carried out using 32 images in which 20 images are of diabetic people and 12 images are of healthy people. In second phase testing of images are done. There are 59 images in testing data in which 47 are of diabetic 12 images are of healthy people.

3.7 FRR and FAR

FRR is known as False Rejection Rate. FRR is the number of diabetic images in testing data N1 which is not recognized by classifier as diabetic images or number of diabetic images in the testing data which is classified as healthy by the classifier. In the same way, FAR is known as the False Acceptance Rate respectively. FAR is the number of healthy images in the testing data N2 which is not recognized by classifier as healthy images or number of healthy images those are recognized as diabetic in the classifier result [63].

$$\text{FRR} = \frac{N1}{Total\ number\ of\ images\ in\ the\ testing\ data} \tag{3.2}$$

$$\text{FAR} = \frac{N2}{Total\ number\ of\ images\ in\ the\ testing\ data} \tag{3.3}$$

The technique is performed on a dataset and FRR and FAR is computed on several threshold values to create a Receiver Operating characteristic (ROC) curve.

3.8 Chapter Summary

The various steps in the proposed algorithm for Detection of Diabetes like, how to reduce the effect of light reflections, image manipulation to reduce the time and computational complexity using different threshold values, segmentation using Hough Transform, normalization using Rubber sheet model, feature extraction based on DCT along with SVM classification are described in detail in this chapter. In the next chapter, the results are discussed which are obtained experimentally and also various factors are discussed related to them.

Chapter 4

Results and Discussions

4.1 Introduction

The automatic segmentation using Hough Transform is successful when iris part is completely present in the original input iris image. In Hough Transform iris region is localized and segmented by assuming the facts that iris and pupil boundaries were clearly distinguished and iris, pupil, and sclera portions are perfect circles. Now, after the successful localization of iris, the iris region is extracted out from the eye images. In next phase from the complete iris, only Region of Interest is extracted. Now these images are normalized using Daugman's Rubber sheet model which converts the iris images into polar coordinates obtained from the Cartesian coordinates. In next step for the extraction of features, DCT is applied. In this phase, FV coefficients are calculated from the normalized iris images using DCT as a result for the complete dataset FV coefficient matrices are generated i.e. for training as well as testing images. In the last step, classification is carried out using SVM classifier. The experimental results of various steps in the whole process are explained in this chapter and accuracy analysis is done after classification, and after which it is compared with the existing iridology methods.

4.2 Experimental Results

The performance of this algorithm is typically described in term of overall accuracy of the scheme which is based on the false acceptance rate (FAR) and a corresponding false rejection rate (FRR). A false acceptance occurs when the classifier classified a Healthy image as Diabetic image. A false reject ratio represents a Diabetic image is rejected and considered as a Healthy image. FAR and FRR are highly correlated with each other. These two errors are inversely affecting each other i.e. increase in one error automatically decreases the second error. Iris recognition process with SVM classifier is used for determining diabetes in humans using DCT for feature extraction. In this process, 32 images are used for the training of SVM classifier and complete 59 images are used for the testing.

The various information regarding database is shown from Figure 4.1 to Figure 4.4. Figure 4.1 shows the total number of images in the dataset, Figure 4.2 the number of left and right eyes images in the dataset, Figure 4.3 tells the number of male and female persons in the dataset, while Figure 4.4 shows the distribution of dataset based on the duration of diabetes. The accuracy of the proposed scheme is calculated with different combinations of feature vectors for all iterations independently. After which False Rejection Rate (FRR) and False Acceptance Rate (FAR) are computed for all iterations.

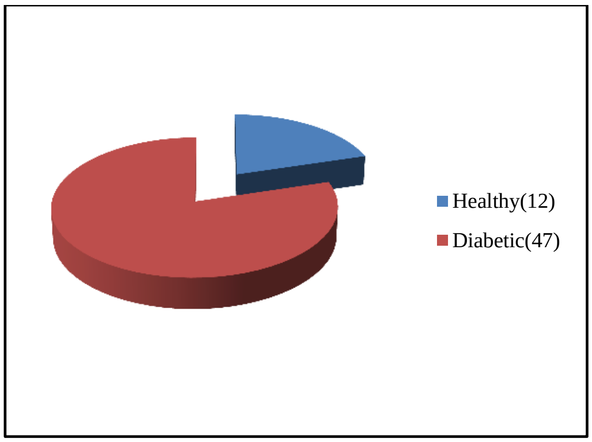


Figure 4.1: Distribution of iris images

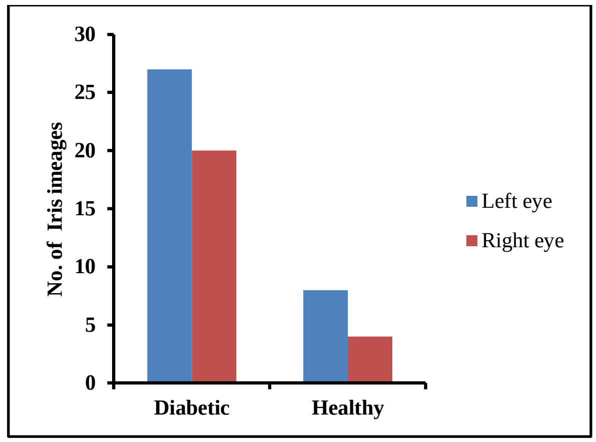


Figure 4.2: Number of left and right eye images

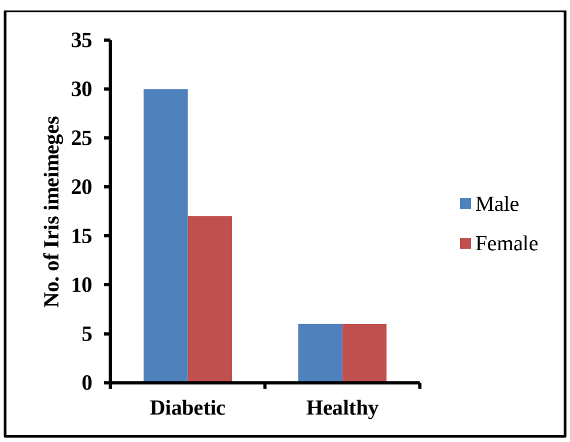


Figure 4.3: Number of male and female

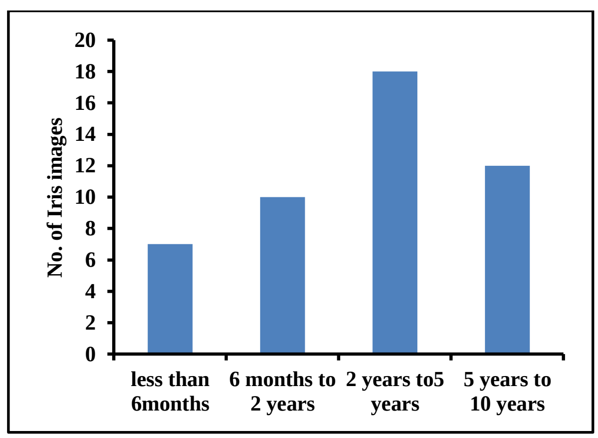
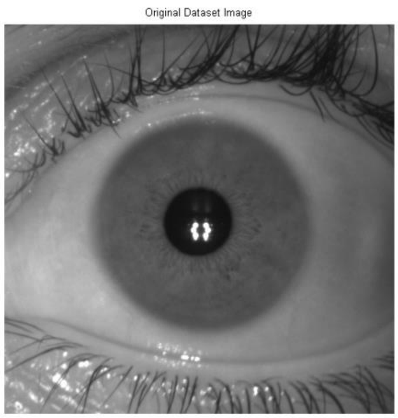
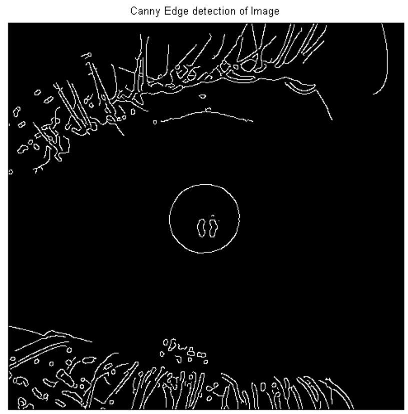


Figure 4.4: Distribution of diabetic dataset upon the duration of diabetes

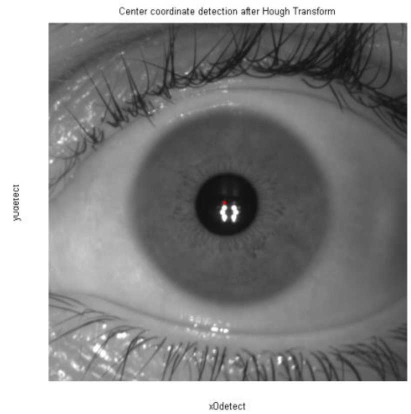
The observed experimental results after iris localization, segmentation, and normalization for four eye images are below.



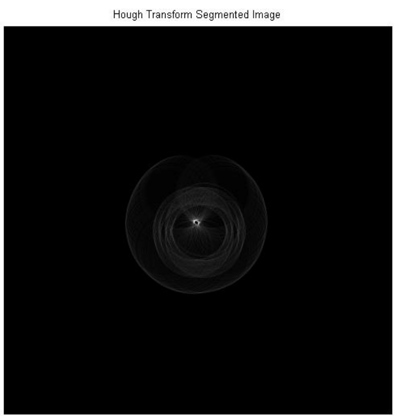
(a) Left eye of Diabetic person



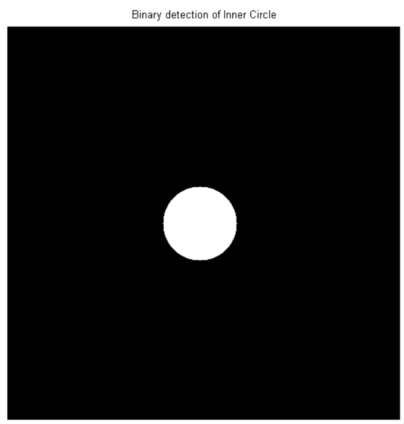
(b) Image after edge detection



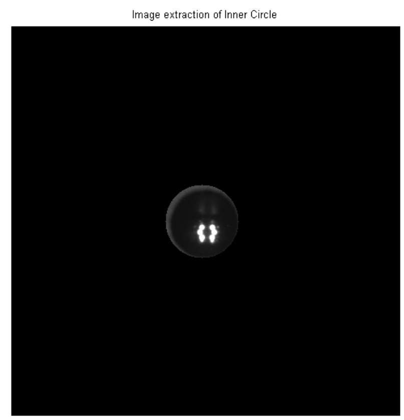
(c) Centre coordinate detection



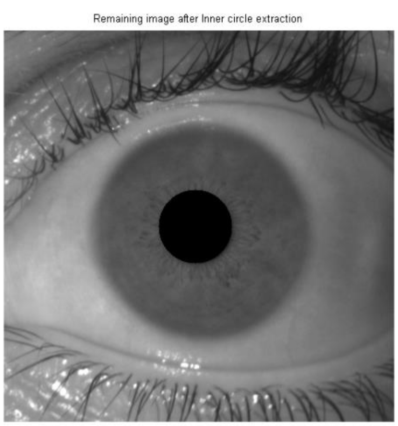
(d) Hough Transform segmented image



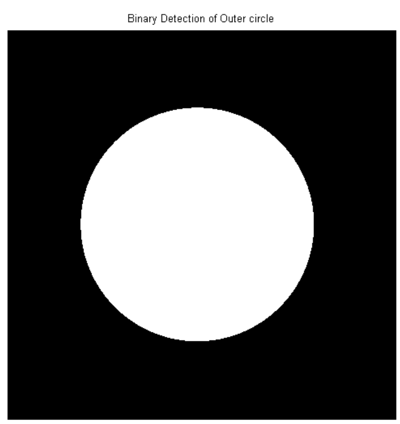
(e) Binary detection of inner circle



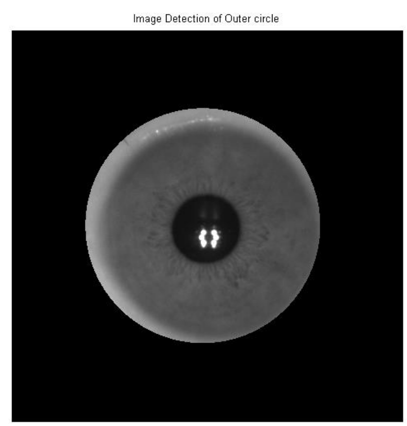
(f) Image extraction of inner circle



(g) Remaining image after inner circle extraction

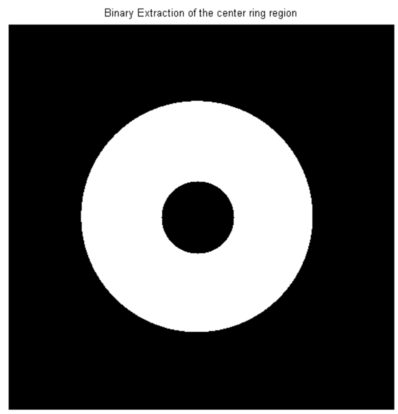


(h) Binary detection of outer circle ring



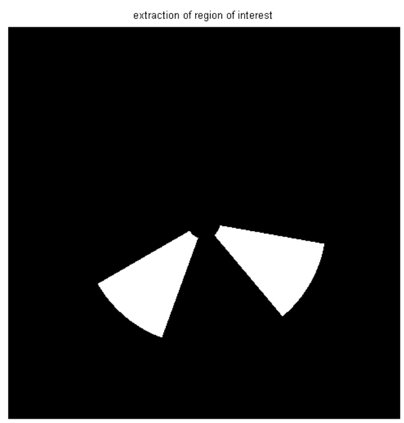
(i) Image detection of outer circle

Figure 4.5: Experimental results of iris localization, segmentation, and normalization for Diabetic left eye of a person

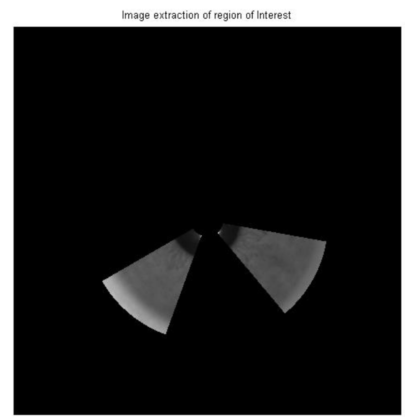


(j) Binary extraction of iris region

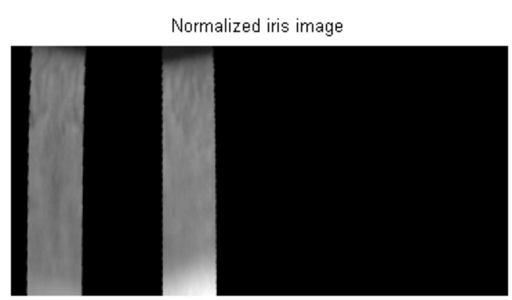
(k) Image extraction of iris region



(l) Binary detection of region of Interest



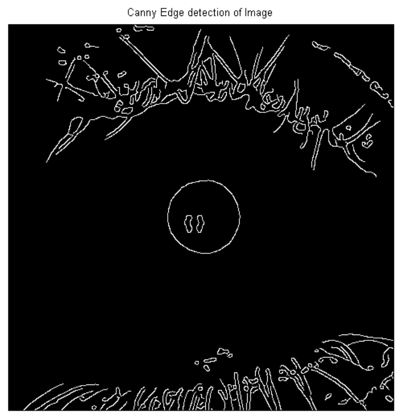
(m) Image after ROI extraction



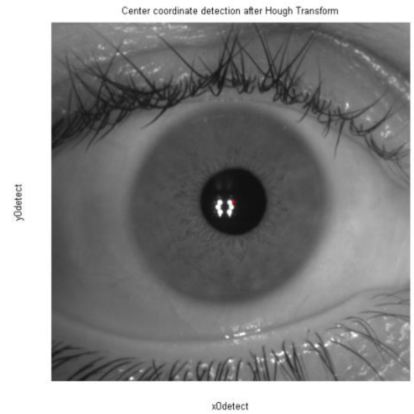
(n) Normalized iris image

Figure 4.5: Experimental results of iris localization, segmentation, and normalization for Diabetic left eye of a person (contd.)

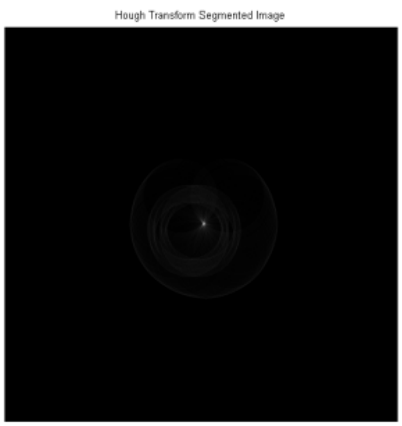
(a) Right eye of Diabetic person



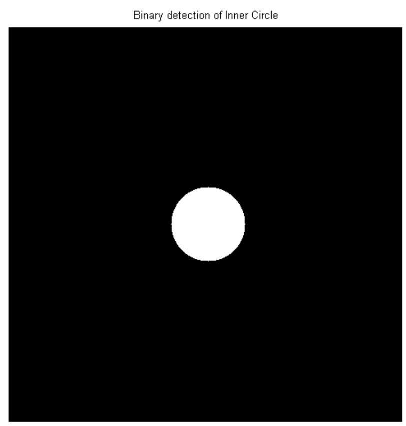
(b) Edge detection of image



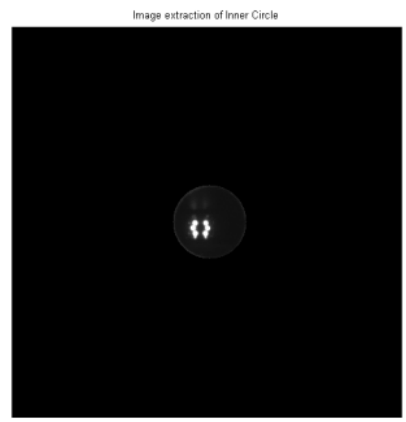
(c) Centre coordinates detection



(d)Hough Transform segmented image

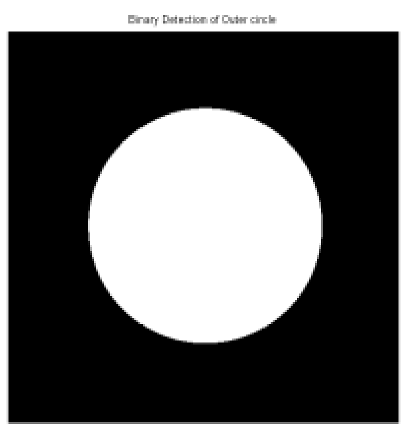


(e) Binary detection of inner circle image

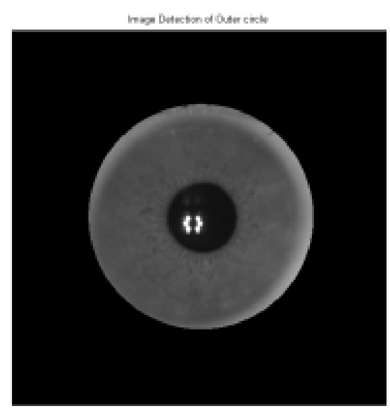


(f) Extraction of inner circle

(g) Remaining image after inner circle extraction

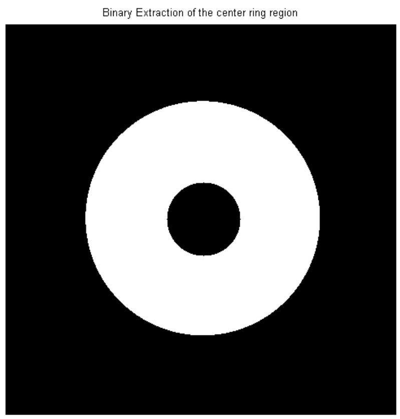


(h) Binary detection of outer circle



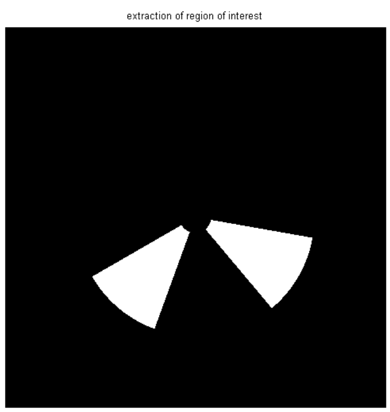
(i) Image detection of outer circle

Figure 4.6: Experimental results of iris localization, segmentation, and normalization for Diabetic right eye of a person

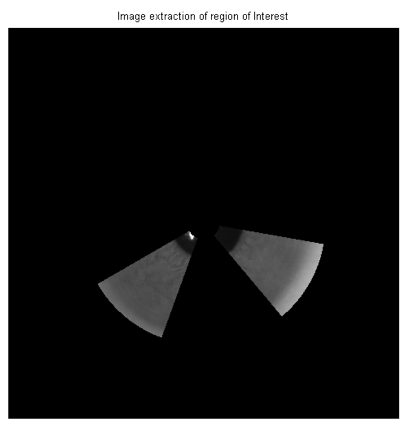


(j) Binary detection of iris region

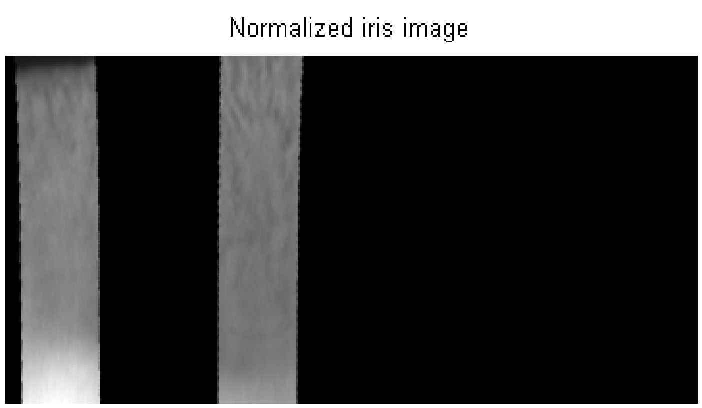
(k) Image after iris region extraction



(l) Binary detection of ROI

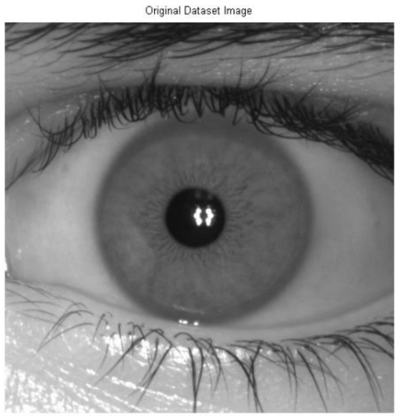


(m) Image extraction of ROI

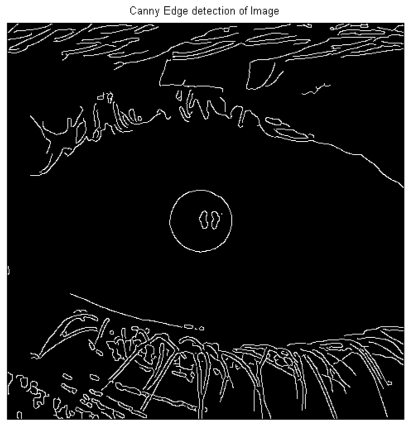


(n) Normalized iris image

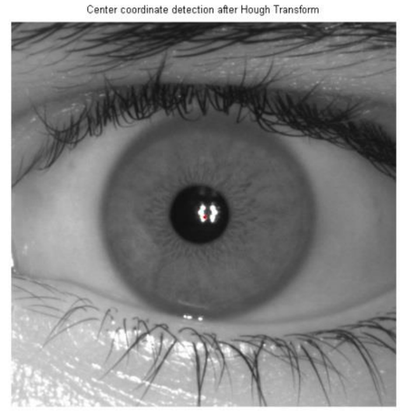
Figure 4.6: Experimental results of iris localization, segmentation, and normalization for Diabetic right eye of a person (contd.)



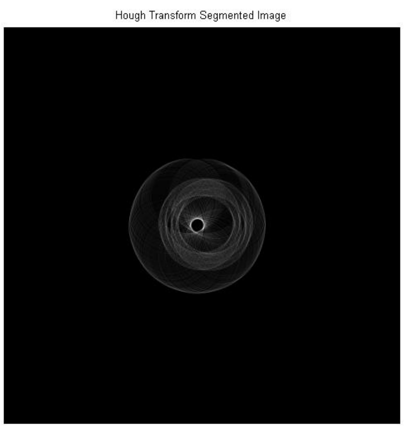
(a) Left image of a healthy person



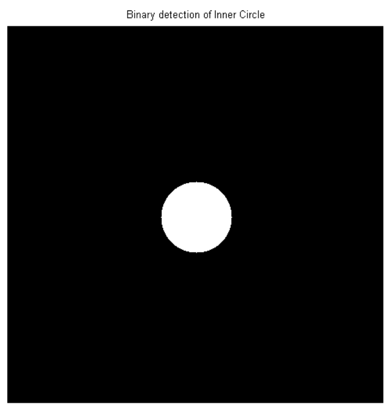
(b) edge detection of image



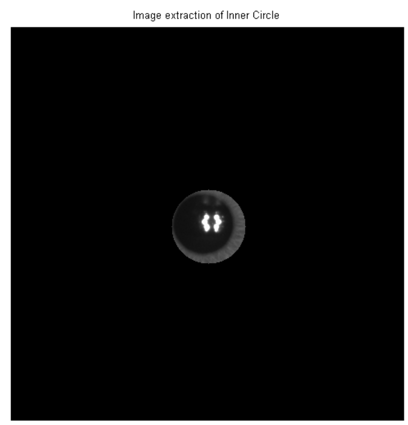
(c) Centre coordinate detection



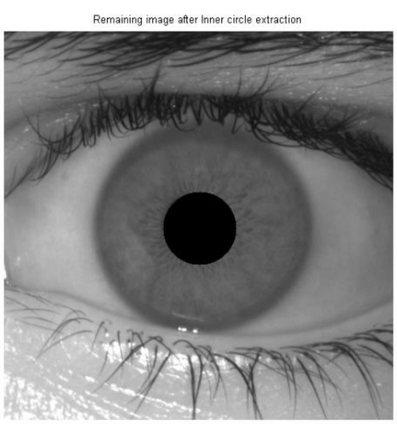
(d) Hough Transform segmented image



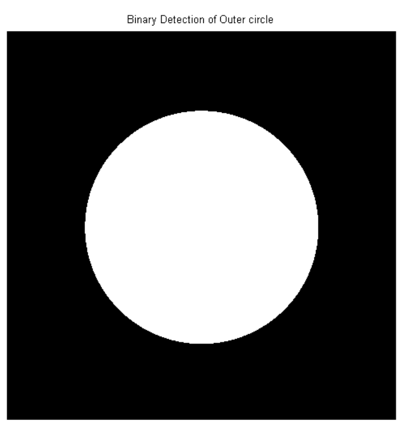
(e) Binary detection of inner circle



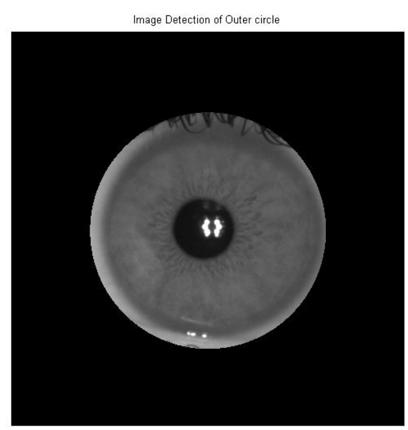
(f) Extraction of inner circle



(g) Image after extraction of inner circle

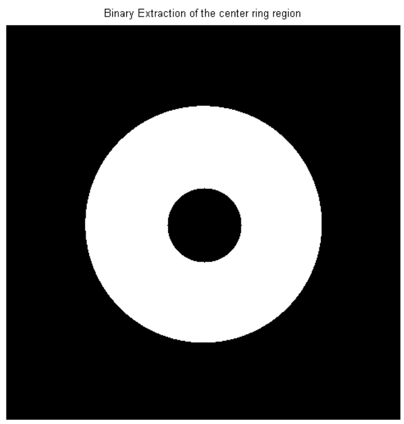


(h) Binary detection of outer circle

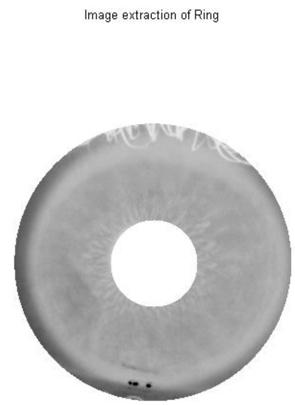


(i) Image detection of outer

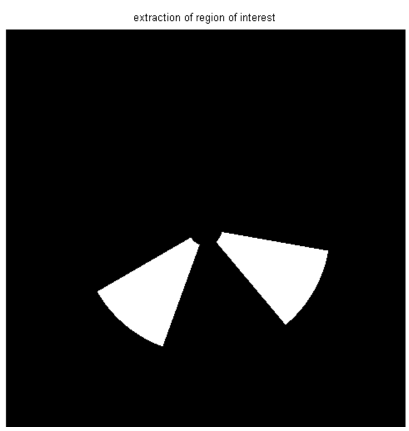
Figure 4.7: Experimental results of iris localization, segmentation, and normalization for Healthy left eye of a person



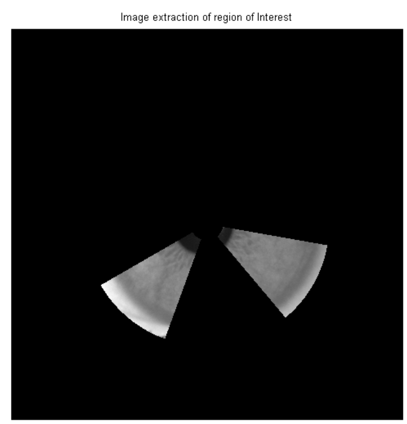
(j) Binary detection of iris ring



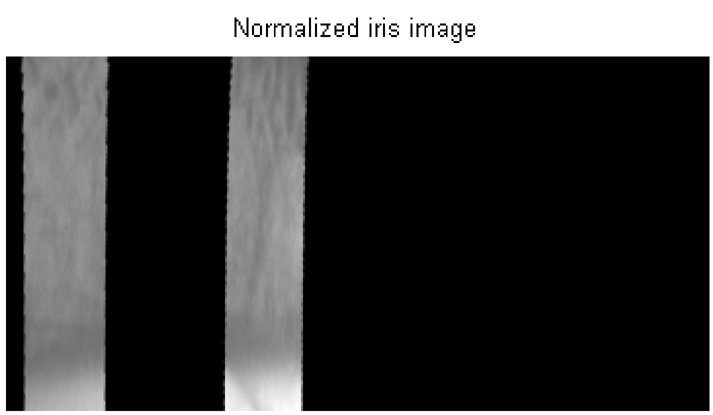
(k) Image extraction of iris ring



(l) binary detection of ROI



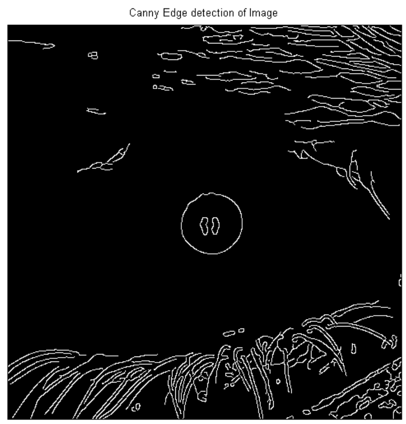
(m) Image of ROI



(n) Normalized iris image

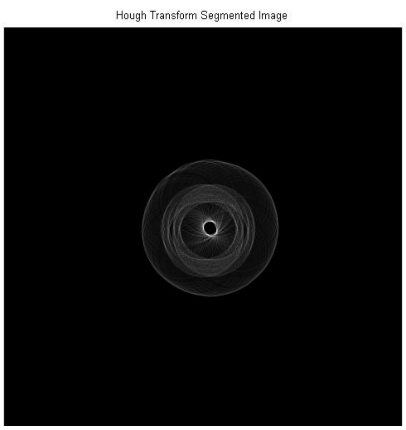
Figure 4.7: Experimental results of iris localization, segmentation, and normalization for Healthy left eye of a person (contd.)

(a) Right eye of Healthy person

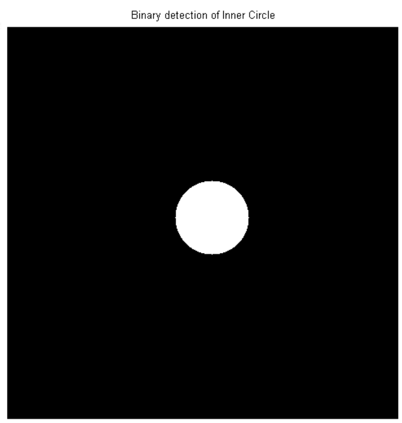


(b) Edge detection of image

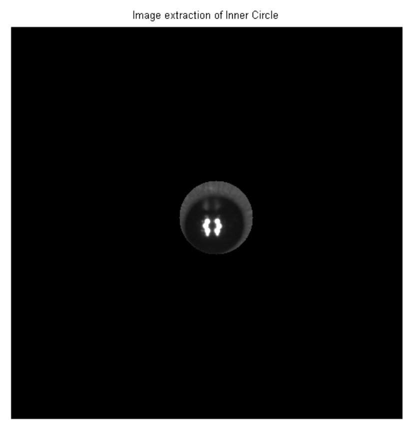
(c) Centre coordinate detection



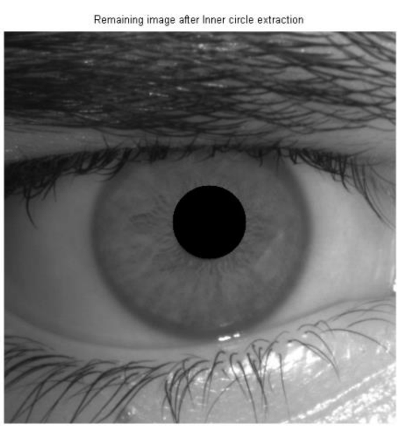
(d) Hough Transform segmented image



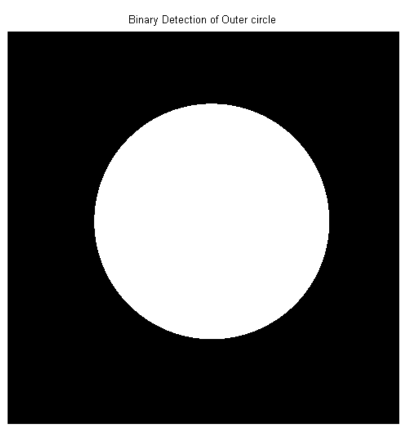
(e) Binary detection of inner circle



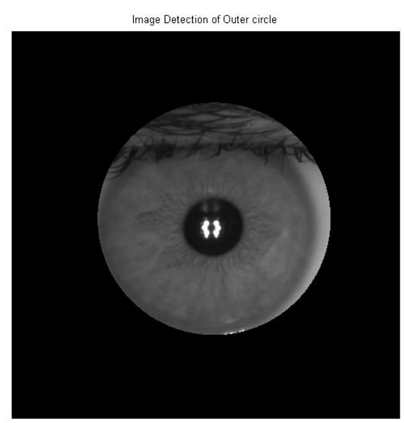
(f) Image extraction of inner circle



(g) Image after extraction of inner circle

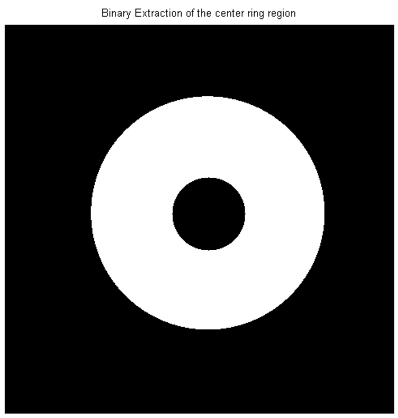


(h) Binary detection of outer circle



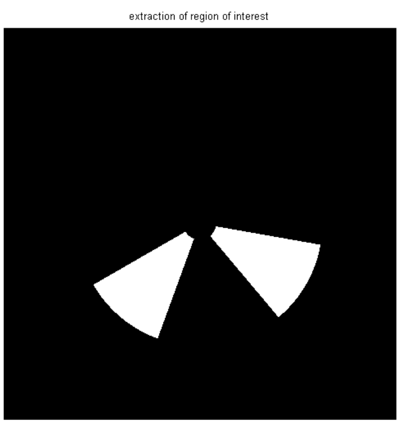
(i) Image detection of outer

Figure 4.8: Experimental results of iris localization, segmentation, and normalization for Healthy right eye of a person



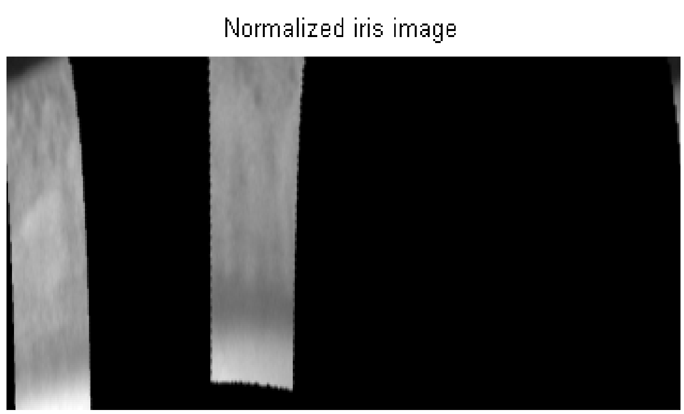
(j) Binary detection of iris ring

(k) Image extraction of iris ring



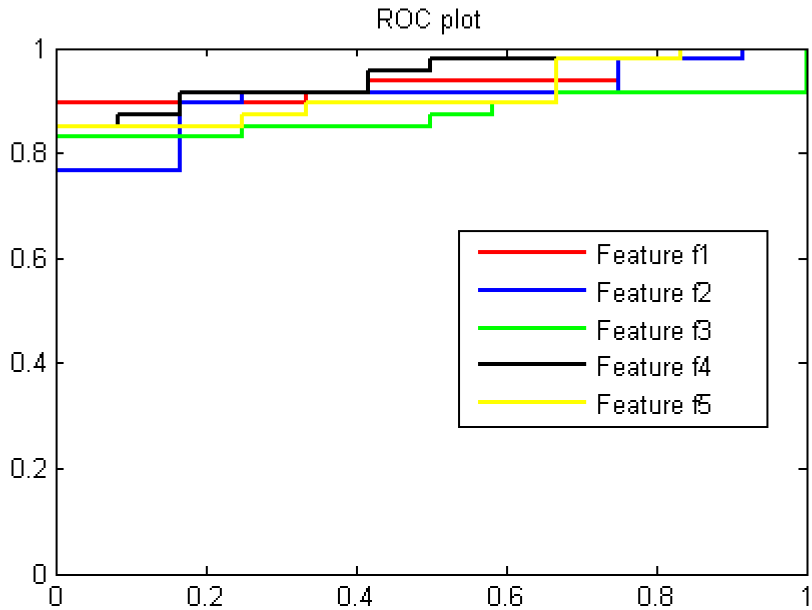
(l) Binary detection of ROI

(m) Image extraction of ROI

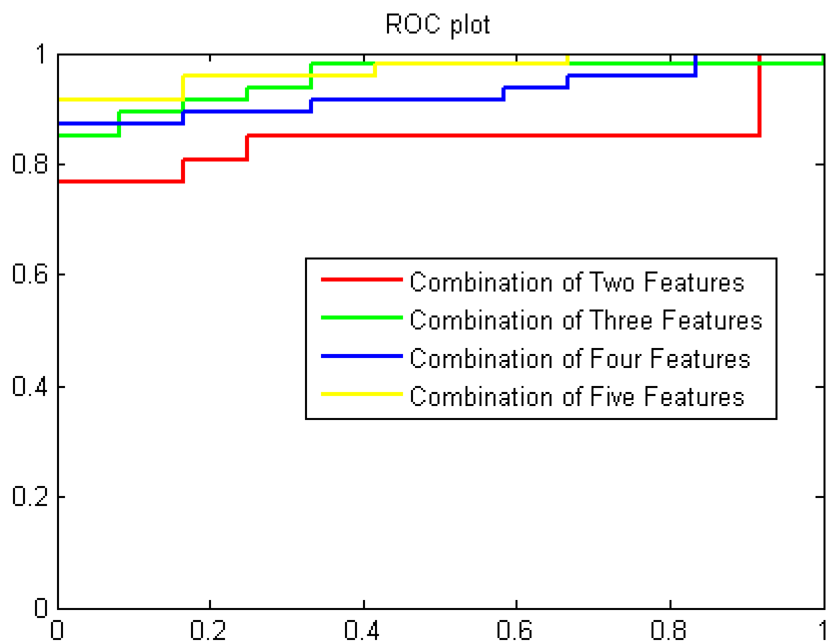


(n) Normalized iris image

Figure 4.8: Experimental results of iris localization, segmentation, and normalization for Healthy right eye of a person (contd.)



(a) ROC curve for single feature vector



(b) ROC curve for various combination of feature vectors

Figure 4.9: ROC curve for different feature vectors

4.3 Accuracy Comparison

For the calculation of accuracy for the proposed model different feature vectors are calculated. Five features vectors namely mean, variance, standard deviation, skewness, and kurtosis are calculated using standard formulas after which these vectors are used one after one for the training of the SVM classifier. After the training of SVM, this training dataset is used for the testing of the whole dataset one by one for the different feature vectors and accuracy is calculated. Due to change at the step of normalization in which normalization is carried out for the only region of interest, a significant improvement is obtained by the feature calculation and a decrease in the computational complexity is also recorded.

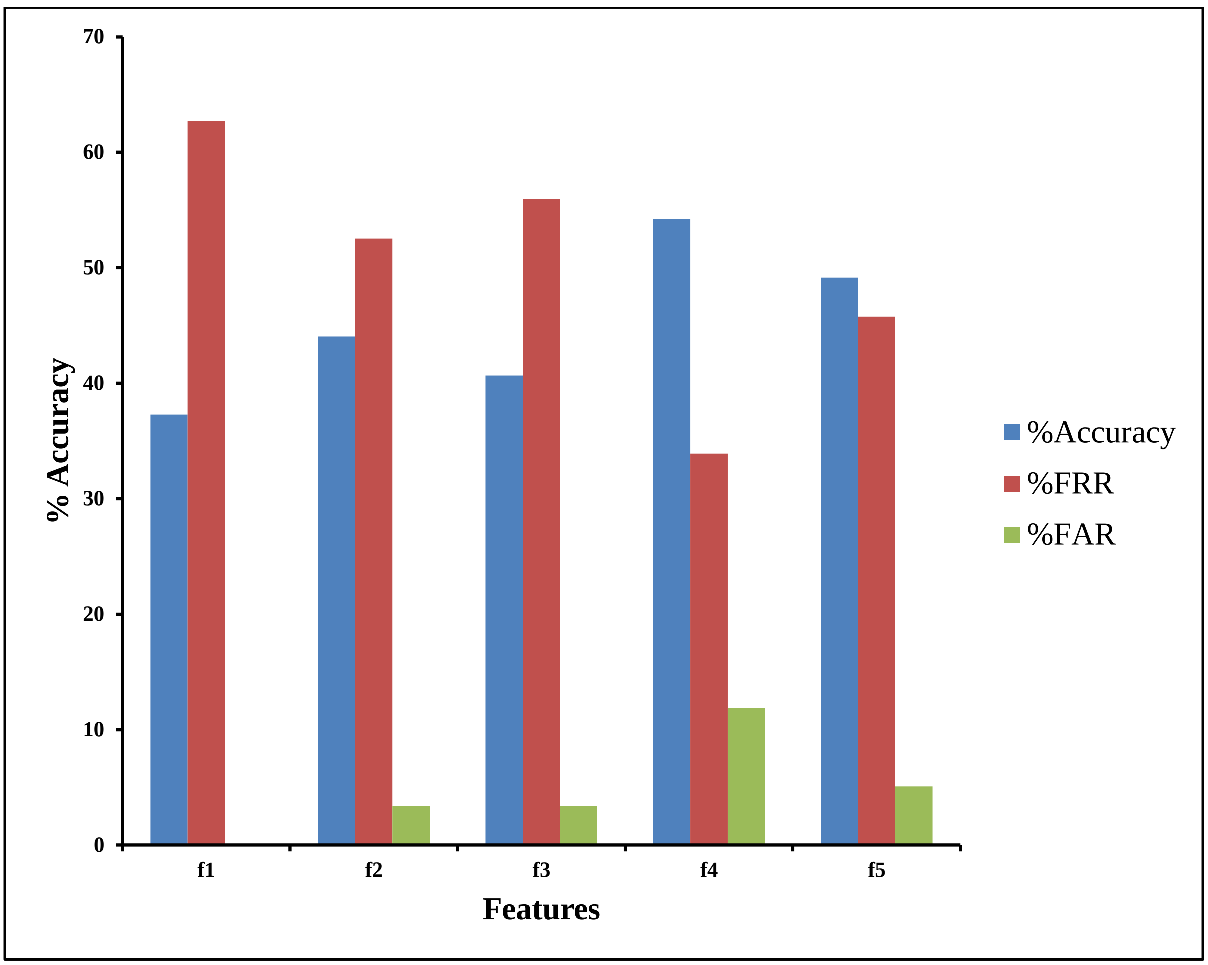


Figure 4.10: Accuracy of proposed model with single feature vector

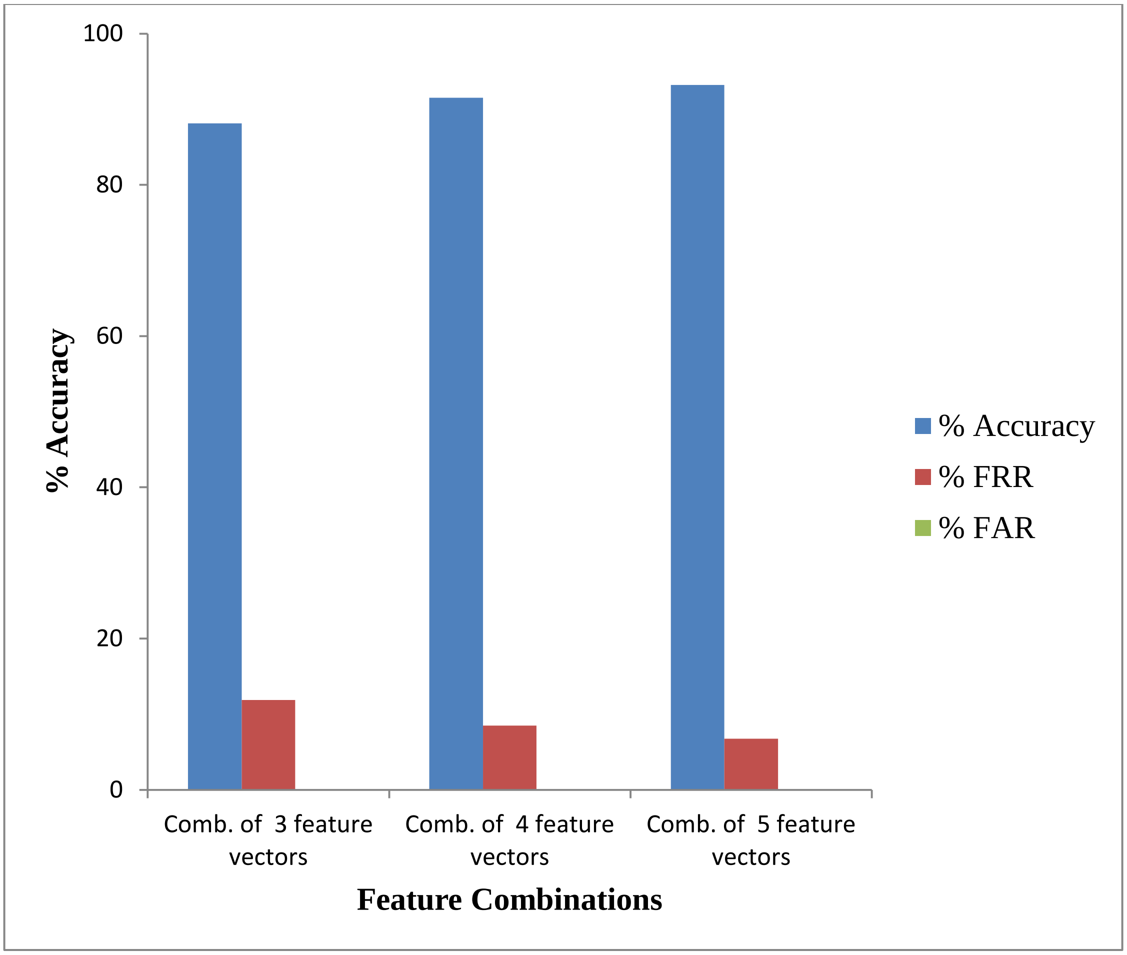


Figure 4.11: Accuracy of proposed model with different combinations feature vectors

It is seen in Figure 4.9 that accuracy of the algorithm is not so good for the single feature. Then combinations of these features vectors are used for the training of SVM classifier. Now feature vector is obtained by the combining of two features and a single feature vector is generated and again the same process is repeated three times for the generation of feature vectors firstly by combining three, four feature vectors and then by combining the all five features as shown in Figure 4.10. Now these feature vectors, which are formed using different combinations are used for the training of the SVM classifier and the accuracy of the offered scheme is calculated for the complete 59 test images. An increase in the accuracy is observed when the dimensions of the feature vector are increased by the combining the different features of DCT coefficients. The highest accuracy 93.22% is obtained with FRR of 6.78% and FAR is 0% when all the five features are combined.

An attempt has been made in the direction of overall accuracy by studying the effects of the different combination of feature vectors.

Table 4.1 Table comprising features with their Accuracy, FRR, and FAR

S.No	Features	Accuracy (%)	FRR (%)	FAR (%)
1.	f1	37.29	62.71	0
2.	f2	44.06	52.54	3.39
3.	f3	40.6	55.93	3.39
4.	f4	54.23	33.90	11.86
5.	f5	49.15	45.76	5.08
6.	Combinations of two feature vectors	82.35	15.08	2.57
7.	Combinations of three feature vectors	88.13	11.87	0
8.	Combinations of Four feature vectors	91.52	8.48	0
9.	Combinations of Five feature vectors	93.22	6.78	0

Table 4.1 shows the overall accuracy of the algorithm, FRR, and FAR for different feature vectors. It is seen from the table the highest accuracy is obtained when all the five feature vectors are combined to generate a single vector which is further used for the training and creating a hyperplane in the SVM classification process. After which testing of different images are done and improved results are obtained with this combination.

Table 4.2 Evaluation of accuracy of proposed method with previous methods

S.no	Author(s)	Disease	samples	Accuracy (%)
1	MH Purnama et al. [4]	Condition of Pancreas	50	83.3
2	A.Bansal et al. [10]	Diabetes	80	87.5
3	Proposed model	Diabetes	59	93.22

In this table 4.2, the comparison between proposed model and existing techniques is given for the same disease. MH Purnama [4] gives a computerized method to detect the pancreas disorder based on the Neighborhood Modified Backpropagation using Adaptive Learning Parameters and then A. Bansal [10] gives a method based on DWT to detect the changes in the pancreas which are directly a cause of diabetes and obtained a very good accuracy. Now the proposed model is based on the DCT to detect diabetes but some changes are made from the previous method that normalization is done after extraction of ROI while in previous methods normalization is done for the whole iris and then after this ROI is extracted. Therefore, there is a reasonable increase in overall accuracy is obtained with the proposed model.

4.4 Discussion

The final results are able to show the health condition of a patient i.e. able to tell the whether person is diabetic or not. So far, in complete process, 59 images are being tested and results are calculated. The results are shown in Table 4.1. For the accuracy of the results, it is not 100% accurate as the accuracy of results is highly dependent on the consistency of the results. In the experiment, it is done by taking both left and right eye images iris image of a patient and analyzes the iris using the proposed algorithm. There is few factor that contributes to the accuracy of results, i.e. lighting issue, position, and size of the eye.

4.4.1 Lighting Issue

Lighting is the most important factor that disturbs the excellence of iris image acquisition. If the environment is too bright, the iris image will become white and it is very difficult to search the center of the iris. After it goes through image manipulation, it is very difficult or unable to search the center of the iris in the image. Furthermore, the brighter environment will tend to produce more noise to the iris image which will highly affect the accuracy of results.

4.4.2 Position and size of eyes

The position of the eye is one of the factors that affect the size of iris captured by iris scanner, if the position of the eye is too far from the scanner, the captured iris will become small, and it will tend to fail in search for the center of the iris. Furthermore, if there is any movement of the eye during capturing the image then iris part is not completely present in the image; some informative part will be missed, and will have too many unwanted parts and will give inaccurate results. Therefore, there is a significant decrease in the accuracy of the method.

4.5 Chapter Summary

In this chapter, experimental results accomplished subsequently every phase of processing such as iris localization, segmentation, Region of Interest extraction, normalization is explained with the help of images and the final results of accuracy are clarified in the form of a table demonstrating the performance accuracy of Iridology system is explained with a comparison results of related work with proposed work are in a tabular form.

Chapter 5

Conclusion and Future work

5.1 Conclusion

In the present scheme, iris recognition method is effectually joined with iridology to examine diabetes in the human body. In the proposed methodology, at first step image acquisition is done after which segmentation of a region of interest is extracted out from the iris image then only Region of Interest is normalized using rubber sheet model instead of the method where the whole iris was normalized, and then Region of Interest was extracted. Iris normalization is done to remove the dimension inconsistencies and for the classification, SVM classifier is used.

In this scheme both left and right eye images are considered while in the previous work only left eye images was considered for detection of diabetes. High energy compaction is obtained using DCT for feature calculation due to these changes training of SVM classifier is improved. Hence 100% training accuracy is obtained with the different training set images. At last, testing of iris images is done. To prove the effectiveness of technique, the overall accuracy obtained is 93.22% with FRR is 6.88% and FAR is 0% with the testing data. This method works well with the iris image that captured under controlled environment. Improvement on the iris image acquisition is required in order to give better results in terms of accuracy and consistency.

5.2 Future work

The present method is able to analyze both left and right iris, Furthermore, the results can be explained in more detail such as gives a recommendation for every particular health condition. The project has many opportunities for improvement in the future and can be implemented in VLSI to develop Graphical User Interface. Currently, in India there is rare research on iridology software, thus it is a great opportunity to improve this algorithm in India and one day in future, the developed system can be sold all over the world.

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LIST OF PUBLICATIONS

1. "A survey on Iridology", in *International Conference on Signal Processing*, Samrat Ashok Technological Institute (SATI), Vidisha (M.P.) – *Communicated*, 2016.
2. "Detection of Diabetes based on Iris images using DCT coefficients", *Computerized Medical Imaging and Graphics*– *Communicated*, 2016. (*SCI Indexed*).

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