Indian Iris Image Segmentation using Nelder-Mead Simplex Method

Anupam Tiwari
Sri Shankaracharya College of Engineering and Technology,Bhilai

Vinay Jain
Sri Shankaracharya College of Engineering and Technology,Bhilai

ABSTRACT
In this paper, we describe a new approach of employing Nelder-Mead optimization (NMO) simplex method in Iris image segmentation. In this paper we are using modified way of Libor masek method. In modified Libor masek method mainly in preprocessing phase in segmentation we are using Nelder-Mead search method also called as simplex method for calculation of center coordinates, radius and threshold in iris image. Here we are using IIT Delhi database of Indian person's iris for our iris image segmentation.

Keywords
Iris recognition, Nelder-Mead simplex method, iris image segmentation, features extraction.

1. INTRODUCTION
Biometrics system has the ability for application programs to identification and verification of individuals for operating get at to secured areas; many countries endorse biometrics research for unique identification of a person. America came in ahead to begin a plan (known as USVISTOR) to supervise all person traveling USA by employing his or her biometrics features as face, iris and fingerprint [1]. Iris biometrics gets more publicity and has influenced conduct of research and development attempts in recent years leading to be one of the most accurate and unique biometrics systems currently usable. The iris biometrics, still, has not so far become omnipresent as compared to face and finger-prints [2]. It uses physiological or behavioral features to recognize an individual. The physiological features of human are iris, fingerprint, face, and hair and hand geometry. The behavioral features of human are voice, signature and keystroke dynamics. Between these features, iris posses unique phase information which bridges about 249 degrees of exemption This reward let iris recognition be the most accurate and true biometric identification.[3]Before going in to the actual procedure it is needed to the properties of the iris thus compared to other biometric technique, iris recognition has many virtues:

Uniqueness: The seeable features in an iris admit the trabecula mesh of connective tissue, collagenic stromal fibers, ciliary processes, muscle contraction and free mount, these textures ascertain that many persons have unique iris, yet twins as well differ through iris, no two irises are similar in their mathematical form, still between identical (monozygotic) twins. The chance of two irises could give rise to precisely the similar iris code is approximately 1 in 10^78. This reality is the conclude why we use iris to recognize personal identity [4],

Reliability: Iris is an internal organ in human eyes and covered by eyelid, eye lash and cornea. In any accident finger or palm may have damage but not the iris as this is inner organ of human eye. Unlike finger and palm, it is seldom injury and error of recognition caused by scratch will never happen. In this common sense, iris recognition is better than fingerprint and palm-print recognition. Iris shaping takes on the early stages of birth and irises grow when humans are one year old and would not change in their life span and become stable.

The iris became a much researched field. Human iris comprises unique and very important feature about persons. Related works have been done in the medicine's domain (determination of some possible health condition [5]), in biometrics domain (identification and recognition of a person [6]) and others. Biometrics deals a vital role in public safety, security and each individual to determine them from each other [7]. The conventional technique simply using magnetic cards or cards with some bar codes printed on it. The major problem in these types of technique is that the cards should be expressed on where ever a person goes. There are probability of the cards may be stolen or misplaced. Of course there are many instances of duplicating of finger prints and magnetic cards and there have come into light. The department of forensic and cyber crime has difficult a time in hacking the cases and tracking the culprits.

The human iris is unique and cannot be replicated or imitated, afterwards it is impractical to evoke an iris image without the knowledge of an individual. Iris region is the portion between the pupil and the white sclera. This field is sometimes called iris texture. The iris texture provides many minute features such as freckles, coronas, stripes, furrows, crypts, etc [5]. From the born of a person till death, the patterns of the iris are relatively stable over a person's lifetime [6][7]. Because of this uniqueness and stability, iris recognition is a true human recognition technique. The procedure of iris recognition comprises of iris image capturing, pre-processing, and recognition of iris region in eye image. The iris image preprocessing includes localization.

In practice, the recognition procedure starts when an image of the eye from a person located in front of the digital camera is taken. In the process of image acquisition$T_x = f(f_x)$a digital representation of the biometrics $T_x$is obtained from a real biometricf_x. Iris is outwardly seeable, due to epigenetic nature whose pattern is in same state throughout adult's life. These unique feature make it suitable for use for analysis of biological data as biometric for distinguish individuals.

Image processing techniques is apply to evoke the unique iris pattern from a digital eye image, and further using to encode it into a biometric template. The unique information stored in the iris is determined by some form of mathematical transformation gives biometric template, and these are for make a equivalence or comparison between template. When any one wants to identify himself through iris recognition system, the eye image is first captured by using a camera and some transformation is apply to make a template for iris region in an eye image. This at a time taken or currently made template put on iris recognition system to compare with the other template stored in a database, until the final result has come as subject is identified or subject is unidentified.

In section 2 we are discuss the steps in iris recognition, in section 3 we discuss the proposed method, in section 4 template matching, and in section 5 we discuss results.

2. STEPS IN IRIS RECOGNITION SYSTEM

There are three main steps of an iris recognition system. They are, image preprocessing, feature extraction and template matching. Image can be captured by using high resolution Gray scale iris camera and then it is fed to the following steps involve in iris recognition system process. So here we are already prepare a database for iris recognition. When we get iris template after preprocessing and feature extraction as in (fig.1)

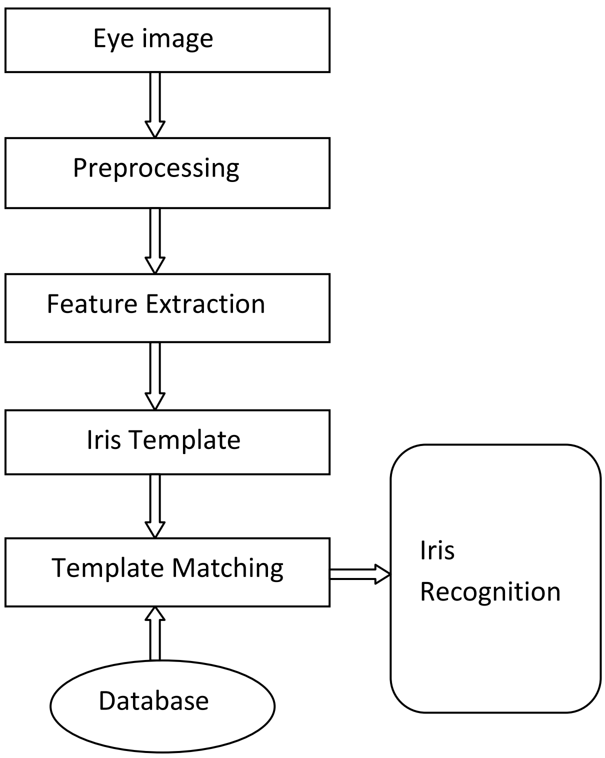

Figure 1: Steps in iris recognition system

2.1 Preprocessing and Segmentation

After putting in the eye images in the database, the images for generic information from the pupil and iris are detected. To extract out the true image of iris the unused portion across the iris has to be removed. The iris image is to be preprocessed to get useful information in iris region. Image preprocessing is divided into three steps: iris localization, iris normalization and image enhancement. Iris localization detects the inner and outer boundaries of iris from eye image [1], [2]. In iris normalization, iris image is transformed from Cartesian coordinates to Polar coordinates. Basically the iris image has low contrast and non-uniform illumination caused by the placing of the light source. All these reason can be compensated by the image enhancement algorithms. In iris recognition system, accuracy is a measure of performance. Accuracy of the system is highly depends on accurate iris segmentation. Better the iris is localized, better will be the performance of the iris recognition system [3]. Iris segmentation detects the true iris region in an eye image. It is vital to the success of system followed by feature extraction and template matching steps. We are not focusing on template matching the instead we are interested in segmentation hence we have used the existing algorithms for matching but focusing only on image preprocessing normalization feature extraction and segmentation algorithm.

2.2.1 Iris Segmentation

In preprocessing stage, several methods were implemented for feature extraction and noise removal in order to extract the iris from the captured image. In the process of segmentation, it may be necessary to use certain algorithms whose task is to further prepare the image for processing by the feature extraction algorithms.Portions of the work tested on the IITD Iris Database [14].

The author have modeled the iris boundary as an elliptical surface and used Daughman's Integro-differential Operator [6] to segment the iris portion accordingly. eq. (1)

$$max_{(r,x_0,y_o)}\left|G_\sigma(r)*\frac{\partial}{\partial r}\oint_{r,x_0,y_0}\frac{I(x,y)}{2\pi r}\,ds\right| \qquad (1)$$

A coarse search is done to extract the approximate pupil image and a fine search is done to the obtained pupil for an exact iris image. The upper and lower part of the pupil image is discarded to avoid the effects of eye lashes and eye lids.

2.2.2 Iris Normalization

After segmentation certain portions of the circular iris is thrown away in order to void occlusion [3][4]. This step is often needed, because almost in all the images an occluded iris is meeting. After detecting the non concentric outer and inner circular shapes of the iris, the circular shape of the iris image can now be transformed into a rectangular image by normalizing the iris image. The transformation can be done as shown below eq. (2)

$$I\big(x(r,\theta),y(r,\theta)\big) \quad \rightarrow \quad I(r,\theta) \qquad (2)$$

Daugman's Rubber Sheet Model Daugman [6] prepared homogenous rubber sheet modal in which it remaps each point are in iris image region to a another polar coordinates (r, θ) where r is varying to interval [0,1] and θ is varying to interval [0,2π]. The Cartesian coordinates (x, y) are remaps in normalized eccentric polar coordinates (r,θ).where I (x, y) iris image region.

2.2 Iris Feature Extractions

Feature extraction is to extract out the selective information of an iris normalized image as color and texture, as compared with color of the iris image, Texture posses most distinguish features or characteristics in iris image. We are talk about here some methods used in feature extraction of eye image. The iris biometric £ can be examined in many ways to get its digital template T. In all cases regarding iris recognition system, results are based on iris texture filtering, but they can vary significantly in their using method. The most feasible way is the phase-based method suggested by Daugman, which has been successfully employed in the most of available iris recognition systems. The main minus point of this approach is that the lighting conditions are not looked at while feature extraction. But here it is take over that the lighting conditions do not have much impression on the feature extraction. As well as , this method does not need a complex and costly vision system. This methodology, which is described in detail in [9], is very reliable and efficient. Therefore, many other solutions have been developed for iris feature extraction. The best-known techniques use spatial transformation of the iris texture and correlation of templates, as suggested by Wildes [10]; "zero crossings wavelet representation," as proposed by Boles and Boashas [11].

3. PROPOSED METHOD IN SEGMENTATION

Image segmentation is a significant element in an artificial visual system, it comprises in extracting out objects from the background or separate different regions in an image prospective. The segmentation problem has obtained a great deal of attention; hence any effort to review the literature would require too much space. The development of the algorithm aims at improving the performance of the segmentation techniques in current practice, Nelder-Mead simplex method [12] in order to integrate their advantages and features. NM method is very effective for local search but its convergence is very sensible to the starting point selected in problem domain.

Nelder-Mead method (simplex method)

It is a definitive powerful local descent algorithm making no use of the objective function derivatives. A simplex is a geometrical figure containing, in n-dimensions, of (n+1) points $x_0, \dots\dots, , x_n$[12]. If any point of the simplex is chosen as the reference point, the n other points define vector directions that bridge the n-dimension vector space. If we abruptly describe as initial starting pointx_0, then the other points are generated by the relation$x_i = x_0 + \lambda . e_j$, where e_j n unit vectors, and λ is a constant (typically equal toone).

The simplex employs four simple geometric transformations: reflection, contraction, expansion and multi-contraction. Through these operations the simplex can improvise itself and come nearer to a local optimum sequentially. The initial simplex moves, expands or contracts. To select the appropriate transformation, the method only using the values of the function to be optimized at the vertices of the simplex considered. After each transformation, the current worst vertex is substituted through a better one. Trial moves are generated according to the following elementary operations (where x is the average value of the vector components and are constants): equations are (3) (4) (5)

reflection: $x_r = (1-\delta)\tilde{x} - x_{n+1}$ (3)

expansion: $x_e = \gamma\, x_r + (1-\gamma)\tilde{x}$ (4)

contraction; $x_c = \beta x_{n+1} + (1-\beta)\tilde{x}$ (5)

The algorithm initiates through moving only the point of the simplex, where the objective function is "high" and another point image of the worst point is generated (reflection operation). If the new point is better than all the others, the simplex is expanded in this direction, other then, if it is at least better than the worst, the reflection is executed again with the new worst point. The algorithm performs a contraction step when the worst point is at least as good as the reflected point, in such a direction that the simplex accommodates itself to the function landscape and finally fences the optimum. If the worst point is better than the contracted point, the multi contraction is executed. At each step, we check that the generated point is not outside the allowed reduced solution space. A simplex is a geometric figure in n dimensions that is the convex frame of n + 1 vertices. We denote a simplex with verticesx_1, x_2 . . .x_{n+1}byΔ.The Nelder-Mead method iteratively generates a sequence of surplices to approximate an optimal point in iterations, the vertices$\{x_j\}_{j=1}^{n+1}$ of the simplex are ordered according to the objective function values eq. (6)

$$f(x_1) \le f(x_2) \le \dots\dots\, f(x_{n+1}) \quad (6)$$

We referx_1 to as the best vertex, and $x_{n+1}$to as the worst vertex.
Let $\tilde{x}$be the centroid of the n best vertices. Then

$$\tilde{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Nelder-Mead algorithm for segmentation

1. Sort. Evaluate f at the n+1 vertices of Δ and sort the vertices so that (2.3) holds.

2. **Reflection**. Calculate the reflection point x_r from

$$x_r = (1-\delta)\tilde{x} - x_{n+1}$$

Evaluate f_r= f (x_r). If$f_1 \le f_r \le f_n$, substitute with$x_{n+1}$with x_r.

3. Expansion. If $f_r < f_1$ then calculate the expansion point $x_e$from

$$x_e = \gamma\, x_r + (1-\gamma)\tilde{x}$$

And measure f_e= f (x_e). If,$f_e < f_r$substitute $x_{n+1}$with x_e; otherwise replace with x_r .

4. outside Contraction. If $f_n \le f_r \le f_{n+1}$, calculate the outside contraction point

$$x_{oc} = \beta x_{n+1} + (1-\beta)\tilde{x}$$

And evaluate f_{oc}= f (x_{oc}). If $f_{oc} \le f_r$, substitute$x_{n+1}$with; x_{oc}otherwise go tostep 6.

5. inside Contraction. If $f_r \ge f_{n+1}$, calculate the inside contraction point x_{ic} from

$$x_{ic} = \beta x_{n+1} + (1-\beta)\tilde{x}$$

And evaluate f_{ic}= f (x_{ic}). If $f_{ic} < f_{n+1}$substitutex_{n+1} with x_{ic}; otherwise, go tostep 6.

6. Shrink. For, define$2 \le i \le n+1$

$$x_i = x_1 + \delta(\, x_i - x_1)$$

4. TEMPLATE MATCHING

Template matching compares the user template with templates from the database using a matching algorithm. The matching metric will give a measure of similarity between two iris templates. It gives a range of values when comparing templates from the same iris, and another range of values when comparing templates from different irises. Finally, decision with high confidence level is made through matching methods to identify whether the user is an authentic or imposter.

Hamming Distance

The Hamming distance gives a measure of how many bits are the same between two bit patterns. Using the Hamming distance of two bit patterns, a decision can be made as to whether the two patterns were generated from different irises or from someone. The Hamming distance establishes a measure of how many bits are the same as between two bits patterns which we are get from feature extraction process. Employing the Hamming distance of two bit patterns, a conclusion as to whether the two patterns were generated belongs to other irises or from the same one. In comparing the bit patterns X and Y, the Hamming distance, HD, is define as the sum of disagreeing bits (sum of the exclusive-OR between X and Y) over N, the total number of bits in the bit pattern. eq. (7)

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j(XOR)Y_j \qquad (7)$$

Later on an individual iris region comprises features with high degrees of freedom, each iris region will give a bit-pattern which is autonomous to that given by another iris, on the other side, two iris codes generated from the same iris will be highly correlated. If two bits patterns are completely independent, such as iris templates generated from different irises, the Hamming distance between the two patterns should equal 0.5. This why because independence reflects the two bit patterns will be completely random, that's why there is 0.5 probability of setting any bit to 1, and vice versa. Hence, half of the bits will agree and half will disagree between the two patterns. If two patterns are deduced from the same iris, the Hamming distance between them will be close to 0.0, since they are highly correlated and the bits should agree between the two iris codes. The Hamming distance is the matching metric suggested by Daugman, and computing of the Hamming distance is taken only with bits that are produced from the actual iris region. The time to point the iris camera can be improved with faster hardware, or by a strategy of tracking people as they approach the system, so the iris camera can be already pointed close to their position when they pause and look at the camera. We expect the system such that iris location and segmentation time to be significantly faster when using commercial iris recognition systems, relative to the Masek implementation [8].

Weighted Euclidean Distance

The weighted Euclidean distance (WED) can be used to compare two templates, especially if the template is composed of integer values. The weighting Euclidean distance gives a measure of how similar a collection of values are between two templates. This metric is employed by Zhu et al. [13] and is specified as eq. (8)

$$WED(k) = \sum_{i=1}^{N} \frac{(f_i - f_i^{(k)})^2}{(\delta_i^{(k)})^2} \qquad (8)$$

Where f_i is the i^{th} feature of the unknown iris, and $f_i^{(k)}$ is the i^{th} feature of iris template, k, and $\delta_i^{(k)}$ is the standard deviation of the feature in iris template k. The unknown iris template is found to match iris template k, when WED is a minimum at k.

For matching, the Hamming distance was chosen as a metric for recognition in our proposed method, because bit-wise comparisons were requirement. The Hamming distance algorithm used also integrate noise masking, such that only significant bits are used in computing the Hamming distance between two iris templates. Now when taking the Hamming distance, only those bits in the iris pattern that regards to '0' bits in noise masks of both iris patterns will be used in the calculation. The Hamming distance will be calculated using only the bits generated from the true iris region, and this modified Hamming distance formula is given as eq.(9)

$$HD = \frac{1}{N - \sum_{k=1}^{N} Xn_k(OR)Yn_k} \sum_{j=1}^{N} X_j(XOR)Y_j(AND)Xn'(AND)Yn' \qquad (9)$$

Where, X_j and Y_j are the two bit-wise templates to compare, Xn' and Yn' are the corresponding noise masks for X_j and Y_j, and N is the number of bits represented by each template.

Although, in theory, two iris templates generated from the same iris will have a Hamming distance of 0.0, in practically this will not often occur. Normalization is not perfect and complete, and also there will be some noise that goes underdetermine, so some alteration will be delivering when comparing two intra-class iris templates. In order to account for rotational inconsistencies in normalization process, when the Hamming distance of two templates is calculated, one template is shifted left and right bit-wise and a number of Hamming distance values are calculated from successive shifts. This bit-wise shifting in the horizontal direction corresponds to rotation of the original iris region by an angle given by the angular resolution used. If an angular resolution of 180 is used, each shift will correspond to a rotation of 2 degrees in the iris region. This method is suggested by Daugman [6], and corrects for misalignments in the normalized iris pattern caused by rotational differences during imaging. From the calculated Hamming distance values, only the lowest is taken, since this corresponds to the best match between two templates. The number of bits displaced at each shift is given by two times the number of filters used, since each filter will produce two bits of information data from one pixel of the normalized region of iris image. The actual number of shifts required to normalize rotational inconsistencies will be determined by the maximum angle difference between two images of the same eye, and one shift is defined as one shift to the left, followed by one shift to the right.

5. RESULTS AND DISCUSSION

To evaluate the proposed algorithm, for iris image segmentation discussed has been applied for IIT Delhi database. The results have been shown in figure 2.

The convergence profile is shown in figure.3. Segmentation performed using proposed method having better performance as compared with existing method. We are calculating up to 500 iterations. In Table 5.1 and 5.2 Cix, Ciy are center coordinates of the iris, radius iris of, and Δ is optimum threshold.

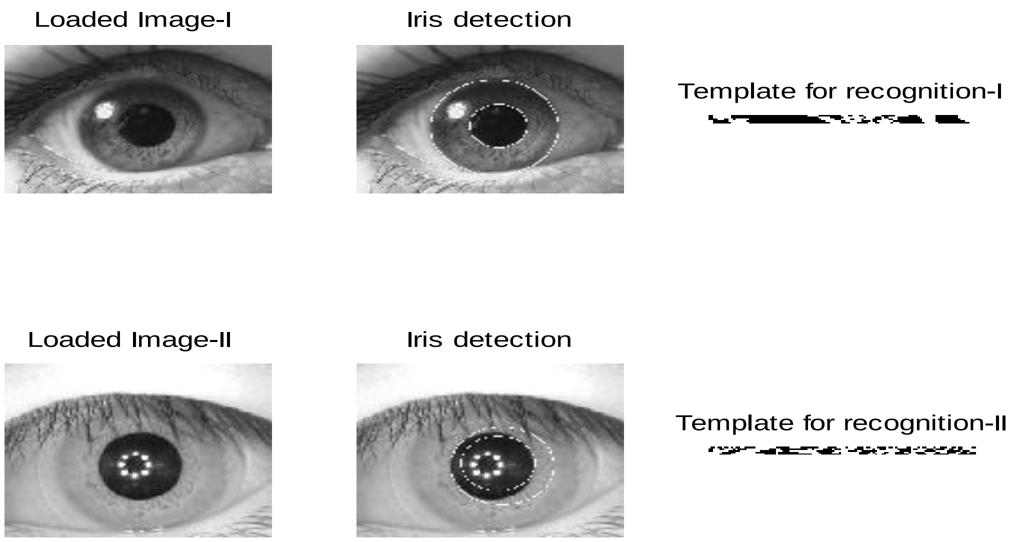

Figure 2: for iris image segmentation using Nelder-Mead method

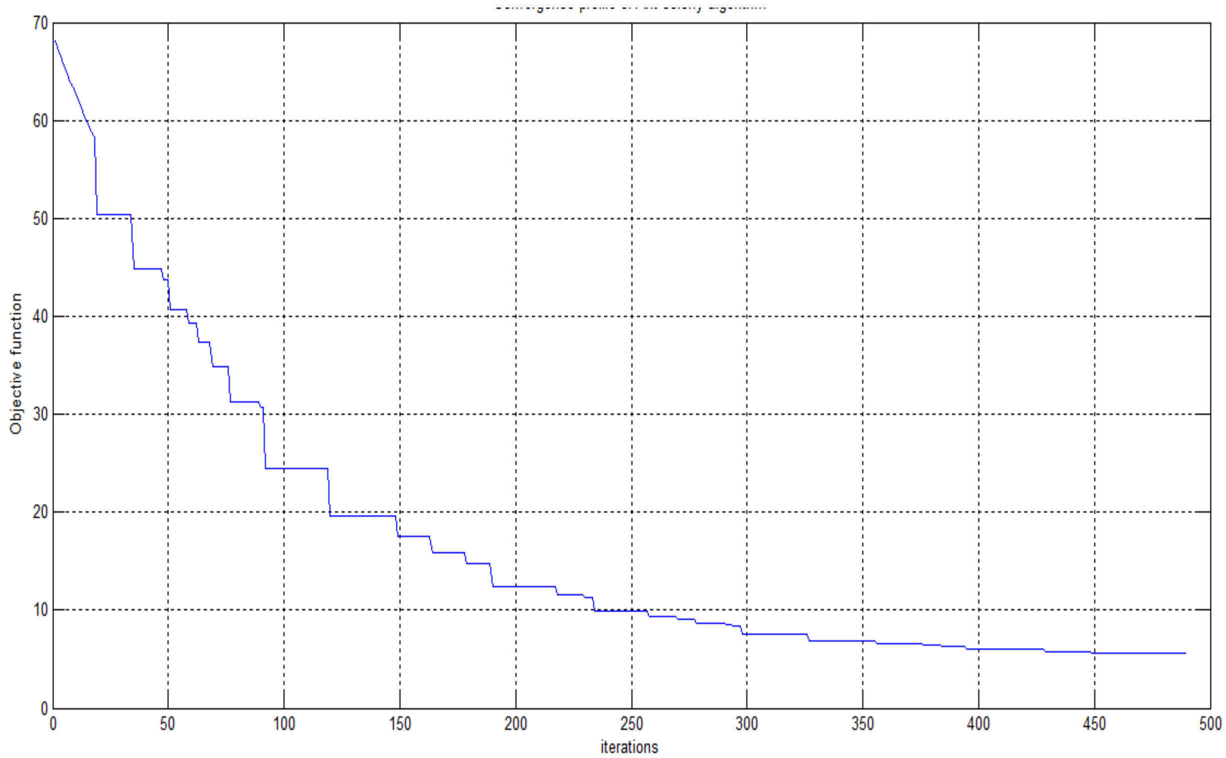

Figure 3: convergence profile of Nelder-Mead method

Table 1: Iris center coordinates, radius, threshold Using Nelder-Mead optimization

S.N.	Image	Cix	Ciy	radius	Δ (Threshold)
1.	1	148	136	64	0.49
2.	2	107	147	64	0.61
3.	3	139	140	67	0.49
4.	4	150	145	90	0.55
5.	5	134	115	68	0.46
6.	6	130	163	80	0.56
7.	7	143	103	76	0.45
8.	8	142	112	86	0.53
9.	9	132	156	70	0.37
10.	10	109	93	64	0.53
11.	11	141	158	67	0.44
12.	12	130	172	75	0.35

Table 2: Pupil center coordinates, radius, threshold using Nelder-Mead optimization

S.N.	Image	Cpx	Cpy	radius	Δ (Threshold)
1.	1	156	142	27	0.49
2.	2	103	150	17	0.61
3.	3	137	137	8	0.49

4.	4	147	142	7	0.55
5.	5	134	115	7	0.46
6.	6	127	168	7	0.56
7.	7	140	100	14	0.45
8.	8	139	118	37	0.53
9.	9	137	163	11	0.37
10.	10	110	98	7	0.53
11.	11	145	159	7	0.44
12.	12	128	180	9	0.35

6. CONCLUSIONS AND FUTURE SCOPE

The accuracy of iris recognition is dependent on the performance of the iris segmentation and matching method. The proposed algorithm is an improvement over existing algorithm in terms of its performance and efficiency in segmentation.

Segmentation is an important step in any iris recognition system, and in future most of the security environments are based on iris recognition. So most research continued in future would be improving the performance of iris recognition system.

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