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Iris Recognition based on Region Growing using Wavelet Transformation

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Abstract: An accurate biometric system that is responsible for reliable identification and verification of an individual. The reliability and accuracy of identification is provided by distinctive patterns of person iris which differs from human to human up to the level of identical twin shaving distinct iris patterns. In this paper segmentation and the normalization processing for biometric iris recognition system, implemented and validated in MATLAB Software. In this work, image database digitized in gray scale, where iris recognition algorithms were implemented based on region growing using wavelet decomposition with Gabor filter; finally an alternative algorithm was designed and implemented. The experimental results show that accuracy of proposed iris recognition system is improved over existing system.

Keywords—Iris recognition, biometrics, iris segmentation, region growing, wavelet decomposition, Normalization.

I. INTRODUCTION

The term "Biometrics" refers to the authentication techniques in which a science including the biological characteristics. These measurable biological characteristic can be physical or behavioural such as eye, retina vessel, face, fingerprint, hand, voice, signature and typing rhythm. Biometrics is unique person identification, is one of the researches that is growing fast [1][2]. The merits of unique identification are several, such as secure access control and fraud prevention. A biometrics system provides great aids with esteem to other authentication techniques. They assured the physical existence of the user and more users friendly. Iris recognition is best reliable biometric technology for verification performance and identification. The iris is the blue colour portion that surrounds the pupil of the eye as shown in Figure1 [3][4]. This portion controls light levels inside the eye like as aperture on a camera. The iris is firmly with tiny muscles that enlargeand constrict the pupil size. The black colour portion inside the iris is called the pupil. This is fully rich textured patterns that offer various individual attributes which are distinct between the left and right eye of a person and between the identical twins. Iris patterns are highly stable with unique and time as compared with other biometric features, as the possibility of the presence of two irises that alike is probable to be as low as.

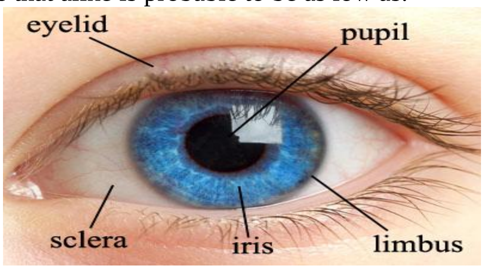

Figure1: Image of the eye

In this paper, image enhancement techniques are applied such that only useful data are encoded.Furthermore, the best combination of wavelet coefficient is found and used for effectiveID and the finestquantity of bits used for convertingthe feature vector has been deduced while maintaining low template size.
Daughman [3] offered the first positive implementation of an iris recognition system on the 2-D Gabor filter to generate a 2048 bits iris code by extracting texture phase structure information of the iris.
Several biometric methods have been marshalled in support of this experiment. The results are based on recognition of handwritten signature, retinal vasculature, hand shape, fingerprints, face and voice. The most important aspects for evaluating different biometric methods are universality, measurability, user friendliness, uniqueness, non-invasiveness, and permanence. For identification usesrequiring a huge database of people's records and effective comparison is necessary for biometric IDs. As per the above requirements, iris pattern is for reliable visual recognition of personswhen imaging done at distances of smaller than one meter. A pattern of human eye's irisvaries from person to person, even in identical twin. Thensize and shape changes continuously causing the iris, irises react with high sensitivity to light,

extremely difficult the counterfeiting based on Iris patterns. However, the pattern is fully detailed so it is also hard to recognize it.

In which present a general framework for image processing of iris images with a specific view on feature extraction. The process uses the set of texture and geometrical features based on the information of the difficult vessel structure of the sclera and retina. The extraction of feature contains the segmentation of the region of interest (ROI), image pre-processing and locating. The image processing of region of interest and the feature extraction are preceded then the feature vector is resolute for the human recognition and ophthalmology diagnosis. In the proposed method implement the"Biometric Iris Recognition based on the Region Growing using Wavelet Decomposition".

Iris recognition systems are divided into four blocks, iris segmentation, iris normalization, and feature extraction and matching. Iris segmentation separates an iris region from the entire captured eye image. Iris normalization fixes the dimensions of segmented iris region to allow for accurate comparisons. Feature extraction draws out the biometric templates from normalized image and matches this template with reference templates. The performance of an iris system closely depends on the precision of the iris segmentation. The present methods assume that pupil is always central to an iris; hence both pupil and iris share a central point. This inaccurate assumptions results in wrong a segmentation of an iris region. The upper and the lower parts of the outer iris boundary are generally obstructed by eyelids and eyelashes, this provides problems during segmentation. These eyelids and eyelashes act as noise which needs to be eliminated to achieve optimum segmentation results[5][6].

The remainder of this paper is organized as the following. At first, in Section II illustrate the various components of our proposed technique to ocular detection. Further, in Section III present some key experimental results and evaluate the performance of the proposed system. At the end provide conclusion of the paper in Section IV and state some possible future work directions.

II. PROPOSED TECHNIQUE

This section illustrates the overall technique of our proposed "Iris Recognition based on the Region Growing using Wavelet Transformation".In this paper iris segmentation using Wavelet transformation is effective in segmenting the iris portion. But the segmentation accuracy should be improved. Thus a novel segmentation approach based on region growing has been provided. Region growing segmentation is a direct construction of regions. Region growing methods are usually better in noisy images where edges are enormously difficult to detect**.** The region based segmentation is splitting of the image into homogenous areas of connected pixels through the application of homogeneity criteria among candidate sets of pixels. Each of the pixels in a region is similar with respect to some characteristics or computed property such as colours, intensity and texture. Three major procedures involved in the proposed iris segmentation approach, namely papillary detection, limbic boundary localization, and eyelids and eyelash detection, were carefully designed in order to avoid unnecessary and redundant image processing, and most importantly, to preserve the integrity of iris texture information.

Iris recognition is most accurate and reliable biometric identification system available in the current scenario. Iris recognition captures an image of an individual's eye; the iris is used for segmentation and normalized for feature extraction process. The performance of iris recognition systems highly depends on the segmentation process. With the help of segmentation, localization of the iris region in an eye is detected and it must be done correctly and accurately to remove the eyelashes, eyelids, pupil noises and reflection present in iris region. In our proposed work wavelet decomposition for Iris Recognition used. In which iris images are chosen from the IIT and MMU Database, then detected the iris and pupil boundary from rest portion of the eye image and removing the noises. Normalized segmented iris region to minimize the dimensional contradictions between iris. The features of the iris was encoded by convolve the iris region byGabor filters,so as to produce a bit-wise biometric template.For accurate separation point between the intra class and inter class distribution, using false reject rate and false accept rate.

The (FRR) false reject rate measures the probability of an enrolled individual which is not being identified by the system. The (FAR) false accept rate measures the probability of an individual who is falsely identified as another individual[5]. The FRR and FAR can be evaluated by the overlap amount between two distributions.

FAR is defined as

$$FAR = \text{no. of incidents of false acceptance} \div \text{total no. of samples} * 100 \quad \ldots (1)$$

FRR is defined as:

$$FRR = \text{no. of incidents of false rejections} \div \text{total no. of samples} * 100 \quad \ldots (2)$$

A. Characteristics of Iris

Iris is a circular diaphragm that lies between the lens and thecornea of the eye. Figure shows iris's front-on view. The iris function is to control the light level entering through the pupil.The size of the pupil is adjustedby the sphincter or dilator. The average iris diameter is 12 mm, and the pupil size of iris diameter may bevarying from 10% to 80%. Iris contains various layers; the lowermost is the epithelium layer (EL) which consistsof pigmentation of cells. The next above the EL layer is stromal layer which contains blood vessels, iris muscles and pigment cells. To determines the colour of the iriswith the help of stromal layer pigmentation density. In which iris of multi-layeredhave two zones, thatare differ in colours and these two zones are inner pupillary zoneandouter ciliary zone that appears as a zigzag pattern.It is the colour portion (brown or blue) of the eye that regulates the size of the pupil. The coloration and structure of two irises is genetically linked but the details of patterns are not. They have stable and distinctive features for personal identification.

*1) Iris segmentation:*The first step of iris recognition system is to isolate the actual iris region from the captured digital eye. The iris region may be estimatediris/pupil boundary and interior of the iris/sclera boundary. The eyelids and eyelashes normally obstruct the lower and upper iris region parts. In iris region specular light reflections can arise that corrupting the iris pattern, therefore a technique is essential to isolate and eliminate these artefacts. For our proposed system wavelet decomposition technique is used. Region growing segmentation is a direct construction of regions. Region growing methods are usually better where edges are hard to detect and also useful in noisy images[7][12][13]**.** The region based image segmentation into similar or homogenous areas of connected pixels through the application of homogeneity or similarity criteria among candidate sets of pixels. The region based image segmentation method is region growing and isfurther classified as a pixel based segmentation of image thatincludes the collection of initial seed points. This segmentation observesneighbouring pixels of the initial seed points and concludes whether the pixel neighbourswould be added to the region. Firstly, according to similarity constraints an initial set of small areas are iteratively merged. It starts by selecting an arbitrary seed pixel and compared theseseed pixels with neighbouring pixels. Then, the region is grownup due to seed pixel by addition of neighbouring pixels that are increasing the region size. When growth of one region stops, and then simply chooses another seed pixel which does not yet belong to any region and start again. The main advantages involved in the proposed method are that, the region growing techniques can distinct the regions which havesame properties and also provide unique images with good segmentation outcomes and clear edges. So multiple criteria's can be chosen at the same time and executes well according to noise [8] [14] [15].

*2) Iris Normalization:*Once the iris region issuccessfullysegmented from a captured image, the next process is to fix the dimensions of the segmented image in order to allow for comparisons. There are various causes' inconsistencies between eye images. Some of them are due to head tilt, rotation of the eye within the eye ball, pupil dilation, rotation of the cameraand changing of the imaging distance. The most affected inconsistency is due to the variation in the light intensities and illumination causes pupil dilation resulting in stretching of the iris. In order to remove these inconsistencies, segmented image is normalized [9] [11]. The normalization procedure will producesame constant dimensions for iris regions, so that under different conditions two same iris images which have same characteristicfeatures.

Remapping formula is given by eq.1.1

$$r' = \sqrt{\propto \beta} \pm \sqrt{\alpha\beta^2 - \alpha - r_1^2} \quad \dots (3)$$

with

$$\propto = O_x^2 + O_y^2$$

$$\beta = \cos\left(\pi - arc\tan\left(\frac{O_y}{O_x}\right) - \theta\right)$$

Where displacement of the centre of the pupil relative to the centre of the iris is given by $\boldsymbol{O_x}$**,** $\boldsymbol{O_y}$, and ***r'*** is the distance between the edge of the pupil and edge of the iris at an angle, θ around the region, and r_1 is the radius of the iris. The remapping formula first gives the radius of the iris region 'doughnut' as a function of the angle θ.

*3) Iris Localization:*Iris Localization determines overall efficiency of iris recognition algorithms. Image acquisition captures the iris of a large image thatholds data derivefrom the surrounding eye region. So, prior to performing iris pattern matching, firstlyportion of the acquired image is to be localize. It is essential to localize the image portionthat derive from the limbusand outside the pupil in which limbus is the edgebetween iris and sclera. Usually, the limbic boundary is imaged with high contrast, owed to the sharp change in eye pigmentation that it marks. The upper and lower portions of this boundary can be occluded by the eyelids. The image contrast between a heavily pigmented iris and its pupil can be quite small. If occlude part of the iris are eyelids, so only that partoverhead the lower eyelid and under the upper eyelidwould be involved [7] [10]. While the pupil normally is darker than iris, the inverse relationship holdsthe lens leads to a substantialquantity of backscattered light. The eyelid contrast may be relatively variable dependsupon relative pigmentation in iris and skin like as pupillary boundary. Due to the presence of eyelashes the eyelid boundary can be irregular. According to thatobserved iris localization should be delicate to a wide rangingof edge contrasts, capable of dealing with variable occlusion and robust to irregular borders. The systems differ mostly in the way that they search theirparameter spaces to fit the contour models to the image information.

4) Iris Recognition: Iris recognition is a technique used for recognize the peoples based on unique patterns and it is considered a form of biometric verification. The iris is an outwardly visible, however organ whose unique epigenesist pattern unchanging throughout life. These characteristics areused as a biometric for recognizing individual. Image processing methods can be used to extract the unique pattern of iris from aneye's digitized image and stored in a database after encoded into a biometric template. This type of biometric template comprisesmathematical representation of the distinctive information stored in the iris, and permits comparisons to be through between templates. Once a subject needs to be identified by iris recognition system, their eye is first photographed, and at that time a template created for iris region. Then this resulting template is compared with those templates that stored in a database till either found a matching template so the subject is well-known, or if no matching templateso the subject remains unidentified [8][16].

*5) Wavelet Decomposition:*Discrete Wavelet Decomposition (DWD) is a mathematical tool for hierarchically decomposing an image. It is useful for processing of non-stationary signals. The transform is based on small waves, called wavelets, of varying frequency and limited duration. Wavelet transform provides both frequency and spatial description of an image [9]. Unlike conventional Fourier transform, temporal information is retained in this transformation process. Wavelets are created by translations and dilations of a fixed function called mother wavelet. DWT is the multi resolution description of an image the decoding can be processed sequentially from a low resolution to the higher resolution. The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts. The high frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges. In two dimensional applications, for each level of decomposition, first perform the DWD in the vertical direction, followed by the DWD in the horizontal direction [6] [17].

6) Gabor filter: In image processing, a Gabor filteris a used for edge detection and it is a linear filter. Gabor filter's frequency and orientation representations are like as human visual system, and has been found to be mainlyfor texture representation and discrimination. 2D Gabor filter (GF) ismoderated by a sinusoidal plane wave in the spatial domain. So, perception in the human visual system is similar to the analysis of image by using Gabor functions. The impulse response of these filters is defined by a sinusoidal wave multiplied by a function of Gaussian. For the reason that of the Convolution theorem, the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the Gaussian function and the Fourier transform of the harmonic function. The filters havea real and an imaginary part representing orthogonal directions.These two constituents may be formed into a complex number or may be used individually.

Complex

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}\right) \exp\left(i\left(2\pi \frac{x'}{\lambda} + \psi\right)\right) \ldots (4)$$

Real

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}\right) \cos\left(2\pi \frac{x'}{\lambda} + \psi\right) \ldots (5)$$

Imaginary

$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}\right) \sin\left(2\pi \frac{x'}{\lambda} + \psi\right) \ldots (6)$ Where

$$x' = x\cos\theta + y\sin\theta$$

and

$$y' = -x\sin\theta + y\cos\theta$$

In this equation,θrepresents the orientation of the normal to the parallel stripes of a Gabor function, λ represents the wavelength of the sinusoidal factor,γ is the spatial aspect ratio,ψis the phase offset and σ is the sigma deviation of the Gaussian envelope. Gabor filters arerelated to Gabor wavelets directly, so they can be used for a number of dilations and rotations. In usually, they require computation of bi-orthogonal wavelets so extension is not useful for Gabor wavelets which could be very time consuming. Hence a filter bank containingGabor filters with numerousrotations and scalesaremade. Palmer and Jones shows that the real part of the complex Gabor function is a best fit to the receptive field weight functions set up in simple cells in a cat's striate cortex. The filters are convolving with signal, resulting in a Gabor space and this process is thoroughly related to primary visual cortex processes.The Gabor space is suitable in applications of image processing such as fingerprint recognition, optical character recognition and ocular detection.Additionally, essential activations can be taken out from the space of Gaborto create a sparse object representation. In an image relations between activations for a specificspatial location aredistinguishing between objects [10].

7) *Region Growing:*Region growing segmentationisadirect construction of regions. Region growing techniques are generally better in noisy images where edges are extremely difficult to detect**.** The region based segmentation is partitioning of an image into similar or homogenous areas of connected pixels through the application of homogeneity or similarity criteria among candidate sets of pixels. Region growing is a modest region based segmentationtechnique. It is classified as a pixel based segmentation of image that includes the collection of initial seed points. This segmentation observes neighbouring pixels of the initial seed points and concludes whether the pixel neighbours would be added to the region. Firstly, an initial set of small areas are iteratively merged according to similarity constraints. It starts by choosing an arbitrary seed pixel and compare it with neighbouring pixels. Then, the region is grown from the seed pixel by adding neighbouring pixels that are similar, increasing the size of the region. When growth of one region stops, and then simply chooses another seed pixel which does not yet belong to any region and start again. The main advantages involved in the proposed method is that, the region growing approaches coulddistinct the regions that have same properties and also provide the images that have clear boundaries with effective segmentation results. The multiple measurescan be selected at the time and well performed with respect to noise.

This level of accuracy of an iris recognition system depends on the precision of the segmentation of an iris region. The eyelids and eyelashes which obstruct the upper and lower parts of the outer iris boundary are removed perfectly. This enhances the accuracy of the system in that, only the iris region can be converted to biometric templates for matching. Wavelet decomposition method proposed on this paper proofed to be more effective compared to prevailing methods [18].

IV. BI-ORTHOGONAL WAVELET TRANSFORM

A bi-orthogonal wavelet is a wavelet where the associated wavelet transform is invertible but not necessarily orthogonal. Designing of bi-orthogonal wavelets permits extra degrees of freedom than orthogonal. In which one degree of freedom is the possibility to construct symmetric wavelet functions.

Syntax:

[Lo_D,Hi_D,Lo_R,Hi_R] = biorfilt(*DF*,*RF*)

[Lo_D1,Hi_D1,Lo_R1,Hi_R1,Lo_D2,Hi_D2,Lo_R2,Hi_R2] = biorfilt(*DF*,*RF*,'*8*')

The command biorfilt returns the four or eight filters associated with bi-orthogonal wavelets.[Lo_D,Hi_D,Lo_R,Hi_R] = biorfilt(*DF*,*RF*) calculates four filters associated with the bi-orthogonal wavelets identified by decomposition filter (DF) and reconstruction filter (RF). These filters are

Table1: Bi-orthogonal wavelet filters

Lo_D	Decomposition low-pass filter
Hi_D	Decomposition high-pass filter
Lo_R	Reconstruction low-pass filter
Hi_R	Reconstruction high-pass filter

The wavelet transform is implemented with a perfect reconstruction filter bank. The idea is to decompose the image signals into sub-images corresponding to different frequency contents. Let H(ω) and $G(\omega)$ be the low-pass and high-pass filters of a perfect reconstruction filter bank, respectively. In the one-dimensional (1-D) case with one-level decomposition, the input signal $x[n]$ is filtered by $h[n]$ and $g[n]$. Then, the resulted sub-image signals are down-sampled by a factor of two. For the bi-orthogonal wavelet transform used here, the decomposition procedure takes the form:

$$x_L[n] = \sum_k h[k]\, x[2n-k] \text{ and} x_H[n] = \sum_k g[k]\, x[2n-k] \ldots (7)$$

where $x_L[n]$ and $x_H[n]$ denote the approximation and detailed sub-image signals, respectively. The perfect reconstruction is performed by the complementary synthesis filters $h[n] and g[n]$ as follows:

$$x[n] = \sum_k h[2k-n]\, x_L[n] + \sum_k g[2k-n] x_H\, [n] \ldots (8)$$

A) Proposed algorithm

1) Firstly load the iris image.
2) Apply canny edge detection on image from step (1).
3) Apply gabor filtering using equation (4), (5)&(6) on image from step (2).
4) Apply normalization on iris image from step (3) and calculate displacement of pupil centre from the iris centre with help of equation (3).
5) Then load dataset of iris images.
6) Perform recognition with bi-orthogonal wavelet using equation (7) & (8).
7) Calculate percentage matching with FAR and FRR by using equation (1) &(2) that provide recognised image.

V. RESULTS AND DISCUSSION

Wavelet transformation provides better results in case of identification and verification. Wavelet transform is an operative tool forIris Recognition.To verify the effectiveness (qualities and robustness) of the proposed iris recognition, conduct several experiments on several images.The first objective of this thesis work is fulfilled by normalization of iris image for feature extraction.

To fulfil the second objective, to create recognition algorithm for image recognition that gives better results as compared to present matching algorithms. This recognition of images has been possible with help of bi-orthogonal wavelet. Proposed Recognition algorithm applied on IIT Delhi and MMU databases for performance evaluation.

Performance evaluation has been done using two databases these are – IIT Delhi and MMU databases. In IIT Delhi database there are 70 images of different persons having size of 320x240 are stored and in MMU database there are containing 67 images of different people having size of 320x238 are stored. Some sample grayscale iris images are shown in Figures:

Figure 2: IIT Dataset of Iris Images

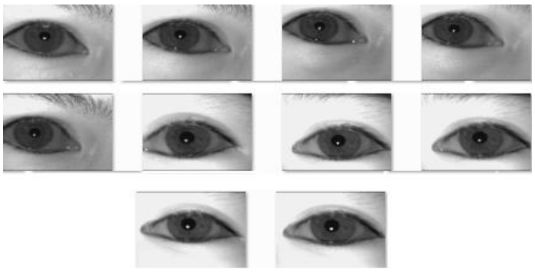

Figure 3: MMU Dataset of Images

The main figure window of our proposed method is given below:

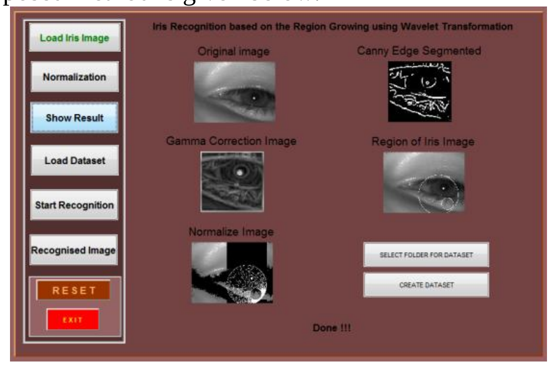

Figure 4: Running Figure Window

Results:

Figure 5: Original Iris Image

In this thesis work firstly load the original iris image for person's identification and verification. At backend folder have many iris images that are used for recognition. These iris images are compared with particular iris dataset after normalization. Recognition depends on FAR and FRR values of image. If FAR value greater than FRR so iris image matched with dataset otherwise iris image does not match with dataset. Normalization applied by various techniques such as canny edge detection, gamma correction, Hough transform etc. In this normalization process has following iris images:

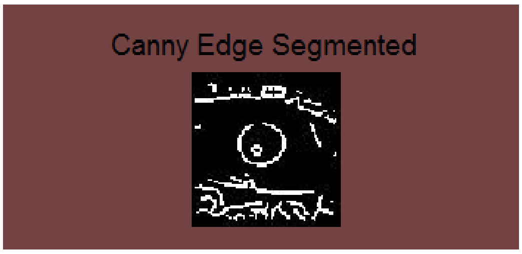

Figure 6: Edge Image

Canny edge segmented is used for edge detection of iris image. All the edges have been detected and almost all of the noise has been removed after applying canny operator on original image.

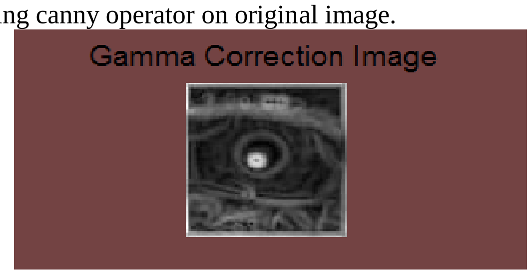

Figure 7: Gamma Correction Iris Image

Gamma Correction controls the overall brightness of an image. Images which are not properly corrected can look either bleached out or too dark.It defines the relationship between a pixel's numerical value and its actual luminance.

Figure 8:Region of Iris

The Hough transform is a feature extraction technique used in image analysis, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform.

Figure 9:Normalized Image

After that finally received normalized image that image matched with dataset. If this image matched with dataset so image recognized otherwise not.

Flow Chart of proposed method:

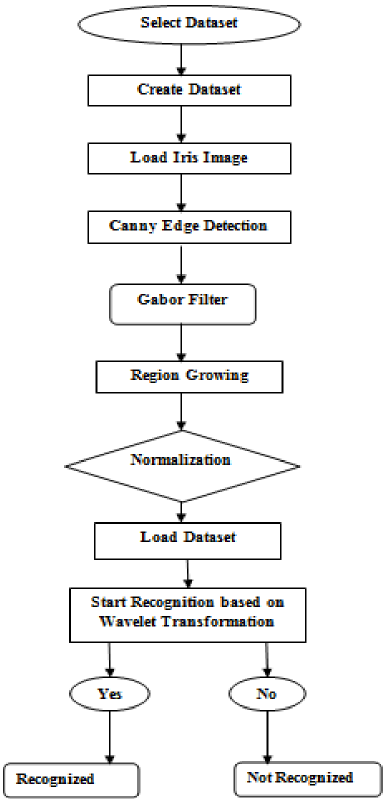

Figure 10: Flowchart of Proposed System

For objective evaluation various parameters like FAR (False Acceptance Rate) and FRR (False Rejection Rate) are used.Graphical comparison shows result of MMU dataset and IIT dataset by using FAR and FRR values taking from different images is shown in Figure 11-12.The final graph shows exact % of both dataset using these two values shown in Figure 13.

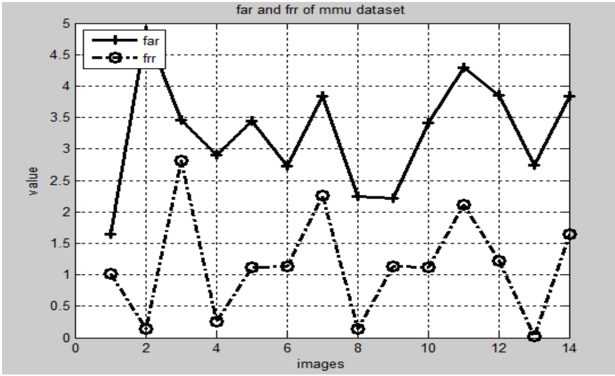

Figure 11: Result of far and frr of mmu dataset

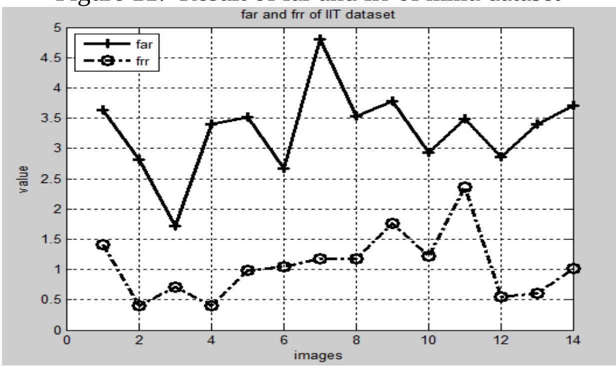

Figure12: Result of far and frr of IIT dataset

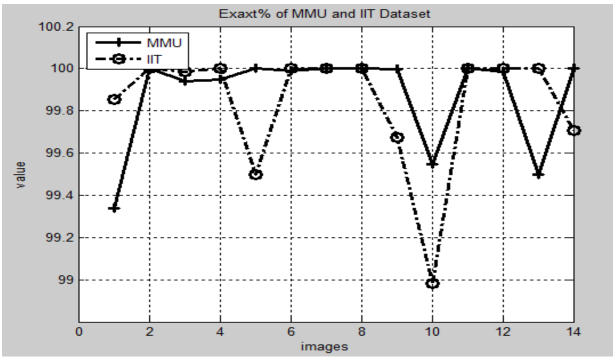

Figure13: Result of Exact (%) of both dataset

VI. CONCLUSION AND FUTURE SCOPE

In the proposed work, Iris Recognition based on the Region Growing using Wavelet Transformation is presented. Canny algorithm for edge detection among others is characterized for its versatility. In this work many databases and use 1000 images in dataset. Simulationshows that the Accuracy of the proposed iris recognition system is improved than present system. In which FRR is always greater than FAR in case of image is not matching with datasetand FAR is always greater than FRR in case of image matching with dataset.Our proposed method has more accuracy and capacity of recognition.

This work can extended further on iris video with help of matching technique. The main limitation of this work is that it does not provide 100% accuracy. In future achieve 100% accuracywith the help of other matching technique and also increase the limit of dataset. Dataset can store unlimited images in future.

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