A study on Iris Recognition using Wavelet Transformation and Nonlinear Function

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Abstract

In todays security industry, personal identification is also based on biometric. Biometric identification is performed basing on the measurement and comparison of physiological and behavioral characteristics, Biometric for recognition includes voice dynamics, signature dynamics, hand geometry, fingerprint, iris, etc.

Iris can serve as a kind of living passport or living password. Iris recognition system is the one of the most reliable biometrics recognition system. This is applied to client/server system such as the electronic commerce and electronic banking from stand-alone system or networks, ATMs, etc.

A new algorithm using nonlinear function in recognition process is proposed in this paper.

An algorithm is proposed to determine the localized iris from the iris image received from iris input camera in client. For the first step, the algorithm determines the center of pupil. For the second step, the algorithm determines the outer boundary of the iris and the pupillary boundary.

The localized iris area is transform into polar coordinates. After performing three times Wavelet transformation, normalization was done using sigmoid function.

The converting binary process performs normalized value of pixel from 0 to 255 to be binary value, and then the converting binary process is compare pairs of two adjacent pixels.

The binary code of the iris is transmitted to the server by the network. In the server, the comparing process compares the binary value of presented iris to the reference value in the database. Process of recognition or rejection is dependent on the value of Hamming Distance.

After matching the binary value of presented iris with the database stored in the server, the result is transmitted to the client.

Key Words: Iris recognition; Wavelet transforma-tion; Sigmoid function;

1. Introduction

In bygone days, human race have knew ways to distinguish or recognize individual. In the 1890s, an anthropologist and police desk clerk in Paris named Alphonse Bertillon sought to fix the problem of identifying convicted criminals and turned biometrics into a distinct field of study, and then the police used fingerprinting for recognition individual [1][2].

Knowledge-based recognition makes use of a secret word, phrase, number or fact that an individual must remember to be able to prove his/her identity. Examples are passwords to log in on a computer system, and a personal identification number (PIN) to withdraw money from a bank account. Token-based recognition uses a particular token that should be presented by an individual to prove his/her identity. Examples include a chip card to enter a building, and a credit card to pay at a shop. The most obvious disadvantage of these techniques is that both knowledge-based and token-based recognition do not recognize the individual, but only the knowledge or the token. Anyone who can present the correct knowledge or token is accepted, but knowledge can be overheard and tokens can be stolen. Moreover, knowledge can be forgotten and tokens can be lost.

Biometric person recognition operates by recognizing an individual by means of distinctive personal characteristics, such as face, fingerprint, iris and voice. The advantage of a biometrics approach is that these characteristics cannot be forgotten, lost or stolen. Moreover, clever use of biometrics may make access and checking procedures faster and more friendly, and the accuracy can be improved substantially. Still, this does not mean those biometrics are a panacea for all automatic recognition purposes. Especially, constructing a biometric feature set which is measurable, distinctive and robust is a non-trivial task.

Iris recognition technology combines computer vision, pattern recognition, statistical inference, and optics. Its purpose is real-time, high confidence recognition of a person's identity by mathematical analysis of the random patterns that are visible within the iris of an eye from some distance. Because the iris is a protected internal organ whose random texture is stable throughout life, it can serve as a kind of living passport or a living password that one need not remember but can always present.

Iris image is inputted into camera and passed to client. In the client, the system determines the localized iris, and transforms the localized iris part into polar co-ordinates [3]. And the featured image of the iris is converted to binary value and then transmitted the server by the network. The database is stored in the server. In the database, presented recorded iris code is stored for future comparison. In the server, the system compares binary values of the presented iris to the reference recorded iris code in the database. After comparison, the result of recognition is transmitted to the client.[4][5]

Using the iris recognition system through networks can be ordered as Fig. 1.

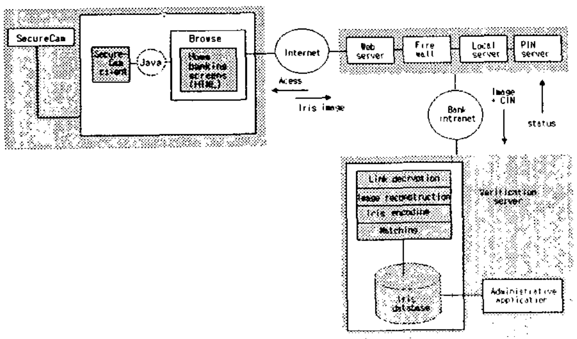

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Fig. 1 Iris recognition system diagram.

The structure of a recorded iris-code in the server

That's why iris recognition technology is becoming an important biometric solution for people identification in access control as networked access to computer application. Compared to fingerprint, iris is protected from the external environment behind the cornea and the eyelid. No subject to deleterious effects of aging, the small-scale radial features of the iris remain stable and fixed from about one year of age throughout lif[6][7].

The statistical probability that two irises would be exactly the same is estimated at $1/10^{72}$ [8].

2. Determine the center and the outer boundary of the Iris and the pupillary boundary

Localization of iris is defined clearly, the location of iris area for the recognition is an area excluding the pupil (the area of the pupil is *dark circular* opening in the center of the iris) and the outer boundary of the iris. So, it is important to determine the center of the pupil and the circle of pupillary boundary and the circle outer boundary of the iris for extracting exactly iris region. For performance that process, the eye image is projected into row and column axis of 640x480. [9] And at first we will have to determine the center of pupil. Second base on the centers position and the threshold detection of pupils area, and determine the radius of pupil and the circle of pupillary boundary. Base on the centers position and the threshold detection of scleras area, we can determine the radius of iris and iris outer boundary circle[10].

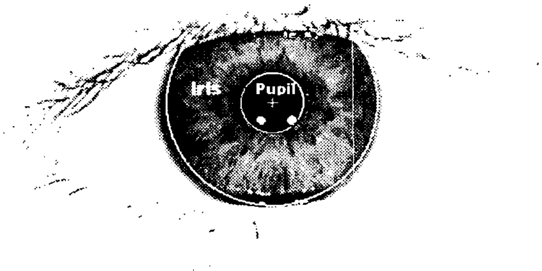

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Fig. 2 Determining the center, outer boundary of iris and pupil by the system.

Base on the defined position of the center and according to the real value of the papillary circles radius and the threshold detections value of pupils area, we can inspect the correctly of centers position.

Pupils area is a dark region and the threshold detection of pixels gray level value in pupils area are 50 and 90, so for determining the center of the pupil, the system counts the number of pixels carrying gray levels value more than 60 and less than 90 .

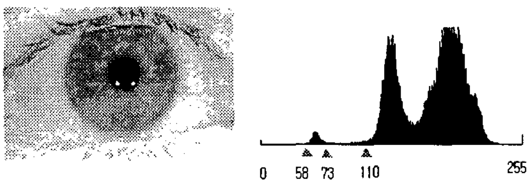


Fig. 3 Histogram of eye image

Gray level value of pixel in pupil's area is defined by a value more than 50 and left than 90. And gray level value of pixel in iris's area is defined more than 90. So, determining the radius r_p of pupil's circle is defined by an algorithm as:

1. From the center, drawing a circle with radius(r),
2. The pixel's value on the circle by r are test,
3. if(number of (50 $\leq$ the pixel value $\geq$ 90) $\geq$ 90%) then increase r and goto 2
   else r is radius of pupil(r_p)

Whole pixels in scleras area is carrying a value of gray level defined by a value more than 140, so determining the radius r_i of iris is defined by an algorithm as:

1. From the center, drawing a circle with radius($r=r_p$),
2. The pixel's value on the circle by r are test,
3. if(number of (the pixel value $\geq$ 140) $\geq$ 90%) then increase r and goto 2
   else r is radius of out-bound

For locating of the iris area, the system determines the circle of the outer boundary of the iris and the circle of the pupillary boundary.

With r_i is radius of pupil: ri is radius of iris: and (x_0,y_0) is the center of the pupil. The circle of the outer boundary of the iris is determined as:

$$(x-x_0)^2+(y-y_0)^2=r_i^2 \quad (1)$$

The circle of the pupillary boundary is determined as:

$$(x-x_0)^2+(y-y_0)^2=r_p^2 \quad (2)$$

Generally, the sclera is lighter than iris, and pupil darker than iris.

$$\max(r,x_0,y_0)+\left\{\frac{\partial}{\partial r}\int_0^{2\pi} I(r^*\cos\theta+x_0,\ x^*\sin\theta+y_0)\right\} \quad (3)$$

From equal (1) and (2), we express the center (x_0,y_0) coordinates in function of the two first-order gradient components (G_x along axe x, G_y along axe y) as follows:

$$x_0=x\pm\frac{r}{\sqrt{1+\frac{Gy^2}{Gx^2}}} \qquad y_0=x\pm\frac{r}{\sqrt{1+\frac{Gx^2}{Gy^2}}} \quad (4)$$

The gradients Gx and Gy are computed both during the unique travel of the eye image. Thus the problem is reduced to increment the number of occurrences for each supposed center through two accumulators (X0 in x,Y0 in y), and to determine the point (x0,y0) of image where it appears a maximum in the accumulators of equation (5).

$$X_0(x_0)=\sum_x\sum_y\sum_{r=r_{max}}^{r=r_{min}} nbre.occurences.\ x_0$$

$$Y_0(y_0)=\sum_x\sum_y\sum_{r=r_{max}}^{r=r_{min}} nbre.occurences.\ y_0$$

(5)

3. Transform the localized iris's part and wavelet transformation.

The system requires that the localized iris is an area excluding the outer boundary of the iris and the pupil. For facilitation of the next process, the localized iris should be transformed into polar coordinates. The Cartesian to polar reference transform suggested by Daugman [11] authorizes equivalent rectangle shown as figure 3.5. In this way we compensate the stretching of the iris texture as the pupil changes in size, and we unfold the frequency information contained in the circular texture in order to facilitate next features extraction. Moreover this new representation of the iris breaks the no-eccentricity of the iris and the pupil.

The process transforms a circle to a linear line, by transformation of the position A(x_A,y_A) in a circle, to polar coordinates. And assumer that A is ordered as Fig. 4

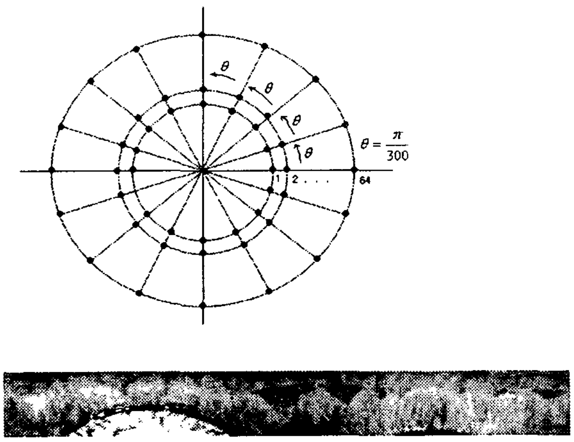
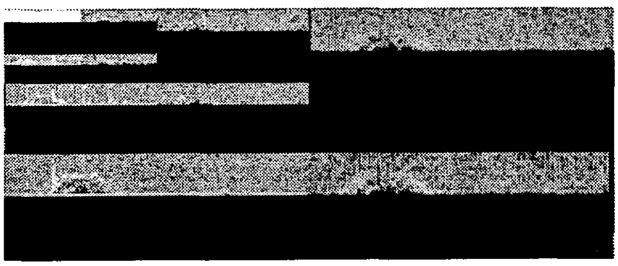


Fig. 4 Transform the localized iris part of Fig. 2.

The two-dimensional DWT can be implement using digital filters and down-samplers. With separable two-dimensional scaling and wavelet function, we simply take the one-dimensional FWT of rows of f(x,y), followed by the one-dimensional FWT of the resulting columns.The two-dimensional FWT filters the scale j+1 approximation coeffici -ents to construct the scale j approximation and detail coefficients. In the two-dimensional case, however, we get three sets of the detail



coefficients-the horizontal, vertical, and diagonal details[12][13][14].

Fig. 5 3-level wavelet transform of Fig. 4

Fig. 5 show an example of performance the t3-level wavelet transformation an iris image. The image is reduced step by step. After one time of wavelet transformation, the size of the image is reduced a haft of horizontal and a haft of height.

4. Results and Discussions

The pixels number of the image in polar coordinates is 64x600 and the image in polar coordinates is divide 15 sectors, so the pixels number of any sector is 64x40.

Some sector may carry eye hair or eyelid, so that the system selects locations of two sectors numbed sector 1 and sector 8, for recognition in next process, because two those sector are from areas carrying no eye hair and eyelid if the eye image captured in a good quality for the recognition process.

As Figure 6, we can see 15 sectors of the image in polar coordinates transformed from the iris area carry some area including eye hairs.

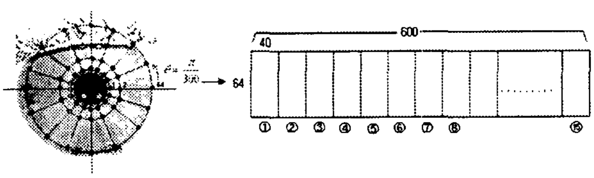


Fig. 7 Transformation 15 sectors and circular coordinates to polar coordinates.

4.1 Normalization using sigmoid function and convert binary values

We had performed hundreds of the process of iris recognition, the captured values of performance three times wavelet transformation.

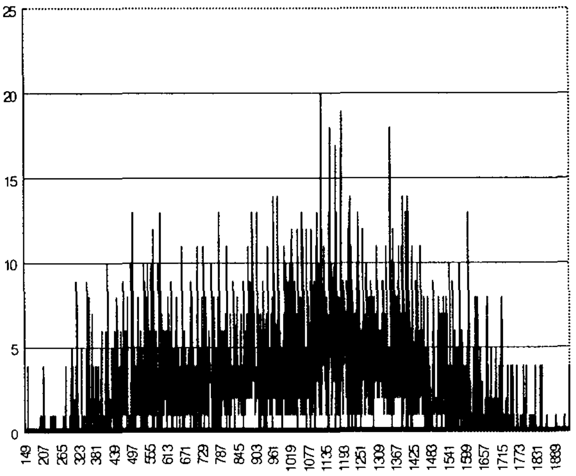
Fig. 7 shows histogram of values from minimum value equal 149 to maximum number equal 1923 of 5050 pixels each sectors of 3-level wavelet transformations of several iris images. Performance the statistics of the values, we have got the mean value is equal 1028 (region of values that less than 1028 take approximate 50% in whole values; and region of values that more 1028 take approximate 50%). Region of value that is less than 544 take approximate 10. Region of value that is more than 1509 also take approximate 10%.

We define that xp[5] is mean; xp[1] includes a value that values are less than xp[1] taking 10% values; xp[9] includes a value that values are more than xp[9] taking 90% values.

The frequency of present pixels values in region of value around mid of xp[1] and xp[9] is dense.

And frequency of present pixels value in two regions of values, first from minimum number to xp[1], second from xp[9] to maximum number is too scattered for comparison to the frequency of present pixels value in region of value around mid of xp[1] and xp[9].

We will make allowance for the region of value around mid of xp[1] and xp[9] in the process of converting to normalized values by using sigmoid



function.

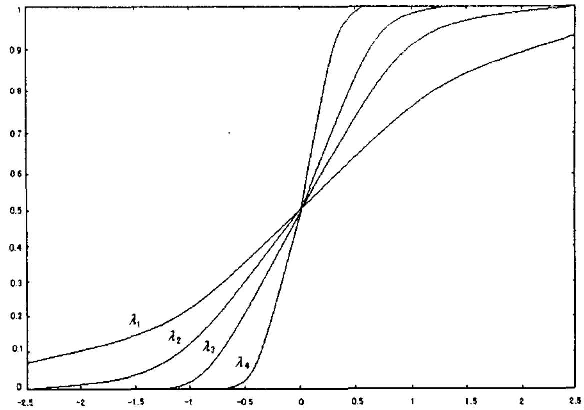
Fig. 7 Distribution of data of sector after 3-level wavelet transformation.

The form of sigmoid function is defined as following:

$$y=\frac{1}{1+\exp(-\lambda x)}$$

we get different graphs forms. Fig. 8 shows four different forms of sigmoid function by four values of λ. Value of x is around mid of -2.5 and 2.5, value captured f(x) is around mid of 0 and 1.Fig. 8 shows four different forms of sigmoid function by four values of γ different values of parameter. that the region of value around mid of xp[1] and xp[9] will be made allowance in the process of converting. Because regional of value around mid of xp[1] and xp[9] carry 80% values in whole pixel value.

Process of converting to binary data is performed in each disconnected set of two sectors. For each sector, binary process is performed according to each row. In each row, comparing any pair of



pixels value [i,j] and [i,j+1], where $1 \leq i \leq 8$; $1 \leq j \leq 5$.

Fig. 8 Graph of sigmoid function $y=\frac{1}{1+e^{-\lambda x}}$

If j=5, comparing pair of pixels value [i,1] and [i,5]. If two those value are different a sub pan that left than 3 then binary value equal 0, else binary value equal 1

For $1 \leq i \leq 8$ and $1 \leq j \leq 5$

$$BinaryData[k]=\left\{ \begin{matrix} 0 & |nData[i,j]-nData[i,j+1]|<3 \\ 1 & elsewhere \end{matrix} \right\}$$

(6-a) where $1 \leq k \leq 80$

For $1 \leq i \leq 8$ and j=5:

$$BinaryData[k]=\left\{ \begin{matrix} 0 & |nData[i,5]-nData[i,1]|<3 \\ 1 & elsewhere \end{matrix} \right\}$$

(6-b) where $1 \leq k \leq 80$

After binary process, a set of two sectors captured 80 binary values. If an iris is analyze by that process for recording in the database for the future recognition, then the process should perform five difference iris images of one human iris to create five sets of normalized value sectors. And then perform averaging of values of five sets to capture one set of normalized values for converting to binary value saving in the database.

4.2 Discussion

The result of the iris recognition is in four possible cases: acceptance of authentic (AA), rejection of imposter (IR), rejection of authentic (AR), and acceptance of imposter (IA). The first case and the second case are desired. The third case and the fourth case are mistakes. The object of the systems decision is how to make the first case and second case are appeared almost in the recognition process. Making the third case and the fourth case are appeared scarce in the recognition process.

We have performed so many comparisons. In most cases of comparing two different irises. Fig. 9 shaw a HD approximates to 49%. In most cases of comparing the same irises, a HD approximates to 12%.

So, a value of HD is decided for recognition or rejection is 0.30 or (30%)

If HDs are more than 30%, then the system concludes that the two irises are different.

If HDs are less than 30%, then the system concludes that the two irises are the same.

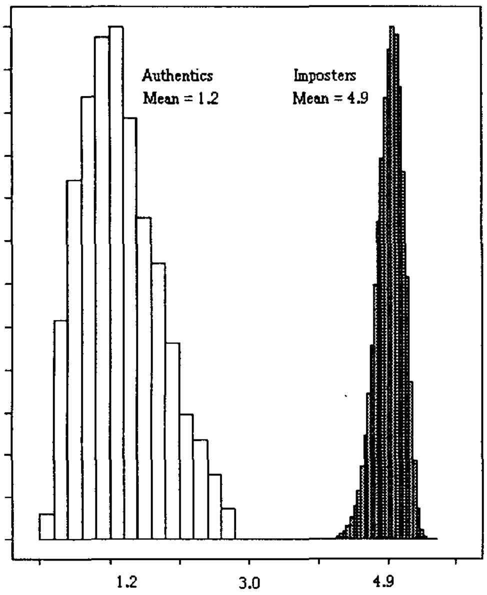


Fig. 9 Hamming Distance using sigmoid function.

Table 1 shows correct ratio(%) of the hamming distance values results of seventy comparisons of irises by two algorithms including using linear function (algorithm 1), using sigmoid function (algorithm 2). The system has performed comparisons of difference irises, and comparisons of the same irises. Whole comparisons of the same irises have got 100% correct with simoid function, but linear function give 91.77% right number of result (91.77% comparisons have HD<30%; 8.33% comparisons have HD>30%). And whole comparisons of different irises have got 100% correct result, whole function give a right number of result (100% comparisons have HD>30).

Table 1 correctness of recognition with linear and sigmoid function.

	linear	sigmoid
The same irises	99%	100%
Difference irises	100%	100%

5. Conclusion

In this paper, we propose new algorithms for iris recognition using sigmoid function.

The process of iris recognition is following as: first is determined the center of the pupil, and determine the outer boundary of the iris and the pupillary boundary. And then, the localized iris part also is detected. And an algorithm of transforming the localized iris part into polar coordinates is also presented. *Wavelet Transform* technique is used three times to compress the two 40x64 images into two 5x8 image.

The normalization is transmitted to 80 binary codes. The system compares the presented iris to the preference iris code in the database. The value of Hamming Distance determines acceptance or rejection of recognition iris process.

By the system, we had tested so many of different eye images from one human and from difference human. And have got almost right result.

Iris identification techniques can use following computer networks, workstations, desktop computer, ATMs, etc to permit or prevent access, it can serve as a kind of living passport or a living password that one need not remember but can always present.

Aknowledgement

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