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Iris recognition: An emerging security environment for human identification

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Abstract

Unlike other biometrics such as fingerprints and face, the distinct aspect of iris comes from randomly distributed features. This leads to its high reliability for personal identification and at the same time, the difficulty in effectively representing such details in an image. Iris is a protected internal organ whose random texture is stable throughout life, it can serve as a kind of living password that one need not remember but one always carries along. Because the randomness of iris patterns has very high dimensionality, recognition decisions are made with confidence levels high enough to support rapid and reliable exhaustive searches through national-sized databases. Iris recognition has shown to be very accurate for human identification. This paper proposes a technique for iris pattern extraction utilizing the graph cut method where the pupilary boundary of the iris is determined. The limbic boundary is identified by adaptive thresholding method. The iris normalization was invariant for translation, rotation and scale after mapping into polar coordinates. The proposed method has an encouraging performance, success rate of localization and normalization and reduces the system operation time. The proposed method involves Graph cut method, Adaptive thresholding, Normalization modules.

Keywords: ***iris, pattern, identification, thresholding, pupilary, normalization***

1. Introduction.

Biometrics is the science of measuring physical properties of living beings. It is a collection of automated methods to recognize an individual person based upon a physiological or behavioral characteristic. The characteristics measured are face, fingerprints, hand geometry, handwriting, iris, retinal, vein, voice etc. In present technology scenario biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solutions. As the level of security breaches and transaction fraud increases, the need for highly secure identification and personal verification technologies is becoming apparent. Biometrics involves using the different parts of the body, such as the fingerprint or the eye, as a password or form of identification. Currently, in crime Investigations fingerprints from a crime scene are being used to find a criminal. However, biometrics is becoming more public. Iris scans are used in United Kingdom at ATM's instead of the normal codes. In Andhra Pradesh Iris recognition is being used to issue house hold ration cards.

Practically all biometric systems work in the same manner. First, a person is enrolled into a database using the specified method. Information about a certain characteristic of the human is captured. This information is usually placed through an algorithm that turns the information into a code that the database stores. When the person needs to be identified, the system will take the information about the person again, translates this new information with the algorithm, and then compares the new code with the ones in the database to discover a match and hence, identification.

Biometrics works by unobtrusively matching patterns of live individuals in real time against enrolled records. Leading examples are biometric technologies that recognize and authenticate faces, hands, fingers, signatures, irises, voices, and fingerprints. Biometric data are separate and distinct from personal information. Biometric templates cannot be reverse-engineered to recreate personal information and they cannot be stolen and used to access personal information.

2. Iris

The iris has been historically recognized to possess characteristics unique to each individual. In the mid 1980s, two ophthalmologists ‘Dr. Leonard Flom’ and ‘Aran Safir’ proposed the concept that no two irises are alike[6]. They researched and documented the potential of using the iris for identifying people and were awarded a patent in 1987. Soon after, the intricate and sophisticated algorithm that brought the concept to reality and it was developed by Dr. John Daugman and patented in 1994[3].

2.1. Features of the Iris

The human iris is rich in features, can be used to quantitatively to distinguish one eye from another. The iris contains many colleagues fibers, contraction furrows, coronas, crypts, color, serpentine, vasculature, striations, freckles, rifts, and pits. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters for identification process. The statistical analyses indicated that the Iridian Technologies IRT process independent measures of variation to distinguish one iris from another. It allows iris recognition to identify persons with an accuracy with a magnitude greater than any other biometric systems.

2.2.Uniqueness of the Iris

The iris is unique due to the chaotic morphogenesis of that organ. Dr. John Daugman stated that "An advantage the iris shares with fingerprints is the chaotic morphogenesis of its minutiae. The iris texture has chaotic dimension because its details depend on initial conditions in embryonic genetic expression; yet, the limitation of partial genetic penetrance (beyond expression of form, function, color and general textural quality), ensures that even identical twins have uncorrelated iris minutiae. Thus the uniqueness of every iris, including the pair possessed by one individual, parallels the uniqueness of every fingerprint regardless of whether there is a common genome".

2.3.Stability of the recognition

An iris is not normally contaminated with foreign material, and human instinct being what it is, the iris, or eye, is one of the most carefully protected organs in one's body. In this environment, and not subject to deleterious effects of aging, the features of the iris remain stable and fixed from about one year of age until death. The human eye has physiological properties that can be exploited to impede use of images and artificial devices to spoof the system.The iris are perforated close to its centre by a circular aperture known as the pupil. The function of the iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of the pupil. The average diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter.

The iris consists of a number of layers, the lowest is the epithelium layer, which contains dense pigmentation cells. The stromal layer lies above the epithelium layer, and contains blood vessels, pigment cells and the two iris muscles. The density of stromal pigmentation determines the colour of the iris. The externally visible surface of the multilayered iris contains two zones, which often differ in color. An outer ciliary zone and an inner pupillary zone, and these two zones are divided by the collarette – which appears as a zigzag pattern.

The iris is the plainly visible, colored ring that surrounds the pupil. It is a muscular structure that controls the amount of light entering the eye, with intricate details that can be measured, such as striations, pits, and furrows. The iris is not to be confused with the retina, which lines the inside of the back of the eye. Figure1 shows human eye characteristics. No two irises are alike. There is no detailed correlation between the iris patterns of even identical twins, or the right and left eye of an individual. The amount of information that can be measured in a single iris is much greater than fingerprints, and the accuracy is greater than DNA.

Iris: This is the colored part of the eye: brown, green, blue, etc. It is a ring of muscle fibers located behind the cornea and in front of the lens.

Pupil: Pupil is the hole in the center of the iris that light passes through. The iris muscles control its size.

Sclera: The sclera is the white, tough wall of the eye. It along with internal fluid pressure keeps the eyes shape and protects its delicate internal parts.

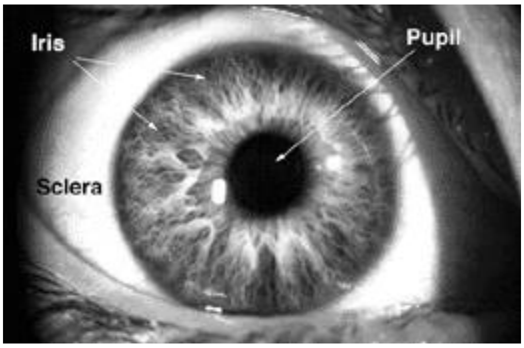

Figure 1: Structure of a human eye

Recently,Du et al. designed a local texture analysis algorithm to calculate the local variances of iris images and generate a one dimensional iris signature which relaxed the requirement of entire whole iris for identification and recognition[7][8].However, all of these algorithms assume that a circular iris pattern has been successfully extracted from a captured image but these algorithms are very complex, takes longer time for code extraction and code matching from the database. But this paper proposes a new and easy methods for *iris localization* and *iris normalisation* when compared to other algorithms which are used for *iris recognition*.

*3. M*ethodology.

This paper deals with the generation of stable key from iris image and it is carried over using iris database. The input image was subjected to segmentation to detect the two circles i.e., iris/sclera boundary and the iris/pupil boundary. The resultant image is normalized to produce iris regions. The proposed method involves three modules namely *i)Graph cut method, ii)Adaptive thresholdingand iii) Normalization.*

3.1. Introduction to Iris Recognition

Iris recognition technology combines computer vision, pattern recognition, statistical inference, and optics. The iris is an externally visible, yet protected organ whose unique epigenetic pattern remains stable throughout adult life. These characteristics make it very attractive for use as a biometric for identifying individuals. Image processing techniques can be employed to extract the unique iris pattern from a digitized image of the eye, and encode it into a biometric template, which can be stored in a database. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates.

When a subject wishes to be identified by an iris recognition system, their eye is first photographed, and then a template created for their iris region. This template is then compared with the other templates stored in a database until either a matching template is found and the subject is identified, or no match is found and the subject remains unidentified. Iris recognition allow user to hands-free operation in application. Iris recognition has highest proven accuracy, had no false matches in over two million cross comparison, according to Biometric Testing Final Report. It allow high speed also for large populations, just look into a camera for a few seconds. The iris is stable for each individual throughout his or her life and do not change with age. The weaknesses are Intrusive, High cost, Contact lenses , sunglasses , optical glasses.

4. *Steps involved*

The first step towards achieving a homogenous region is by setting the values of pixels below 60 and above 240 are equal to 255. By doing this we can easily identify the IRIS boundaries. The purpose for adjusting these values is to reduce the effect of specularities that may be present in the pupil. The input is a Captured Eye image and the output is Homogenized Image.

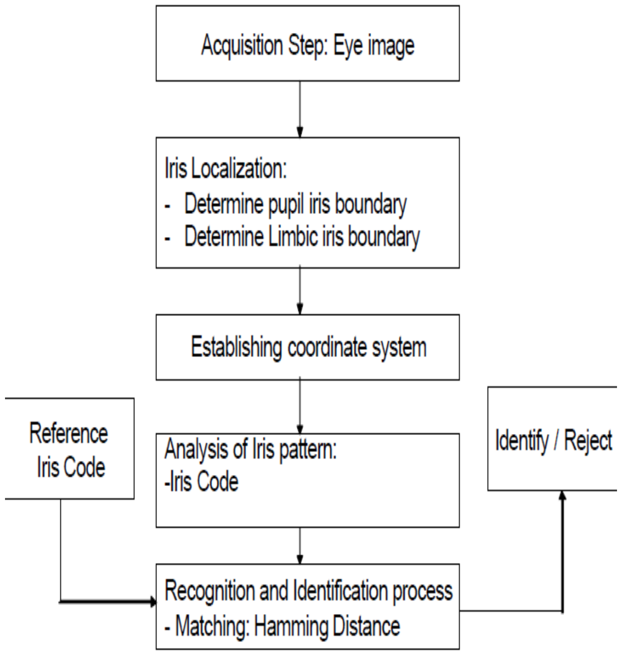

Figure 2: The overall methodology flowchart

4.1. Iris localization

Iris localization involves Pupilary Boundary Detection and Limbic Boundary Detection. The methods used for the detection of PupilaryBoundary(Inner Boundary) is Graph cut method . Even under the ideal imaging conditions the pupil boundary is not a perfect circle and in many cases a small area of the pupil is taken as the iris area by traditional methods. Although the captured area is small, considering the fact that most of the iris patterns exist in the collarette area - which is a small area surrounding the pupil - the error of inaccurate segmentation will be significant. Therefore a method to accurately detect the pupil boundary is highly required. Graph cut method introduced by Y. Boykov [16] is an efficient segmentation method based on energy minimization. This method considers the image as a graph and searches for a cut in the graph that has minimum energy. The min-cut/max-flow energy minimization method is commonly used for the purpose of energy minimization [15]. Using the graph cut based iris segmentation solves the problem of off angle imaging and also the non circularity of the pupil that is one of main sources of error in iris recognition known as pupil error.

The graph cut theory that is used to minimize the energy function defined to segment the input eye image. Consider a graph G=(V,E)in which V is the set of nodes and E is the set of edges that construct the graph. G is called an undirected graph if the change in the cost function from one node to another, is direction independent. An example of a graph is shown in figure 3. We define two terminals for the graph – a source (s) and a sink (t). These two terminals are the main nodes in the graph and are defined by the user. The maximum cost (weight) in the graph will be given to these terminal nodes. Nodes other than the terminals are assigned nonnegative weights being less than or equal to the weights of the two terminals. Subset C (C $\subseteq$ E) is called a cut if it can divide V into two separate sets S and (where T is equal to V - S) in a way that s ϵ S and t ϵ T (s and t are the two terminals of the graph). The cost of a cut is defined as the sum of the costs of its edges. The minimum cut problem or the problem of minimizing the cost function is performed by finding the cut with minimum cost or energy. Cost is defined as

$$\mathrm{cost}(C) = \sum_{e_{i,j} \in C} w_{i,j} \qquad i,j \in V \qquad (1)$$

Where $e_{i,j}$ is the edge or link connecting the two vertices i and j and $w_{i,j}$ is the weight associated with this edge. Several methods [15] have been introduced to solve the minimum cut problem in polynomial time. To segment an image using graph cut method, the pixels of the image are considered as the nodes of the graph. The edges represent the relationship between neighboring nodes or pixels and a cut represents a partitioning of the image constructed via these nodes. Finding a minimum cut for the image graph results in a partitioning of the image which is optimal in terms of the defined cost function for the cut.

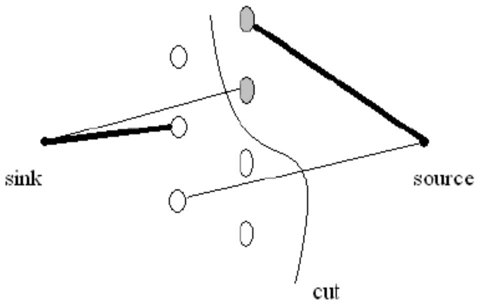

Figure 3: An example of a 2D graph showing two terminals named by source" and "sink", and the cut separating the regions. Thick lines connect the terminal to the pixels of the same region, while the thin lines show its connection to the pixels from the other region (only a few of the links are shown in the figure)

To segment the image, the terms of a graph such as the vertices, source, etc. are defined for the image. The pixels of the image are defined as the vertices of the graph. All neighboring pairs of pixels of the image are assumed to be connected to each other with a link and these links are called the edges. Capacity of each link is defined in terms of the sharpness of the edge existing between the pixels. The sharpness of an edge is defined by the difference between their intensity values. The label O or "object" can be assigned to a set of pixels to specify the source or object terminal and the label B or "background" can be assigned to another set representing the sink or background pixels. The goal is to find a cut or a set of edges that separates the object and the background sets in a way that the cut has the minimum cost. To perform the minimization process the cost or energy function is defined. The general form of the energy function is as follows

$$E = \sum_{p \in P} \left(D_p(f_p) + \sum_{q \in N(p)} V_{p,q}(f_p, f_q) \right) \qquad (2)$$

The D_p cost is defined as

$$D_p(f_p) = \begin{cases} MAX & p \in O, f_p = S \\ MAX & p \in B, f_p = T \\ 0 & \text{otherwise} \end{cases} \qquad (3)$$

Where, Max is the large positive value that is assigned to sink and source terminals during the initial labeling process. The cost function $V_{p,q}$ is demonstrated as

$$V_{p,q} = \begin{cases} \exp\left(\frac{-(I_p - I_q)^2}{2\sigma^2} \right) \Big/ \mathrm{dist}(p,q) & p,q \in N \\ 0 & \text{otherwise} \end{cases} \qquad (4)$$

Where I_p is the intensity value of the pixel p and dist(p,q) is the distance between pixel p and pixel q. The term σ is the variance of pixel intensity values inside the object. In the proposed method a σ value per cluster is calculated for the whole image and then these values will be used in the rest of the process.

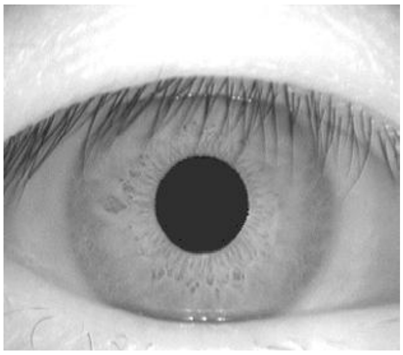

Figure 4:Original image

The described graph cut segmentation algorithm is applied to eye images that are taken for iris recognition purposes to segment the image and detect the pupil boundary precisely. Knowing the fact that pupil is a dark region in any eye, one can assume the gray level of its pixels to be close to zero. Since all regions of the image, except for the eyelashes and the pupil, have high gray values, there is need for the effect eyelashes in the picture. The pixels with small gray level values are marked as potential vertices to be labeled as the source or object vertices of the graph. To detect and eliminate the pixels related to the eyelashes from the pupil pixels, the method given in [17] is applied. This method uses the difference between the pixel intensity value and the mean of the gray level of its neighboring pixels to decide whether it is an eyelash pixel or not.

By using Adaptive thresholding technique we can determine the limbic boundary Note that the iris texture is brighter than the sclera. By finding the difference between these two regions we find out the limbic boundary value . So that we can recognize limbic boundary .we get midpoints of a limbic boundary and radius of the limbic. By calculating the distance between each pixel coordinates of image and midpoint coordinates of limbic, comparing with original radius of limbic we get radius of limbic boundary.

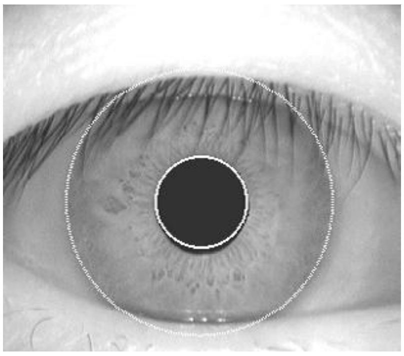

Figure 5:Localized image

4.2.Iris normalization

Iris normalization and enhancement involves converting the polar coordinate system to Cartesian coordinate system. Then converting the iris region from Cartesian coordinates to the normalized non-concentric polar representation is modeled as I(x(r,ø),y(r, ø))→I(r, ø)
With
x(r, ø) → (1-r)Xp(ø)+rXi(ø)
y(r, ø) →(1-r)Yp(ø)+rYi(ø)

where I(x,y) is the iris region images (x,y) are the orginal Cartesian coordinates (r, ø) are the corresponding normalized polar coordinates and Xp,Yp and Xi,Yi are the coordinates of pupil and iris boundary along o direction .

Note : **ø** varies from 0 t0 360
r varies from 0 to Ri-Rp where

Ri=Radius of Iris, Rp=radius of pupil

Figure 6:Normalized image

4.3.Pattern Recognition

Texture near the pupilary boundary and limbic boundary inside the iris has some errors. So we take the middle row of iris in order to overcome the errors. We convert the middle row of bits in to hexadecimal code. In our project the probability of occurring secret code is nearly $\mathbf{16^{90}}$ **.** We consider 360 bits of middle row of an *enhanced image.* Convert these bits into *hexadecimal code.*

F=1001 1110 1100… 0110 1100 0101 1101 1011

9 E C 6 C 5 D B

(360 Bits code)-----(90 Hexadecimal code)

4.4.Pattern Matching

Hexadecimal code is taken from database and converted into bits. The comparison is done by computing the HAMMING DISTANCE between the two codes. The Hamming distance between an Iris code A and another code B is given by

$$HD = \frac{1}{N}\sum_{j=1}^{N} A_j \otimes B_j$$

4.5.Hamming Distance

Given two patterns A and B the sum of disagreeing bits(sum of the exclusive–OR between) divided by N the total number of bits in the pattern. If two patterns are derived from the same iris, the hamming distance between them will be close to 0.0 then it is accepted or else rejected.

5. *Conclusion*

Iris boundaries are recognized by using simple methods and the less complex and faster algorithms than previous algorithms and it eliminates pupilary noises and reflections. Homogenization removes specularities of the pupil., A method based on graph cuts was presented to segment the pupil region in an eye image for iris recognition purposes and thus we can recognize pupilary boundary (inner boundary) accurately.

Adaptive threshold method can find the limbic radius and limbic mid-point. By solving these parameters in circle equation, we can recognize limbic boundary (outer boundary) accurately. The region between inner and outer boundary is iris, it is in the polar form and converted into linear form by converting the polar coordinate system to cartesian coordinate system, then converting the iris region from Cartesian coordinates to the normalized nonconcentric polar representation we get normalized image. By doing enhancement, the logical image with 360 in length and breadth is the difference between the outer and inner boundary is produced. The texture near the limbic and pupilary boundary inside the iris has some noises due to eyelashes and eyelids, by taking the middle row of the enhanced image a secret code is extracted from it. The secret code is converted into Hexadecimal code of length 90. Hamming code distance is being used for pattern matching. It can give the 1690 different iris codes . It can overcome the noises caused by pupil in the image. In this graph cut method only the gray level information of the images was used to perform the segmentation. For future work the method can be expanded to evaluate color images.

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