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HUMAN IRIS RECOGNITION USING FUZZY NEURAL CONCEPTS

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Abstract— **Biometrics is one of the vastly growing fields for human identification. Our paper deals with the recognition of the human iris which overcomes the shortcomings of other methods of personal identification. This system deals with the localization of the iris region using a fast algorithm and extraction is done using fuzzy neural network algorithm to extract the deterministic patterns in a person's iris in the form of feature vectors. Then they are compared in terms of weighted hamming distance to verify the identity. Binary Coding scheme is used for better efficiency. This technology promises variability, stability and security. It is favorable for high protection mechanism in security systems.**

Keywords- Iris Recognition, Harr Wavelet, Fuzzy Neural Concepts.

I. INTRODUCTION

In the present day world, Biometrics technology plays a prime role in public security and information security domains[1]. The two major types of biometric features used for identification are physical and behavioral traits. Physical traits include finger prints, iris patterns, etc. while behavioral traits include voice, signature, etc. However physical traits have been proven to be more beneficial as this accurately identifies each individual and distinguishes one from another. Iris recognition is one of the most important biometric recognition approaches in human identification.

Iris region is the part between the pupil and the white sclera. The iris texture provides many minute characteristics such as freckles, coronas, stripes, furrows, crypts, etc. which are unique for each subject[2]. Because of its speed of comparison, iris recognition is the only biometric technology well-suited for one-to-many identification. A key advantage of iris recognition is its stability, or template longevity, as, barring trauma, a single enrollment can last a lifetime. It consists of the Iris acquisition, pre-processing and recognition of the iris region in a digital eye image. Pre-processing includes the iris localization, normalization, and enhancement. With the developments in the field of Artificial Intelligence, Iris recognition systems may gain speed, hardware simplicity, accuracy and learning ability. In this paper a fast iris segmentation algorithm and iris recognition system based on fuzzy neural networks is proposed.

The content of our paper is divided into the following sections: Section II contains the Iris Image acquisition system, Iris Localization, Normalization and Mapping. Section III describes the Feature Extraction. Section IV gives a comparison. The binary coding scheme will be discussed in section V. In section IV test of statistical independence is discussed. And Section VII gives the conclusion.

II. IRIS RECOGNITION

A. *Image Acquisition*

An important step of an iris recognition system is the process of image acquisition. Since the iris is small in size and dark in color (especially for Asian people), it is very difficult to acquire good image without a proper camera. To capture the rich details of iris patterns, an imaging system should resolve a minimum of 70 pixels in iris radius. In the field trials to date, a resolved iris radius of 100 to 140 pixels has been more typical. Monochrome CCD cameras (480 x 640) was used because NIR illumination in the 700nm - 900nm band was required for imaging to be invisible to humans.

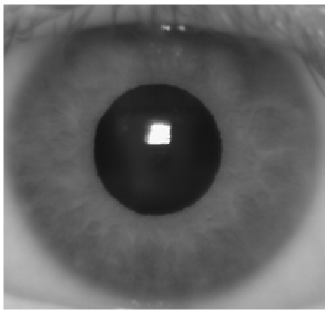


Fig- NIR Iris Image

Further, the eye pictures were taken with appropriate conditions such as lighting and distance from the camera.

B. *Iris Localization*

An eye image contains not only the iris region but also some un-useful parts, such as the pupil, eyelids, sclera, and so on. For this reason, in the first step, segmentation will be done to localize and extract the iris region from the eye image. Iris localization is the detection of the iris area between pupil and sclera. So we need to detect the upper and lower boundaries of the iris and determine its inner and outer circles. A number of algorithms have been developed for iris localization. Some of them are based on the Hough transform. Earlier, iris segmentation algorithm based on the circular Hough transform was applied. In these researches the canny edge detection algorithm with circular Hough transform was applied to detect the inner and outer boundaries of the iris. The circular Hough transform was employed to deduce the radius and centre coordinates of the pupil and iris regions. In this operation, starting from the upper left corner of iris, the circular Hough transform was applied. This algorithm was used for each inner and outer circle separately. The application of the Hough transform requires a long time to locate the boundaries of the iris.

In this paper, a fast algorithm for detecting the boundaries between pupil and iris and also sclera and iris has been proposed. To find the boundary between the pupil and iris, we must detect the location (centre coordinates and radius) of the pupil. The rectangular area technique is applied in order to localize pupil and detect the inner circle of iris. The pupil is a dark circular area in an eye image. Besides the pupil, eyelids and eyelashes are also characterized by black colour. In some cases, the pupil is not located in the middle of an eye image, and this causes difficulties in finding the exact location of the pupil using point-by-point comparison on the basis of threshold technique. In this paper, we are looking for the black rectangular region in an iris image (Fig). Choosing the size of the black rectangular area is important, and this affects the accurate determination of the pupil's position. If we choose a small size, then this area can be found in the eyelash region. A (10x10) rectangular area is used to accurately detect the location of the pupil. Searching starts from the vertical middle point of the iris image and continues to the right side of the image.

A threshold value is used to detect the black rectangular area. Starting from the middle vertical point of iris image, the greyscale value of each point is compared with the threshold value. As it is proven by many experiments, the greyscale values within the pupil are very small. So a threshold value can be easily chosen. If greyscale values in each point of the iris image are less than the threshold value, then the rectangular area will be found. If this condition is not satisfactory for the selected position, then the search is continued from the next position. This process starts from the left side of the iris, and it continues until the end of the right side of the iris. In case the black rectangular area is not detected, the new position in the upper side of the vertical middle point of the image is selected and the search for the black rectangular area is resumed. If the black rectangular area is not found in the upper side of the eye image, then the search is continued in the lower side of image. Fig (a) shows the iris image. In Fig. (b), the searching points are shown by the lines. In Fig. (c), the black rectangular area is shown in white colour.

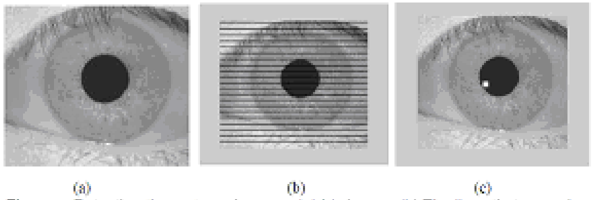


Fig Detecting the rectangular area. (a) Iris image, (b) The lines that were drawn to detect rectangular areas, (c) The result of detecting of rectangular area

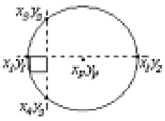


Fig Finding the centre of the pupil

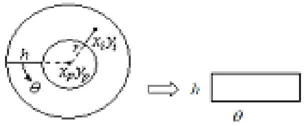


Fig Normalization of the iris

After finding the black rectangular area, we start to detect the boundary of the pupil and iris. In the first step, the points are located in the boundary of pupil and iris, in the horizontal direction, then the points in the vertical direction are detected (Fig). In the next Fig. the circle represents the pupil, and the rectangle that is inside the circle represents the rectangular black area. The border of the pupil and the iris has a much larger greyscale change value. Using a threshold value on the iris image, the algorithm detects the coordinates of the horizontal boundary points of (x_1,y_1) and (x_1,y_2), as shown in Fig. The same procedure is applied to find the coordinates of the vertical boundary points (x_3,y_3) and (x_4,y_3). After finding the horizontal and vertical boundary points between the pupil and the iris, the following formula is used to find the centre coordinates (x_p,y_p) of the pupil.

$$x_p = (x_3+x_4)/2, \quad y_p = (y_3+y_4)/2 \quad (1)$$

The same procedure is applied for two different rectangular areas. In case of small differences between coordinates, the same procedure is applied for four or more different rectangular areas in order to detect a more accurate position of the pupil's centre. After determining the centre points, the radius of the pupil is computed using equation (2).

$$r_p=((x_c-x_1)^2+(y_c-y_1)^2)^{0.5} \text{ or}$$
$$r_p=((x_c-x_3)^2+(y_c-y_3)^2)^{0.5} \quad (2)$$

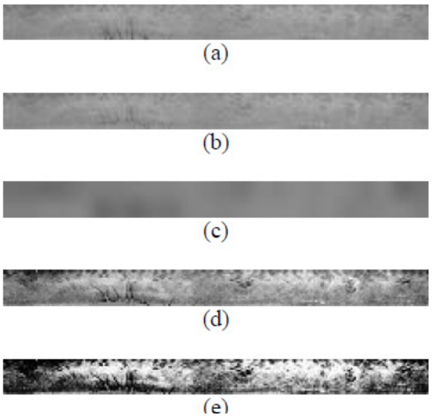
Because the change of greyscale values in the outer boundaries of iris is very soft, the current edge detection methods are difficult to implement for detection of the outer boundaries. For this, another method is applied to detect the outer boundaries of the iris. We start from the outer boundaries of the pupil and determine the difference of sum of greyscale values between the first ten elements and second ten elements in horizontal direction. This process is continued in the left and right sectors of the iris. The difference corresponding to the maximum value is selected as boundary point.

C. *Iris Normalization*

The irises captured from the different people have different sizes. The size of the irises from the same eye may change due to illumination variations, distance from the camera, or other factors. At the same time, the iris and the pupil are non concentric. These factors may affect the result of iris matching. In order to avoid these factors and achieve more accurate recognition, the normalization of iris images is implemented. In normalization, the iris circular region is transformed to a rectangular region with a fixed size. With the boundaries detected, the iris region is normalized from Cartesian coordinates to polar representation. This operation is done using the following,

$$\theta \subset [0,2\pi] \text{ , } r \subset [R_P,R_L(\theta)]$$
$$x_i = x_p + r.\cos(\theta) \text{ , } y_i = y_p + r.\sin(\theta) \quad (3)$$

Here (x_i,y_i) is the point located between the coordinates of the papillary and limbic boundaries in the direction θ. (x_p,y_p) is the centre coordinate of the pupil, R_p is the radius of the pupil, and $R_L(\theta)$ is the distance between centre of the pupil and the point of limbic boundary. In the localization step, the eyelid detection is performed. The effect of eyelids is erased from the iris image using the linear Hough transform.



After normalization (Fig.(a)), the effect of eyelashes is removed from the iris image (Fig.(b)). Analysis reveals that eyelashes are quite dark when compared with the rest of the eye image. For isolating eyelashes, a threshold technique is used. To improve the contrast and brightness of image and obtain a well distributed texture image, an enhancement is applied. Received normalized image is resized using averaging. The mean of each 16x16 small block constitutes a coarse estimate of the background illumination. During enhancement, background illumination (Fig.(c)) is subtracted from the normalized image to compensate for a variety of lighting conditions. Then the light corrected image (Fig.(d)) is enhanced by histogram equalization. Fig.(e) demonstrates the preprocessing results of the iris image. The texture characteristics of iris image are shown more clearly. Such preprocessing compensates for the non-uniform illumination and improves the contrast of the image. Normalized iris provides important texture information. This spatial pattern of the iris is characterized by the frequency and orientation information that contains freckles, coronas, strips, furrows, crypts, and so on.

III. FEATURE EXTRACTION

In Iris based Authorization system one of the most important aspects is generating the patterns, which is essentially an arrangement. It is characterized by the order of the elements of which it is made, rather the by the intrinsic nature of these elements. This definition summarizes our purpose in this paper. This is responsible for extracting the patterns of the iris taking into account the correlation between adjacent pixels. After performing lots of research and analysis about this topic, we decided to use wavelets transform, and more specifically the "Harr Transform".

A. *Harr Wavelet*

Previous systems have made use of Gabor wavelets[11] to extract the iris patterns. But it is time consuming. So we are looking to keep our total computational time as low as possible. We compared the results using the Harr transform with the wavelet tree obtained using other wavelets. We found that the Harr wavelet gave better results. Our mapped image is of size 100x402 pixels and can be decomposed using the Harr wavelet into a maximum of five levels. These levels are CD1h to CD5h (horizontal coefficients), CD1v to CD5v (vertical coefficients) and CD1d to CD5d (diagonal coefficients). We must now pick up the coefficients that represent the core of the iris pattern. Therefore those that reveal redundant information should be eliminated.

Looking closely at the following figure, it is obvious that the patterns in CD1h, CD2h, CD3h and CD4h are almost the same and only one can be chosen to reduce redundancy. Since CD4h repeats the same patterns as the previous horizontal detail levels and it is the smallest in size, then we can take it as a representative of all the information the four levels. The fifth level does not contain the same textures and should be selected as a whole. In a similar fashion, only the fourth and fifth vertical and diagonal coefficients can be taken to express the characteristic patterns in the iris-mapped image.

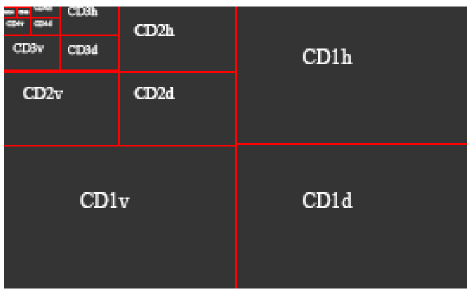


Fig- Five Level Harr Wavelet

Thus we can represent each image applied to the Harr wavelet as the combination of six matrices:

- CD4h and CD5h
- CD4v and CD5v
- CD4d and CD5d

All these matrices are combined to build one single vector characterizing the iris patterns. This vector is called the feature vector. Since all the mapped images have a fixed size of 100x402 then all images will have a fixed feature vector. In our case, this vector has a size of 702 elements. This means that we have managed to successfully reduce the size of the feature vector of Daugman[3] which uses a vector of 1024 elements. This difference can be explained by the fact that he always maps the whole iris even if some part is occluded by the eyelashes, while we map only the lower part of the iris obtaining almost half his feature vector's size.

B. Embedded Zero Tree Wavelet Coding

Embedded Zero tree wavelet (EZW)[7] coding exploits the multi-resolution properties of the wavelet transform to give a computationally simple algorithm with better performance compared to existing wavelet transforms. Embedded Zerotree Wavelet encoder is based on progressive encoding to compress an image into a bit stream with increasing accuracy. When more bits are added to the stream, the decoded image contains more details of the image, a property similar to JPEG encoded images. Coding an image using the EZW scheme, together with some optimizations, results in remarkably effective image compression[9] with the property that the compressed data stream can have any bit rate desired. Any bit rate is possible only if there is information loss somewhere so that the compression is lossy. However, lossless compression is also possible with an EZW encoder, but with less optimal results.

C. Fuzzy Neural Network Algorithm

This algorithm can extract rules that yield much higher accuracy and robustness. Their technique consists of several steps. In the first step, given n-continuous-valued input parameters Ii, i=1,2,…,n, each input parameter is classified into two or more equally populated sets. Then each set is represented with a binary scheme. For example, if each input parameter is divided into two sets, small and large, the set {Ii is small} is represented as [1 0], and the set {Ii is large} is represented as [0 1]. As a result, a problem of n continuous valued input parameters is transformed into a problem of 2n input parameters where each input is binary.

Next, a two layer feed-forward back-propagation neural network is constructed, with 2n inputs and as many output nodes as the number of classes in the data. Once the network is trained, the most dominant rule from each output neuron is extracted. This is done by determining, for each input Ii, its binary input with the highest weight and assuming that input to be 1. Therefore, the antecedents of the extracted rule include all input parameters, some of which can then be pruned. The pruning process allows for the rule to be more general and therefore yield more accurate results. The pruning algorithm first sorts the input parameters in ascending order of their maximum weights. Then, the algorithm prunes the parameters one at a time, starting with the input parameter with the smallest maximum weight, so long as the neuron remains activated even when the maximum-weight binary input of the input parameter is off and the minimum-weight binary input is on. The main problem with this rule-extraction technique lies in the pruning process. It assumes that, the way in which an input parameter affects the activation of an output neuron depends only on the maximum weight of the parameter, and not on the minimum weight. This incorrect assumption causes antecedents that can be pruned to sometimes escape pruning, making the rules less general, and consequently diminishing the accuracy of the fuzzy inference system implementing the extracted rules.

IV. COMPARISON WITH EXISTING METHODS

Several methods have been proposed for iris recognition. Daugman[4] presented a system for iris recognition and reported that it has excellent performance on a diverse database of many images. Wildes[5] described a system for personal verification based on automatic iris recognition. Boles[6] proposed an algorithm for iris feature extraction using zero-crossing representation of 1-D wavelet transform. Both systems, that of Daugman and Wildes employed carefully designed devices for image acquisition to ensure that iris is located at the same location within the image, and the images have the same resolution and are glare free under fixed illumination. However in both methods they achieved only 70-80 percentage of accuracy in authentication, but in our proposed view we are expecting much better results.

V. BINARY CODING SCHEME

It is essential to obtain the feature vector in a binary code because it is easier to find the differences between two binary coded words than between two number vectors. In order to code the feature vector we first observed some of its characteristics. We found that all the vectors that we obtained have a maximum value that is greater than 0 and a minimum value that is less than 0. If "Coefficient (Vect)" is the feature vector of an image then the following quantization scheme converts it to its equivalent code-word:

- If Vect (i) < 0 then Vect (i) = 0
- If Vect (i) >= 0 then Vect (i) = 1

The next stage is to compare two code-words to find out if they represent the same person or not.

VI. TEST OF STATISTICAL INDEPENDENCE

The objective of this test involves the comparison of two iris patterns. This test as already proven. John Daugman, conducted his tests on a very large number of iris patterns and deduced that the maximum Hamming distance that exists between two irises belonging to the same person was 0.32. Since we were not able to access any large iris database and were only able to collect about 20 images, we adopted this threshold and used it[13]. The test was conducted as follows:Initially binary feature vectors are passed to a mathematical function. After getting the numeric value it is compared with the Hamming Distance. Finally the decision is made using the following results.

- If HD <= 0.32, It is the same person
- If HD > 0.32, It is a different person (or left and right eyes of the same person)

VII. CONCLUSION

We have proposed an effective Iris Recognition system using Fuzzy Neural Network. The located iris after pre-processing is represented by a feature vector. Using this vector as input signal, the fuzzy neural network is used to recognize the iris patterns. The recognition accuracy for trained patterns is about 99.25%. This identification system is quite simple requiring few components and is effective enough to be integrated within security systems that require an identity check. The errors that occurred can be easily overcome by the use of stable equipment. Judging by the clear distinctiveness of the iris patterns we can expect iris recognition systems to become the leading technology in identity verification.

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