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(54) **METHOD OF PALM PRINT IDENTIFICATION**

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G06K 9/00 (2006.01)
(52) **U.S. Cl.** **382/115**; 340/5.53; 340/5.83
(58) **Field of Classification Search** 382/115; 340/5.53, 5.83
See application file for complete search history.

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(57) **ABSTRACT**

A method of biometrics identification includes obtaining an image including a portion of a hand of an individual, analyzing the image to find one or more feature parameters defining different characteristics of the hand, and comparing the feature parameters with reference information in a database. The features parameters including a geometrical features parameter, a palm line features parameter or a palm texture features parameter.

8 Claims, 9 Drawing Sheets
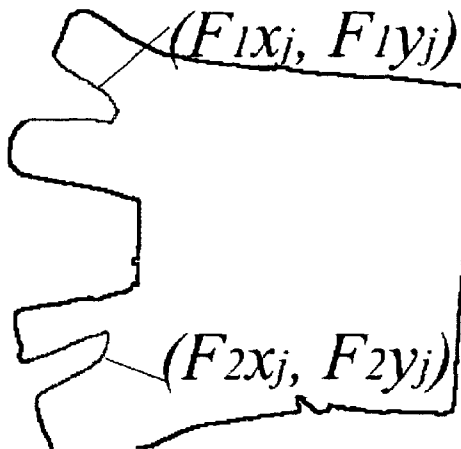
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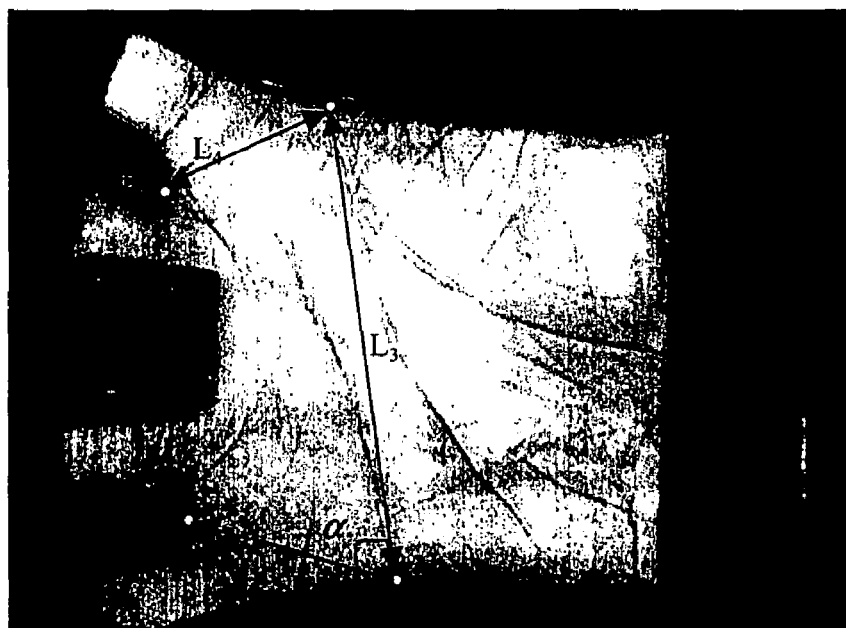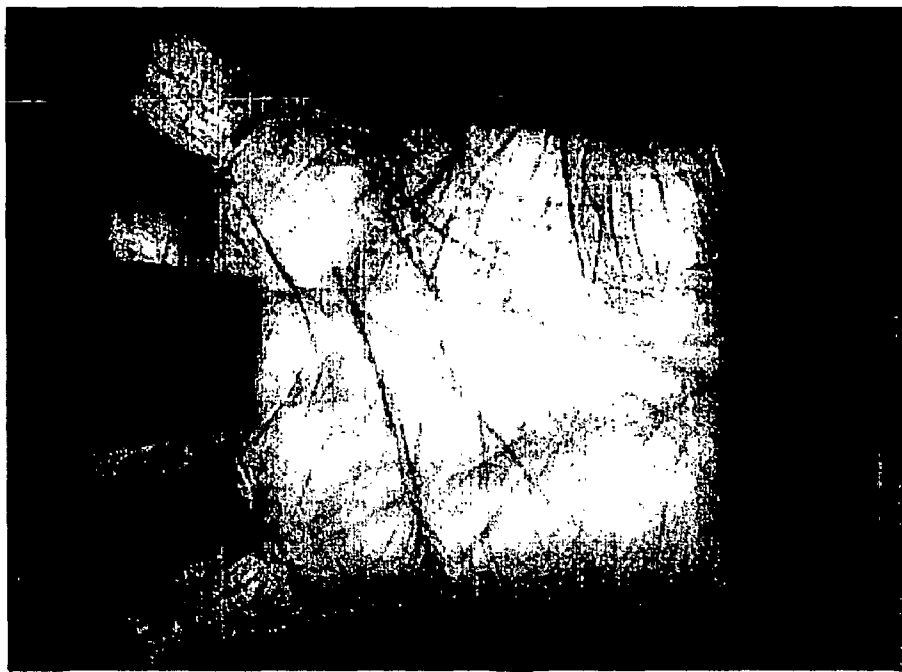
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FIGURE 1
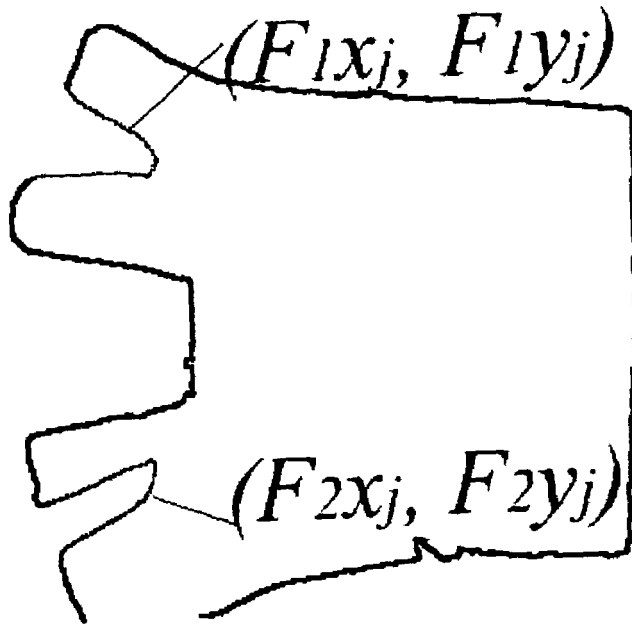

FIGURE 2

FIGURE 3

FIGURE 4

$(F_1 x_j, F_1 y_j)$
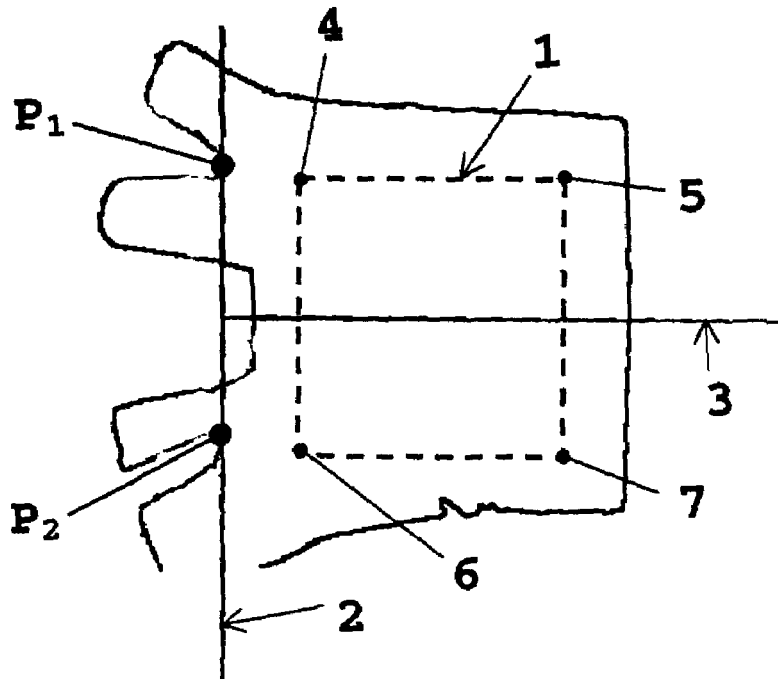
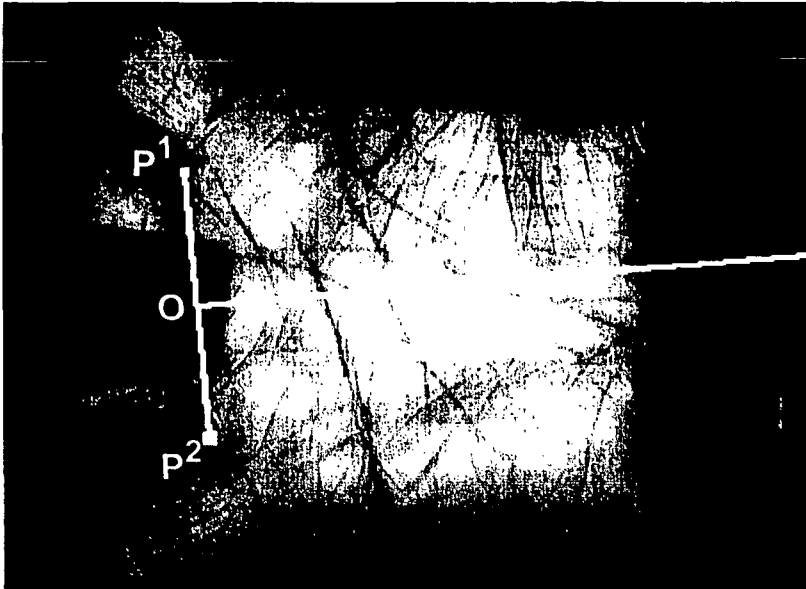$(F_2 x_j, F_2 y_j)$

FIGURE 5

P_1

4

1

5

P_2

3

6

7

2

FIGURE 6

FIGURE 7

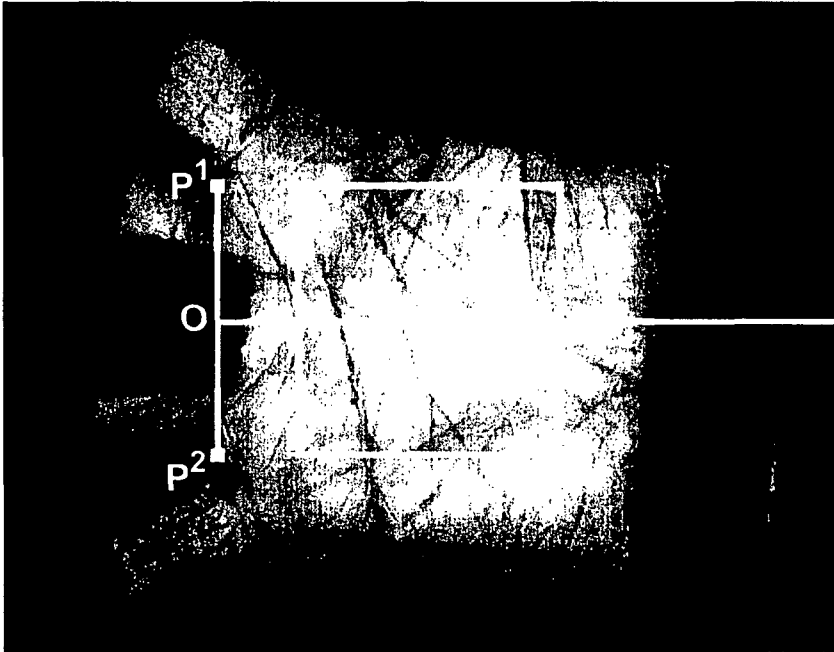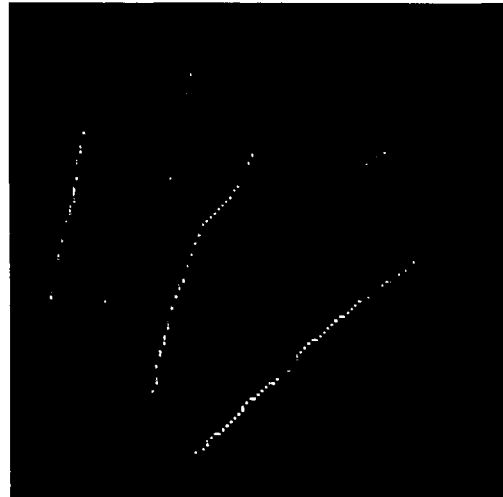FIGURE 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

```
-1   -2   -4   -2   -1            -1    0    2    0   -1

 0    0    0    0    0            -2    0    4    0   -2

 2    4    8    4    2            -4    0    8    0   -4

 0    0    0    0    0            -2    0    4    0   -2

-1   -2   -4   -2   -1            -1    0    2    0   -1
```

FIGURE 14   **FIGURE 15**

```
 0   -1   -4    0    2             2    0   -4   -1    0

-1   -6    0    8    0             0    8    0   -6   -1

-4    0   12    0   -4            -4    0   12    0   -4

 0    8    0   -6   -1            -1   -6    0    8    0

 2    0   -4   -1    0             0   -1   -4    0    2
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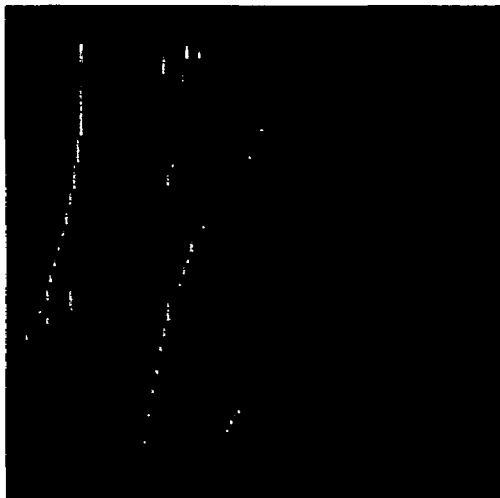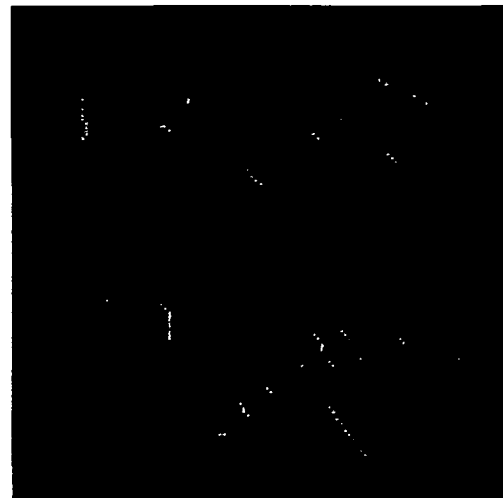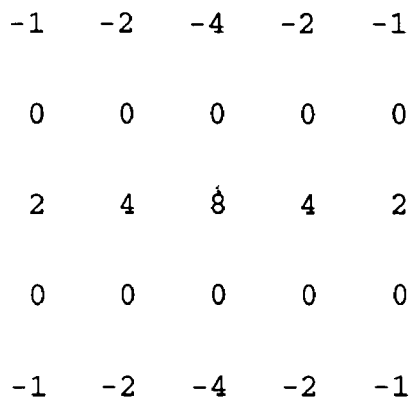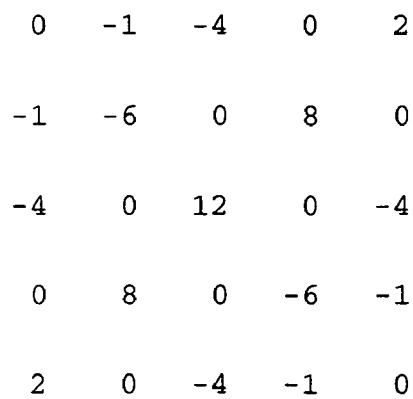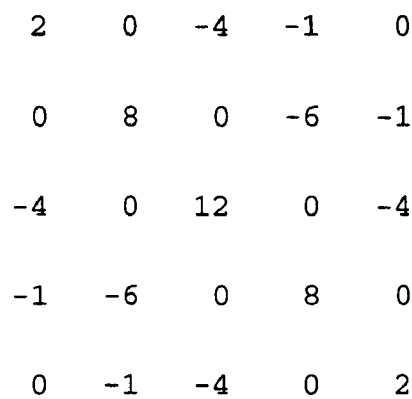
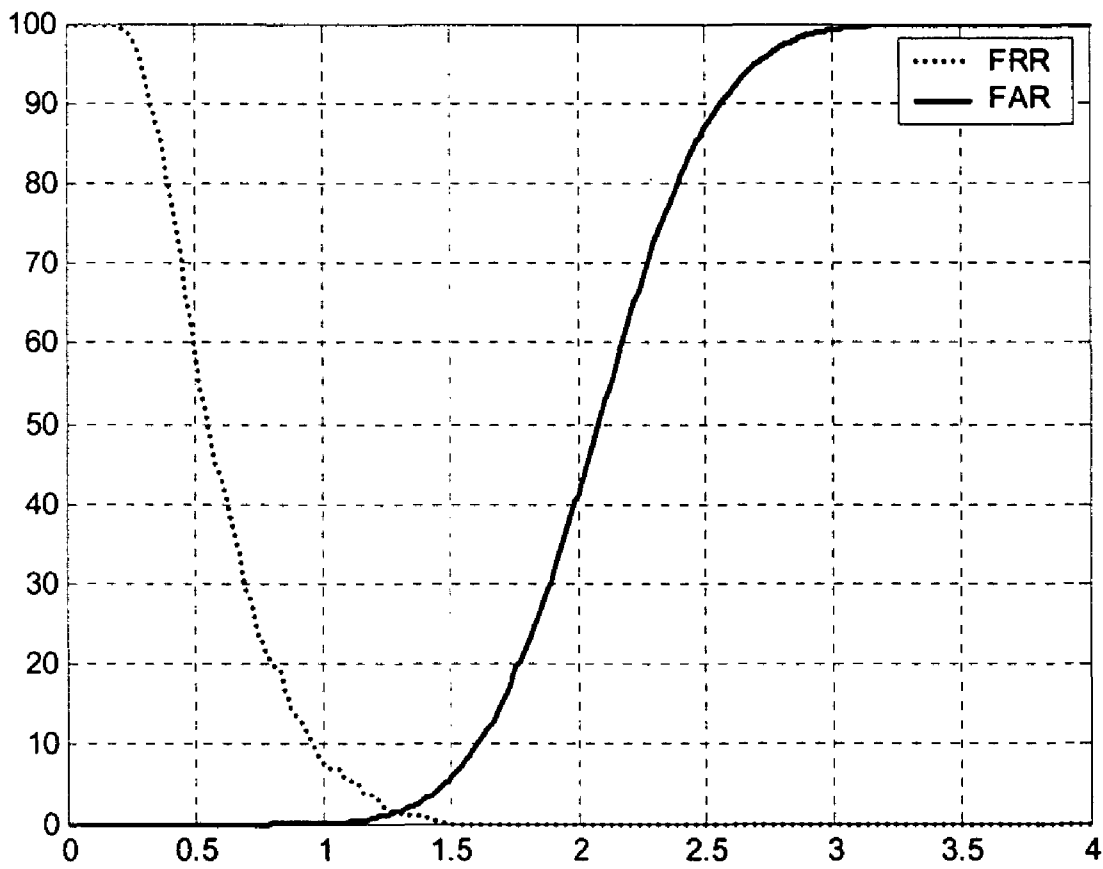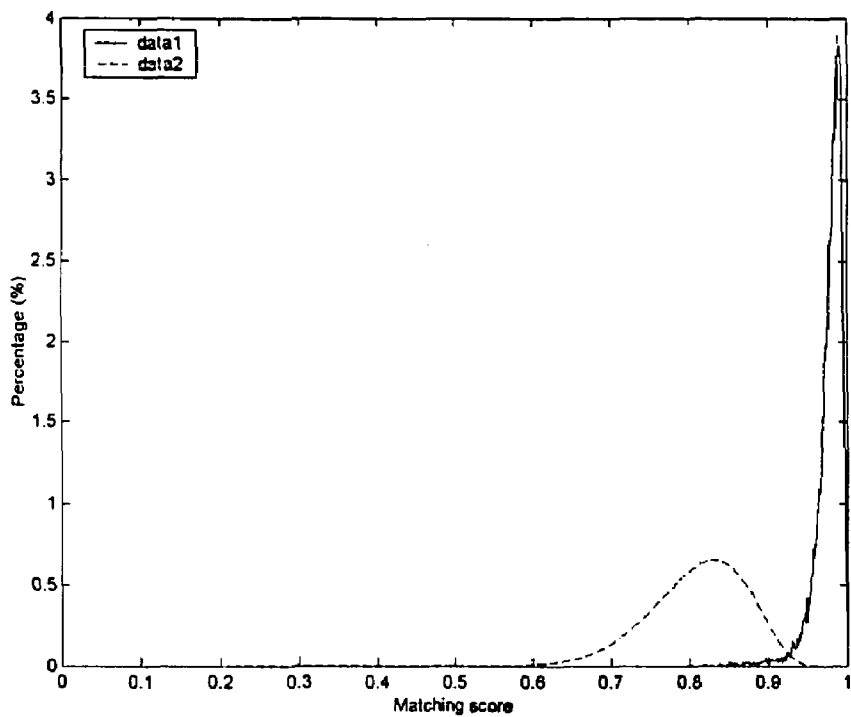**FIGURE 16**   **FIGURE 17**

FIGURE 18

FIGURE 19
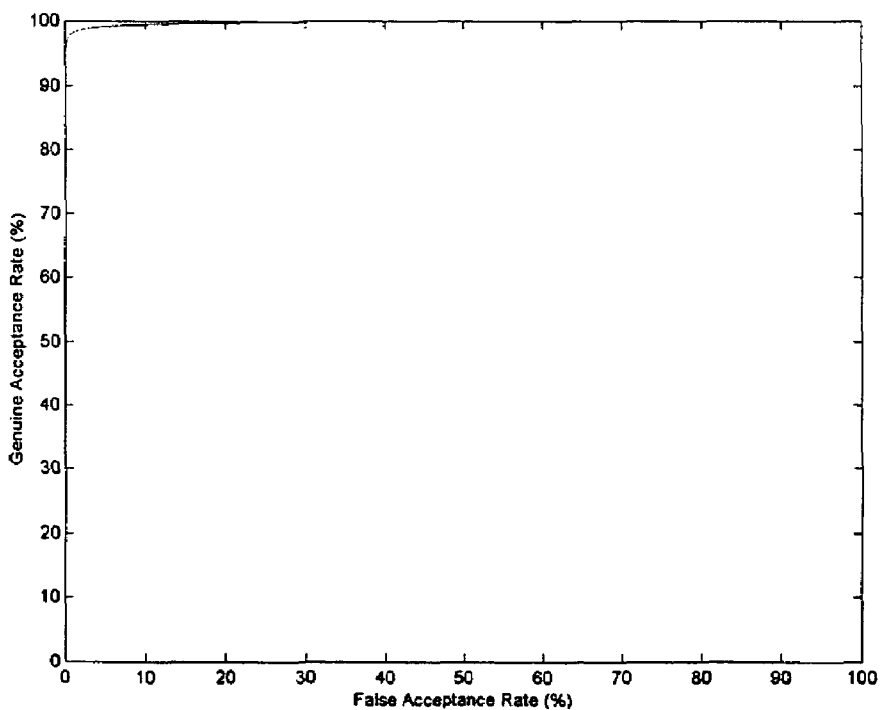

FIGURE 20

METHOD OF PALM PRINT IDENTIFICATION

This is a Continuation-in-part of application Ser. No. 10/253,914 filed on 25 Sep. 2002.

BACKGROUND TO THE INVENTION

1. Field of the Invention

The invention relates to biometrics identification, and in particular to a method for analyzing a palm print for the identification of an individual.

2. Background Information

Computer-aided recognition of individuals is becoming increasingly important in our information society. Biometrics is one of the most important and reliable methods in this field. The most widely used biometric feature is the fingerprint, whereas the most reliable feature is the iris. However, it is very difficult to extract small unique features (known as minutiae) from unclear fingerprints and iris scanners are very expensive. Other biometric features, such as the face and voice, are less accurate and they can be mimicked easily.

Palm print recognition for personal identification is becoming increasingly popular. Known methods include analyzing an image of a palm print to identify singular points, wrinkles, delta points and minutiae in the palm print. However, this requires a high-resolution image. Palmprint scanners that capture high-resolution images are costly and rely on high performance computers to fulfill the requirements of real-time identification.

One solution to the above problems seems to be the use of low-resolution images. In low-resolution palm print images, however, singular points and minutiae cannot be observed easily and only a small proportion of wrinkles are significantly clear. This makes it is questionable whether the use of such features from low resolutions provide sufficient distinctiveness to reliably identify individuals amongst a large population.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of biometrics identification, and in particular a method for analyzing a palm print for the identification of an individual, which overcomes or ameliorates the above problems.

According to the invention there is provided a method of biometrics identification including:

  obtaining an image including a portion of a hand of an individual,

  analyzing the image to find two or more feature parameters defining different characteristics of the hand, said parameters including a geometrical features parameter, a palm line features parameter or a palm texture features parameter.

  comparing the two or more feature parameters with reference information in a database.

Preferably, the geometrical features parameter comprises a relationship between two or more points on the image of the hand.

Preferably, the geometrical features parameter is a line intersecting two or more of a point between the first finger and middle finger, a point between the third finger and little finger, and a point defining the intersection of a palm line with a boundary of the hand.

Preferably, the geometrical features parameter is a line intersecting two or more of a point between the first finger and

middle finger, a point between the third finger and little finger, and a point defining the intersection of a hear line or life line with a boundary of the hand.

Preferably, the geometrical features parameter includes two lines intersecting at least three points on the image of the hand, and an angle between the two lines.

Preferably, finding the palm line features parameter or palm texture features parameter includes extracting a repeatable sub-image from the image.

Preferably, finding the palm line features parameter includes finding the first-order and second-order derivatives of the sub-image in two or more directions to identify lines in the image, and calculating a value for total strength for the lines.

Preferably, finding the palm texture features parameter includes calculating a total texture energy for the image.

Preferably, finding the palm texture features parameter includes calculating a total texture energy for the image using an equation of the form

$$TE(i, j, k) = \frac{\sum_{W_s} \sum_{W_y} (I * A_k)_{rs}^2}{P^2 W_x W_y}$$

where the rs sum is over all pixels within a square window W of size $W_x \times W_y$, centered on the pixel at i,j, A_k is a zero sum "tuned" 5×5 convolution mask, and P is the normalizer $P^2 = \Sigma_{i,j}(A_{i,j})^2$.

Further aspects of the invention will become apparent from the following description, which is given by way of example only.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings in which:

  FIG. **1** shows the surface features of a palm print,

  FIG. **2** shows the geometrical features of a palm print,

  FIGS. **3** to **5** illustrate the steps to find two of the geometrical features of FIG. **2**,

  FIGS. **6** to **9** illustrate the steps to obtain a normalized palm print image,

  FIGS. **10** to **13** illustrate identified surface features of the palm print image in FIG. **9**,

  FIGS. **14** to **17** illustrate 'tuned masks' for palm print texture extraction for horizontal, vertical, 45° and –45° lines, and

  FIGS. **18** to **20** are graphs of verification test results for a method according to the invention.

DESCRIPTION OF THE PREFERRED EXAMPLE

In a preferred embodiment of the invention palmprint identification uses comparison of one or more feature parameters, which define a set of physical properties whose values describe different characteristics of the palm, with stored parameter information. In another embodiment identification relies on comparison of three feature parameters describing characteristics of the palm with stored parameter information.

The method of identification includes obtaining an image of the hand of an individual, analyzing the image and building two, or three, feature parameters describing different characteristics of the hand and palm print, and comparing these parameter to reference parameters stored in a database. The

feature parameters are a geometrical feature vector (GFV) which describes geometric characteristics of the hand, a palm line feature (PLF) parameter which describes the characteristic lines on the palm, and a texture feature vector TFV) which describes the texture characteristic of the palm. The following sections described how to obtain these feature parameters.

Geometrical Feature Extraction

Referring to FIG. **2**, the image of a hand has easily identifiable features comprising points P_1, P_2, P_3, P_4. P1 lies between the first finger and middle finger, P_2 between the third finger and little finger, P_3 is the intersecting point of the hear line with the palm boundary and P_4 is the intersecting point of the life line with the palm boundary. The relationship between the points P_1, P_2, P_3, P_4 can be defined by straight lines with L_1, L_2, L_3 and L_4 representing the distance between points P_1 and P_2, P_2 and P_3, P_3 and P_4, P_4 and P_1, respectively. Also, an angle α is the number of degrees between the lines L_2 and L_3 joining points P_2, P_3, and P_4.

The geometrical feature vector is GRV=$(L_1, L_2, L_3, L_4, \alpha)$, and it is unique to an individual hand. The geometrical feature vector is used to identify an individual from their palm print. To obtain GFV, the points P_1, P_2, P_3 and P_4 must be found. Because these points exist on the boundary of the image and between prominent features such as the figures and major palm lines they can easily be found in low resolution images using known image processing techniques.

In the preferred embodiment of the invention points P_1, P_2 are also needed to define a repeatable sub-image for palm line feature extraction. Palm line feature extraction identifies the hear line and life line, and so points P_1, P_2, P_3 and P_4 can be found as part of the palm line feature extraction to obtain the GRV (L_1, L_2, L_3, L_4, α).

Palm Line Feature Extraction

A person does not always place their hand in the same position of the palm print scanning device and so it is desirable, but not essential, that the palm print sub-image is extracted and 'normalized' before PLF parameter is defined. This involves defining a repeatable sub-image of the palm area of the raw palm print image from a palm print scanner. This improves the accuracy of recognition. The points P_1 and P_2 defining the areas between the figures are obtained and used to find the sub-image.

FIG. **3** shows a low-resolution image of a portion the inside surface of a hand that was obtained using a CCD camera. The sub-image of the palm area is identified by finding the points P_1 and P_2 between fingers building a coordinate system in which parameters that define the sub-image can be found. The preferred embodiment has six main steps, which are given below.

Referring to FIG. **4**, the first step is to apply a low pass filter, L(u,v), such as Gaussian, to the original image, O(x,y). Then, a threshold, T_p, is used to convert the convoluted image to a binary image, B(x,y).

Referring to FIG. **5** the second step is to obtain the boundaries of the holes between the first finger and middle finger, and between the third finger and little finger using a boundary tracking algorithm. These are defined as $(F_i x_j, F_i y_j)$: where i=1, 2. The boundary of the hole between ring and middle fingers is not extracted since it is not useful for the following processing. These holes define points P_1 and P_2. Boundary tracking algorithms are common and well known in the image process field.

Referring to FIG. **6**, the third step is to find a straight line **2** that passes through points P_1 and P_2. If P_1 and P_2 are two points on $(F_1 x_j, F_1 y_j)$ and $(F_2 x_j, F_2 y_j)$, respectively, where

$P_1 = (x_1, y_1)$ and $P_2 = (x_2, y_2)$, then the line y=mx+c passing through P_1 and P_2 satisfies the inequality, $F_i y_j \leq mF_i x_j + C$, for all i and j. The line y=mx+c is the tangent of the two holes between the Fingers. This line, represented by numeral **2** in FIG. **6**, is the Y-axis of a coordinate system used for determining the location of a sub-image **1**.

The fourth step is to find the X-axis of the coordinate system. The X-axis is a line **3** passing through the midpoint of P_1 and P_2 _and_ perpendicular to line **2**.

The fifth step is to extract the sub-image **1** with a dynamic size on the basis of the coordinate system. The size and location of the sub-image **1** are based on the Euclidean distance (D) between points P_1 and P_2. The points **4**, **5**, **6**, **7** representing the corners of the sub-image **1** in the coordinate system are (0.25 D, 0.5 D), (1.25 D, 0.5 D), (0.25 D, −0.5 D) and (1.25 D, −0.5 D) respectively. Thus the sub-image **1** is square with a distance along each side equal to the Euclidean distance and symmetrical about the Y-axis line **3**. Because the sub-image is based on feature of the hand (i.e. the area between the fingers) it is repeatable for each individual hand.

FIGS. **7** and **8** shows the x and y axes **2**, **3** of the coordinate system and the sub-image **1** overlaid on the raw image of FIG. **3**. The sixth step is to normalize the sub-image **1** to a standard size using bilinear interpolation for feature extraction. FIG. **9** shows a normalized sub-image **1**.

To find Point P_3 and P_4 the palm-lines are extracted first by using the following method. And then, according to the length, position and strength of palm-lines, the heart line and life line can be obtained. Lastly, the Point P_3 and P_4 are obtained by finding the intersecting points of the heart line and life line with the boundary of the palm.

Palm-lines are a kind of roof edge. A roof edge can be defined as a discontinuity in the first-order derivative of a gray-level profile. In other words, the positions of roof edge points are the zero-crossing points of their first-order derivatives. The magnitude of the second-derivative indicates the strength of the roof edge. These properties can used to detect palm-lines. Because the directions of palm-lines are arbitrary, detection must be done in different directions. The lines that can be detected in θ direction are called Directional Lines in θ direction. The directional of horizontal lines is in the $\theta=0°$ direction.

Suppose that I(x,y) denotes an image. In order to improve the connection and smoothness of the lines, the image is smoothed along the line direction (say, the horizontal direction) by a 1-D Gaussian function G_{σ_s} with variance

$$\sigma_s : I_s = I * G_{\sigma_s} \qquad \text{(Equation 1)},$$

where * is the convolve operation.

The first-order derivative I' and second-order derivative I'' in the vertical direction are obtained by convolving the smoothed image I_s with the first-order derivative (G'_{σ_d}) and second-order derivative (G''_{σ_d}) of a 1-D Gaussian function G_{σ_d} with variance σ_d. The equations are:

$$I' = I_s * (G'_{\sigma_d})^T = (I * G_{\sigma_s}) * (G'_{\sigma_d})^T = I * (G_{\sigma_s} * (G'_{\sigma_d})^T) \qquad \text{(Equation 2) and}$$

$$I'' = I_s * (G''_{\sigma_d})^T = (I * G_{\sigma_s}) * (G''_{\sigma_d})^T = I * (G_{\sigma_s} * (G''_{\sigma_d})^T) \qquad \text{(Equation 3)},$$

where T is the transpose operation and * is the convolve operation.

If the directional line detectors H_1^θ, H_2^θ are:

$$H_1^\theta = G_{\sigma_s} * (G'_{\sigma_d})^T \qquad \text{(Equation 4) and}$$

$$H_2^\theta = G_{\sigma_s} * (G''_{\sigma_d})^T \qquad \text{(Equation 5)},$$

Then

$$I'=I*H_1{}^0 \qquad \text{(Equation 6), and}$$

$$I''=I*H_2{}^0 \qquad \text{(Equation 7)}$$

where $H_1{}^0$, $H_2{}^0$ are called the horizontal line detectors (directional line detectors in 0° direction).

The horizontal lines are obtained by looking for the zero-cross points of I' in the vertical direction and their strengths are the values of the corresponding points in I''. So

$$L_0^1(x, y) =$$

$$\begin{cases} I''(x, y), & \text{if } I'(x, y) = 0 \text{ or } I'(x, y) \times I'(x+1, y) < 0; \\ 0 & \text{otherwise.} \end{cases} \qquad \text{(Equation 8)}$$

Whether the roof edge is a valley or peak is given by the sign of the values in $L_0^1(x,y)$. Positive represent a valley and minus signs represent a peak. Since all palm-lines are valleys the minus values in $L_0^1(x,y)$ can be discarded. So

$$L_0^2(x, y) = \begin{cases} L_0^1(x, y), & \text{if } L_0^1(x, y) > 0; \\ 0, & \text{otherwise.} \end{cases} \qquad \text{(Equation 9)}$$

Compared to ridges, the palm-lines are much thicker. Therefore, a threshold, T, can be used to get rid of ridges from L_0^2. So

$$L_0(x, y) = \begin{cases} L_0^2(x, y), & \text{if } L_0^2(x, y) \ge T; \\ 0, & \text{otherwise.} \end{cases} \qquad \text{(Equation 10)}$$

L_0 is called the directional line magnitude image in 0° direction.

Because the directions of palm-lines are arbitrary, detection must be done in different directions. The directional line detectors H_1^θ, H_2^θ in a direction θ can be obtained by rotating H_1^0, H_2^0 by angle θ. And the line points can be obtained by looking for the zero-cross points in $\theta+90°$ direction. After discarding the peak roof edges and thresholding the directional line magnitude image L_θ in θ direction is obtained.

There are two parameters σ_s and σ_d in the directional line detectors H_1^θ, H_2^θ. σ_s controls the connection and smoothness of the lines and σ_d controls the width of the lines which can be detected. A small value of σ_s results in the poor connection and poor smoothness of the detected lines while a large value σ_s results in the loss of some short lines and the line segments whose curvature is large. The thin roof edges cannot be extracted when σ_d is large. In general, palm-lines are long, straight and narrow, and so σ_s should be large while σ_d should be small for palm-line detection. For example σ_s=1.8 and σ_d=0.5.

FIGS. 10 to 13 illustrate directional line magnitude images of the palm in FIG. 9 for θ=0°, 45°, 90° and 135° respectively, with σ_s and σ_d are set to 1.8 and 0.5, respectively.

The following explains how to compute the directional line energy (DLE). Let $L_{\theta_j}(1 \le j \le K)$ be K directional line magnitude images of palm print image I. Each L_{θ_j} is divided equally into M×M blocks, labeled 1, . . . ,M×M. The directional line energy (DLE) of block i in θ_j direction is defined as:

$$E_{\theta_j}^i = \sum_{c=1}^{m} \left[L_{\theta_j}(x_c, y_c) \right]^2, \ 1 \le i \le M \times M, \qquad \text{(Equation 11)}$$

where m is the total number of points in the block and (x_1, y_1), (x_2, y_2), . . . , (x_m, y_m) are the coordinates of the points. DLE $E_{\theta_j}^i$ reflects the strength of the palm-lines in block i in direction θ_j.

A K×M×M-dimensional vector V is constructed for the whole palm print. The equations for vector V is:

$$V=(E_{\theta_1}^1,E_{\theta_1}^2,\ldots,E_{\theta_1}^{M\times M},\ldots,E_{\theta_k}^1,E_{\theta_k}^2,\ldots,E_{\theta_k}^{M\times M}) \qquad \text{(Equation 12)}$$

The vector V is normalized by using the maximum and minimum values of its components. The equations for the normalized vector $\tilde{V}$ is:

$$\tilde{V}=(e_{\theta_1}^1,e_{\theta_1}^2,\ldots,e_{\theta_1}^{M\times M},\ldots,e_{\theta_k}^1,e_{\theta_k}^2,\ldots,e_{\theta_k}^{M\times M}) \qquad \text{(Equation 13)}$$

where

$$e_{\theta_j}^i = \frac{E_{\theta_j}^i - E_{\min}}{E_{\max} - E_{\min}}, \ 1 \le i \le M \times M, 1 \le j \le K. \qquad \text{(Equation 14)}$$

and E_{max} and E_{min} are the maximum and minimum values of the components of V respectively. The normalized vector $\tilde{V}$ is called a Palm-line feature (PLF) with K directions.

As described above, to construct a PLF, the palm print image is divided into M×M blocks definitely. Each point on a directional line has only two states: either it belongs to a block or not. Because it is impossible to remove all of the translations and rotations during the preprocessing stage, the points around the boundaries of blocks in an image may not be in the same block of the image captured from the same palm at different time. To avoid this problem, a method of fuzzy block and fuzzy division are used.

Let $2l$ be a positive integer, and U be the collection of all points in the palm print. Then, a fuzzy block, FB_k, whose central point is (x_k,y_k), can be defined as follows.

$$FB_k=\{\mu_k(i,j)/(i,j)\} \qquad \text{(Equation 15)}$$

where (i,j) is the coordinates of the point and $\mu_k(i,j)$ is the corresponding membership function in the FB_k. $\mu_k(i,j)$ is given by:

$$\mu_k(i, j) = \begin{cases} 1, & d \le l/2; \\ \frac{2(l-d)}{l}, & l/2 < d < l; \\ 0, & d \ge l. \end{cases} \qquad \text{(Equation 16)}$$

where $d=\max(|i-x_k|,|j-y_k|)$ \qquad (Equation 17)

According to Equations 16 and 17, the membership grade of a point in a fuzzy block is computed by examining the distance from it to the central point of the block.

We call M×M fuzzy blocks, which are labeled (0, 0), (0, 1), . . . ,(i, j), . . . ,(M−1, M−1), a M×M fuzzy division of an image with size N×N if and only if

$$x_i = l + \frac{3}{2} \times i \times l, \tag{Equation 18}$$

$$y_j = l + \frac{3}{2} \times j \times l, \text{ and} \tag{Equation 19}$$

$$x_{M-1} = y_{M-1} = l + \frac{3}{2} \times (M-1) \times l = N - l, \tag{Equation 20}$$

where (x_i, y_j) is the center point of block (i,j) (i,j=0, . . .,M–1); M and 2 l are two positive integers.

In fuzzy division of an image, each fuzzy block overlaps

$$\frac{l}{2} \times 2l = l^2$$

pixels of the adjacent blocks, thus there is no definite boundary between the fuzzy blocks, so Equation 20 can be rearranged as:

$$M = \frac{2N - l}{3l}. \tag{Equation 21}$$

Because both M and 2 l are positive integers. If for example N=128, then M only has four values: 85, 21, 5 and 1, which can satisfy Equation 21. The corresponding values of l are 1, 4, 16 and 64, respectively. That is, there exist four fuzzy divisions, i.e. a 85×85 fuzzy division, a 21×21 fuzzy division, a 5×5 fuzzy division and a 1×1 fuzzy division. The length of the corresponding PLFs is 85×85×K=7,225K, 21×21× K=441K, 5×5×K =25K and 1×1×K=K (where K is the number of the directional line magnitude images used to compute PLFs), respectively. Obviously, the 1×1 fuzzy division is not suitable for palm print recognition. Because the storage requirements and the computational complexity are direct ratio to the length of the vectors, the PLFs of the 85×85 and 21×21 fuzzy division are too long to use in palm print recognition. Therefore, the 5×5 fuzzy division is employed to compute PLF. For the fuzzy block, p, Equation 11 can be modified as follows:

$$\tilde{E}_{\theta_j}^i = \sum_{c=1}^{m} \left\{ [L_{\theta_j}(x_c, y_c)]^2 \times \mu_p(x_c, y_c) \right\}, \ 1 \le i \le M \times M, \tag{Equation 22}$$

where m is the total number of points in this block and (x_1, y_1), (x_2, y_2), . . . ,(x_m, y_m) are the coordinates of these points. To obtain the definition of the PLF for the fuzzy division of the palm print $E_{\theta_j}^i$ is replaced with $E_{\theta_j}^i (1 \le i \le M \times M, 1 \le j \le K)$ in the Equations 12 to 14.

Texture Feature Vector Extraction

The texture energy (TE) of a palm print image I is defined as below:

$$TE(i, \ j, k) = \frac{\sum\limits_{W_x} \sum\limits_{W_y} (I * A_k)_{rs}^2}{P^2 W_x W_y}, \tag{Equation 23}$$

where the rs sum is over all pixels within a square window W of size $W_x \times W_y$ centered on the pixel at i, j, A_k is a zero sum "tuned" 5×5 convolution mask as shown in FIGS. 14 to 17, and P is the parameter normalizer $P^2 = \Sigma_{i,j}(A_{i,j})^2$. TE is called a texture energy image.

FIGS. 14 to 17 illustrate four kinds of 'tuned masks' for global palm print texture extraction. FIG. 14 is the Horizontal line, FIG. 15 is the Vertical line, FIG. 16 is the 45° line and FIG. 17 is the –45° line.

The texture energy image TE is divided first into M×M blocks equally. Then the local texture energy for each block its is computed using:

$$LTE = \frac{1}{LN} \sum_{i=1}^{L} \sum_{j=1}^{N} \sum_{k=0}^{3} TE(x_i, y_j, k), \tag{24}$$

where L×M is the size of the block and (x_i, y_j) are the coordinates of the points in the block.

Finally, a M×M vector is formed by using the local texture energies of all blocks, which is called texture feature vector (TFV).

Similarity Measurement

Similarity Measurement is used to compare the measured palm print parameters with reference parameters stored in an identification database.

For the GFV and PLF parameters Euclidean distance is used to measure the similarity. The Euclidean distance of two vectors, v_1 and v_2, are defined as follows:

$$D = \sqrt{\sum_{i=1}^{M} (v_1(i) - v_2(i))^2}, \tag{Equation 25}$$

where M is the length of the vectors, v_1 is the GFV or PLF extracted from the palm print, and v_2 is a vector parameter stored in an identification database.

For the TFV parameter the angular distance is used to evaluate the difference of two feature parameters. Let X and Y be two local texture energy feature vectors. The angular distance is as:

$$D_4 = \frac{X^T Y}{\|X\| \|Y\|}, \tag{Equation 26}$$

where T represents transpose of a vector and $\| \ \|$ is a norm of a vector.

The following experimental results illustrate the effectiveness of a system according to the invention. Palm print images were collected from 160 individuals, using a CCD-based palm print scanner. The palm print images were processed and vectors stored to establish a palm print database. The individuals were asked to provide 20 images of their right and

left palms and so there were 3,200 palm prints in the database. The resolution of the images was 384×284 pixels, at 75 dpi. The sub-image 1 size is 128×128 pixels.

For testing the PLF features, six images of each palm were used as training samples to establish the database, and the remaining four were used as testing samples. The variances σ_s and σ_d of the directional line detectors H_1^θ, H_2^θ were 1.8 and 0.5 respectively, and a Hysteresis threshold is used in which the high threshold is obtained by using Otsu' method to the non-zero points of L_θ^1 and the low threshold is chosen as the minimum value of the non-zero points of L_θ^1. A 5×5 fuzzy division of the images is used to compute PLFs. The templates are obtained by averaging PLFs of the training samples from the same palms. PLFs are computed by using six directional line magnitude images (the corresponding direction angles are 0°, 30°, 60°, 90°, 120° and 150°).

An accuracy of 97.5% was obtained in one-against-320 matching tests. The false rejection rate (FRR) and the false acceptance rate (FAR) of one-against-one matching tests at different thresholds are plotted in FIG. **18**. The equal error rate (EER, where FAR equal FRR) is 2.08%.

For testing the TFV parameter Palm print images were collected from 193 individuals using a CCD-based palm print scanner. The palm print images were processed and vectors stored to establish a palm print identification database. The individuals were asked to provide 10 images of their right and left palms and so there were 3,834 palm prints in the database.

The verification accuracy is shown in FIG. **19**. This presents the probability distributions of genuine and impostor of TFV. FIG. **20** is the receiver operating characteristic (ROC) of TFV. This is a plot of genuine acceptance rate against false acceptance rate for all possible operating points.

Where in the foregoing description reference has been made to integers or elements having known equivalents then such are included as if individually set forth herein.

Embodiments of the invention have been described, however it is understood that variations, improvements or modifications can take place without departure from the spirit of the invention or scope of the appended claims.

What is claimed is:

1. A method of biometrics identification including:
   obtaining an image including a portion of a hand of an individual, using a processor or computer to carry out the steps of:
   analyzing the image to find at least two feature parameters defining different characteristics of the hand, said feature parameters consisting of a geometrical features parameter, and at least one of a palm line features parameter or a palm texture features parameter, said geometrical features parameter comprising a relationship between two points located between the figures of the hand,
   comparing the two or more feature parameters with reference information in a database.

2. The method of claim **1** wherein the geometrical features parameter is a line intersecting two or more of a point between the first finger and middle finger, a point between the third finger and little finger, and a point defining the intersection of a palm line with a boundary of the hand.

3. The method of claim **1** wherein the geometrical features parameter is a line intersecting two or more of a point between the first finger and middle finger, a point between the third finger and little finger, and a point defining the intersection of a heart line or life line with a boundary of the hand.

4. The method of claim **1** wherein the geometrical features parameter includes two lines intersecting at least three points on the image of the hand, and an angle between the two lines.

5. The method of claim **1** wherein finding the palm line features parameter or palm texture features parameter includes extracting a repeatable sub-image from the image.

6. The method of claim **1** wherein finding the palm line features parameter includes finding the first-order and second-order derivatives of the sub-image in two or more directions to identify lines in the image, and calculating a value for total strength for the lines.

7. The method of claim **1** wherein finding the palm texture features parameter includes calculating a total texture energy for the image.

8. A method of biometrics identification including:
   obtaining an image including a portion of a hand of an individual, using a processor or computer to carry out the steps of:
   analyzing the image to find at least two feature parameters defining different characteristics of the hand, said at least one feature parameter consisting of a geometrical features parameter, and at least one of a palm line features parameter or a palm texture features parameter, said geometrical features parameter comprising a relationship between two points located between the figures of the hand,
   comparing the at least two feature parameters with reference information in a database,
   wherein finding the palm texture features parameter includes calculating a total texture energy for the image using an equation of the form

$$TE(i, j, k) = \frac{\displaystyle\sum_{W_x} \sum_{W_y} (I * A_k)_{rs}^2}{P^2 W_x W_y}$$

where the rs sum is over all pixels within a square window W of size $W_x \times W_y$ centered on the pixel at i, j, A_k is a zero sum "tuned" 5×5 convolution mask, and P is the normalizer.

*   *   *   *   *