CHAPTER 4
IMPLEMENTATION

Pattern recognition algorithms generally provide reasonable answers for all possible inputs and to perform matching, taking into account their statistical variation of the iris images. Introduction of Iris recognition system then data acquisition, segmentation, normalization, finally feature extraction and pattern matching, conflicting objectives are presented. Then, the algorithmic flow of iris perception algorithm was discussed in detail.

Iris recognition technique is based on biometric information of the subject and used to authenticate the access control. Iris is located between the cornea and lens of the eye.

![Block diagram of iris recognition system](image)

Figure 4.1 Block diagram of iris recognition system
It provides personal identification of an individual based on unique features possessed by the human iris. Iris recognition system involves image acquisition, localization and pattern matching. Image acquisition was the process which deals with the capturing of a high-quality image of the iris with the help of a digital camera. Pattern matching deals with the matching of iris codes which are already stored in the database.

In this work, used iris perception algorithm was used and compared with the edge detector performing the segmentation. This is a technique in iris recognition field that helped novel approach applied recognition performance. The MATLAB tool has been used to implement the work with samples of iris image collected samples from 900 peoples are used for training and testing purposes.

4.1 MATLAB Environment

The simulation was carried out using custom built iterative based simulator in MATLAB 7.10.0(R2010a) which simulates the sending, receiving, dropping and data forwarding. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis and numeric computation. Using the MATLAB product technical computing problems can be sold faster than with traditional programming languages such as C, C++ and FORTRAN.

It is used in a wide range of application including signal and image processing, communication, control design, test and measurement, financial modeling and analysis. Add-on toolboxes extend the MATLAB environment to solve particular classes of problems in these application areas. MATLAB provides some features for documentary work. MATLAB code can be integrated with other languages and applications can give out various new algorithm and application.
4.2 Algorithmic Flow Implementation

Data acquisition involves the acquisition of eye images from a group of live person, in this work a database was created by collecting eye image and saved as .jpg files.

4.2.1 Recent Trends in Iris Recognition Systems

Image acquisition plays a crucial role in successful recognition. Dealing with mobile subjects, and acquisition at a distance, the main concern is the quality of the resulted images for recognition purpose. Poor imaging conditions have been shown to affect the genuine score distribution. In fact, the similarity between iris templates belonging to the same subject considerably decreases under less constrained acquisition conditions. Fundamentals in iris acquisition and recognition systems image quality. The quality of the images is basically related to two major factors: the imaging system itself and the environmental conditions during the capture. Imaging systems must be carefully designed in order to achieve acceptable recognition accuracy. The challenges associated with iris recognition design arise principally from two necessities: (i) enough resolution (number of pixel across the iris diameter) and (ii) enough NIR illumination intensity.

• Resolution: According to the iris image data interchange standard released in 2005, an image with 200 pixels across the iris diameter is considered as a high quality iris image. The lower limit of the number of pixel is set to 100. Below this limit, the recognition performance is dramatically degraded.

• Illumination: The light is emitted from illumination source, with a wavelength range that emphasizes the iris texture while providing sufficient contrast between the pupillary and limbic boundaries, and covering uniformly the iris surface.
The intensity must be sufficient to maximize the signal/noise ratio that is collected by the camera sensor. As high illumination can cause permanent eye damage, the level of illumination must be set carefully. Indeed when working with wavelengths, the human eye does not respond to its natural light protective mechanism such as a version, blinking and pupil contraction. Even if these two issues are addressed properly by the hardware design, relaxing the imposed constraints on the participant during the acquisition causes significantly quality variations in the iris images. In fact, the captured images may suffer from blur due to motion and/or out of focus, distortion, strong occlusions, poor resolution and low contrast and so on. These factors had been handled by software algorithms in order to improve the accuracy of the recognition system.

Figure 4.2  Algorithmic flows in the Implemented Method
4.2.2 Acquisition of the Image

From the UPOL database around nine hundred eye images were taken for the experiment at different timings. Two eye images of a person are taken randomly along with its fields. A single image is randomly selected, and its features are stored in the database, and those images are called as registered listed images and others are unregistered listed images. It is an outcome of a total of nine hundred eye images were used for the experiment.

Acquisition: The First step of iris recognition systems is to acquire an eye image of the person entering into the system using a camera. The video is taken when the person walks through the portal by wearing eyeglasses or contact lenses.

![Input Image](image.png)

**Figure 4.3 Input image**

To improve the image quality, some authors propose engineering the image acquisition system for good quality iris image, regardless of the imaging framework expenses, while others propose developing an intelligent algorithm to classify and enhance the captured images. It is better to develop an intelligent algorithms for enhancements and classification rather than hardware engineering to achieve a high performance unconstrained iris recognition system, because hardware engineering may led to use large imaging equipment which was unsuitable for unconstrained conditions like iris recognition on mobile phones or using webcams.
Taking a photo from Iris is the initial stage of an iris based recognition system. The success of other recognition stages is reliant on the quality of the images taken from iris during image acquisition stage. Images available in CASIA database lack reactions in pupil and iris areas because infrared was used for imaging. Additionally, if visible light was used during imaging for those individuals whose iris is dark, a slight contrast comes to existence between iris and pupil which makes it hard to separate these two areas.

4.2.3 Hough Transform Segmentation

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 recognition 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%. This step involves the determination of circle coordinates and line coordinates followed by Binarization, edge detection, and cropping as shown in Figure 4.2. The process of edge detection was experimented using iris perception algorithm. It was decided to use circular Hough transform for detecting the iris and pupil boundaries. This involves first employing edge detection, to generate an edge map. Gradients were biased in the vertical direction for the outer iris or sclera boundary. Vertical and horizontal gradients
were weighted equally for the inner iris or pupil boundary. Iris perception algorithm in MATLAB function was implemented, which allowed for weighting of the gradients. The range of radius values to search was set manually, depending on the database used. For the UPOL database, values of the iris radius range from 90 to 150 pixels, while the pupil radius ranges from 28 to 75 pixels. The most important and challenging stage of segmentation is detecting the boundary of iris and sclera. Actually there is no specific boundary area and illumination intensity distinction between iris and sclera. There are other edge points in eye image in which illumination intensity distinction was much more than that of the boundary.

As a result, the edge detection algorithms which can detect outer iris edges identify the positive points as an edge. Therefore, to detect outer iris boundary, these points have to be identified and eliminated. In this work, available boundaries are initially enhanced and then extra edge points are identified and eliminated. In the end, through circular Hough transform, outer iris boundary was obtained. To enhance iris outer boundary edges, canny edge detection was performed on eye image in preprocessing stage. By performing such edge detection, a matrix was obtained with the same dimensions as of the image itself which its elements are high in areas where there is a definite boundary and the elements are low in areas where there is no perfectly definite boundary, such as outer iris boundary.

![Segmented Image](image.png)
To make the circle detection process more efficient and accurate, the Hough transform for the iris or sclera boundary was performed first, then the Hough transform for the iris boundary was performed within the iris region, instead of the whole eye region, since the pupil is always within the iris region. After this process was complete, six parameters are stored, the radius and x and y center coordinates for both circles. Eyelids were isolated by first fitting a line to the upper and lower eyelid using the linear Hough transform. A second horizontal line was then drawn, which intersects with the first line at the iris edge that was closest to the pupil. This process was done for both the top and bottom eyelids. The second horizontal line allows maximum isolation of eyelid regions. Iris perception algorithm is used to create an edge map, and only horizontal gradient information was taken. The linear Hough transform is implemented using the MATLAB. If the maximum in Hough space is lower than a set threshold, then no line is fitted, since this corresponds to non-occluding eyelids. Also, the lines are restricted to lie exterior to the pupil region, and interior to the iris region.

### 4.2.4 Gaussian Normalization

The normalization process also proved to be quite accurate and some results have been shown in the figure 4.5. For normalization of iris regions a technique based on rubber sheet model was employed. Here in the implemented system center of the pupil was considered as the reference point, and radial vectors pass through the iris region. A number of data points are selected along with each radial line and this is defined as the radial resolution. The number of radial lines going around the iris region is defined as the angular resolution. Since the pupil can be non-concentric to the iris, a re-mapping formula is needed to re-scale points depending on the angle around the circle. A constant number of points are chosen along each radial line, so that a constant number of radial data points are taken, irrespective of how narrow or wide the radius is at a particular angle. The normalized pattern was created by backtracking to find the cartesian coordinates of data points from
the radial and angular position in the normalized pattern. From the doughnut iris region, normalization produces a 2D array with horizontal dimensions of angular resolution and vertical dimensions of radial resolution. Another 2D array was created for marking receptions, eyelashes, and eyelids detected in the segmentation stage. In order to prevent non-iris region data from corrupting the normalized representation, data points which occur along the pupil border or the iris border are discarded.

![Normalization](image)

**Figure 4.6 Normalized image**

In this method, the segmented doughnut shaped iris portion is converted into a rectangular image, which can be achieved by converting the segmented portion of the iris to dimensionless pseudo-polar coordinates through a method called Homogenous Rubber sheet model, it was just like drawing concentric circles of pixels from the iris image moving from the outer circle immediately around the iris until reaching a pupil ring but instead of drawing circles of pixels, the pixel should be extracted from an oval-shaped iris and it must be put in a linear shape as a rectangle. This can be done by extracting the first upper ring of pixels in the iris at the size of iris diameter at 360° and arranging these pixels in a straight line then decreasing the diameter by one and arranging the extracted pixels in the second line and so on until reaching the pupil. If the first circle of the iris has been parsed with 1° step, the width of the resultant rectangle will be 360 and the height of the rectangle will be equal to the difference in the radius size between the iris and the pupil.
A constant number of points are chosen along each radial line, so that a constant number of radial data points are taken, irrespective of how narrow or wide the radius is at a particular angle. To prevent non-iris region data from corrupting the normalised representation, data points which occur along the pupil border or the iris border are discarded. After normalization, the iris images will have a non-uniform illumination with low contrast. These types of noises are caused by the light source intensity and position. Thus, an enhancement process was needed to minimize the effect of these noises in the normalized iris template to minimize the effect of non-uniform illumination. For reflection removal, detects the 28 region with high intensity values near 255 and applies a threshold operation to remove these regions. All these methods deals with images that have been captured with human subject cooperation and using light source.

In visible wavelength light source, a pre-process should be applied to the input image for increasing the robustness of the recognition system for determining the noisy region in iris image, and they classify the noise affecting the input images into five categories: (eyelids, eyelashes, pupil, light reflection and specular reflection).

![Figure 4.7 Illustration of normalized image](image)

On the left, the original image, the iris was segmented by two circles. On the right, the corresponding unwrapped texture according to Daugman's rubber sheet. This normalization was often referred as the rubber-sheet model of the iris. Such mapping has many benefits. The normalized iris image is invariant to iris size and contraction and eye image translation. Moreover, it
transforms eye image rotation into normalized iris translation. In addition, in the template matching module, the normalized irises can be easily compared to the common fixed size.

4.2.5 Feature Encoding

In recent years, Gabor filter based methods have been widely used in computer vision, especially for texture analysis. Gabor elementary functions are Gaussians modulated by sinusoidal functions. Gabor filters form (GFF) are directly related to Gabor wavelets, since they can be designed for a number of dilations and rotations. However, in general, expansion is not applied for Gabor wavelets, since this requires computation of bi-orthogonal wavelets, which may be very time-consuming. Therefore, usually, a filter bank consisting of Gabor filters with various scales and rotations is created. The filters are convolved with the signal, resulting in a Gabor space. GFF creates featured vector with scales and orientations at (0 & 800 angles).

It is shown that the functional form of Gabor filters confirms closely to the receptive profiles of cortical simple cells, and Gabor filtering was an effective scheme for image representation. Convolution with Gabor filters was still the major contributor to the overall feature extraction time.

![Noise Feature Encoding](image)

**Figure 4.8 Noise and Feature Encoding Outputs**

At each edge point, we draw a circle with center at the point with the desired radius. This circle was drawn in the parameter space, such that our x-axis is the value and the y-axis is the b value while the z-axis is the radius. The coordinates belong to the perimeter of the drawn circle and increment the value in our accumulator matrix which essentially has the same size as the parameter space.
In this way, every edge point in the input image draws circles with the desired radii and incrementing the values in our accumulator. When every edge point and desired radius is used, and turns the attention on accumulator. The accumulator will now contain numbers corresponding to the number of circles passing through the individual coordinates. Thus the highest numbers correspond to the center of the circles in the image.

To provide for an accurate method of recognition of individuals, the features which are most distinctive in an iris pattern must be extracted. Only these significant parts must be extracted so that they can be encoded into biometric templates which can be used for comparisons. Iris recognition systems usually use band-pass method to decompose an iris image into a biometric template. The biometric templates generated in this process can be compared together using appropriate matching algorithm.

Wavelets are usually used to decompose the data in an iris image into different components. A number of wavelet filters are applied on the normalized iris region, one for each of the two resolutions with each wavelet being a scaled version of some mathematical operation. The output of convolving the wavelets is encoded into a biometric template which can be used for comparison.

This stage aims at extracting the texture characteristics of a given iris. Discriminative features of iris texture are the basis for the comparison (also called matching) of any two images. The resulting template is usually represented by using a binary code composed of bits, called iris code. These bits are obtained by the quantization of the iris features. Set the filter frequency to the average based on the average inter-ridge distance. It is approximately 6 pixels in a 600 dpi Iris image. If $f$ is too large, spurious ridges are created in the filtered image where as if $f$ is too small, nearby ridges are merged into one and used with different values on the x-axis. Each sub-image
is respectively filtered by these Gabor filters. This leads to a total of 1120 output images from which the iris features are extracted.

### 4.2.6 Feature Vector

The direction filtered image for scales at different angles $30^0, 90^0, 120^0$ are taken. The average absolute deviation of each sector in each of the eight filtered images defines the components of the feature vector. Our empirical result shows that using features gives slightly better performance than variance in features values.

### 4.2.7 Binarization

In current techniques, the binarization is usually performed either globally or locally. Some hybrid methods have also been implemented. The global methods use one calculated threshold value to divide image pixels into object or background classes. Whereas the local schemes can use many different adapted values selected according to the local area information.

Hybrid methods use both global and local information to decide the pixel label. In binarization, each pixel is converted into one bit. Assign 1 or 0 depending upon the mean value of all the pixels. If the value is greater than mean value then its 1 otherwise 0. The binarization was done by Sigma and scaling center co-ordinates of each image. This step performs feature extraction process by using normalization encoding and then save all the features in the database. It is also known as a training phase section binarization. The final stage of iris recognition systems consists of deciding whether two templates belong to the same iris or not. To this end, a similarity or dissimilarity score was computed between the two binary codes and comparison was done. The decision of acceptance or rejection was taken by comparing the matching score to a threshold. The key stage is to fix this threshold appropriately, in order to take the correct decision. In this study noted that several levels are used for representing the iris during these four
stages: (1) the pixel-level (in the segmentation and normalization steps), (2) the feature-level (in the feature extraction stage), and finally (3) the bit given by a classical iris recognition system.

![Components in a classical iris recognition system](image)

**Figure 4.9 Components in a classical iris recognition system**

The standard components of a classical iris recognition system are iris segmentation, the red regions correspond to the artifacts, detected by the iris recognition system. Iris masks which was considered as noisy regions, then the normalized iris image and Iris code.

### 4.3 Summary

In this research work Hough Transform was used at a level of segmentation. Matching of the system was done by Hamming Distance. The iris recognition system that was developed proved to be a highly accurate and efficient system that can be used for biometric identification. This study again proved that iris recognition is one of the most reliable methods available today in the biometrics field. The implemented iris perception algorithm was best suited for iris recognition system. It works on three principles, low error rate well localization of edge point and one response to a single edge. To enhance the previous edge detection method, hybrid approaches have been implemented in this algorithm for best recognition results. 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 was taken. The
applications of the iris recognition system are innumerable and have already been deployed at a large number of places that require security or access control. Finally, the captured image was checked against a previously stored iris template in the database and time taken to identify iris was approximately within four seconds. The time consumption of the system was also very low and it can identify an Iris within ~3.89 seconds. This time includes segmentation, feature extraction, feature encoding detection and matching time.

In future it can also be used for iris image capturing videos from the moving force. Performance of Iris Perception based iris recognition was better than the Edge detection based iris recognition system which can be calculated by calculating the accuracy. The performance of iris perception based iris recognition system was better than the other detection based iris recognition system which can be calculated by calculating accuracy. The accuracy of the implemented system is 99.21%. Future work could go in the direction of using more than one modality to increase the level of security.