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Fingerprint Identification

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Fingerprint Identification

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I. Introduction

Fingerprints are imprints formed by friction ridges of the skin and thumbs. They have long been used for identification because of their immutability and individuality. Immutability refers to the permanent and unchanging character of the pattern on each finger. Individuality refers to the uniqueness of ridge details across individuals; the probability that two fingerprints are alike is about 1 in 1.9x1015. However, manual fingerprint verification is so tedious, time consuming and expensive that is incapable of meeting today‟s increasing performance requirements. An automatic fingerprint identification system is widely adopted in many applications such as building or area security and ATM machines. Our approach will be described in this project for fingerprint recognition:

Our approach is based on minutiae located in a fingerprint.

II. Approach

Most automatic systems for fingerprint comparison are based on minutiae matching [2] Minutiae are local discontinuities in the fingerprint pattern. A total of 150 different minutiae types have been identified. In practice only ridge ending and ridge bifurcation [5] minutiae types are used in fingerprint recognition [4]. Examples of minutiae are shown in figure 1.

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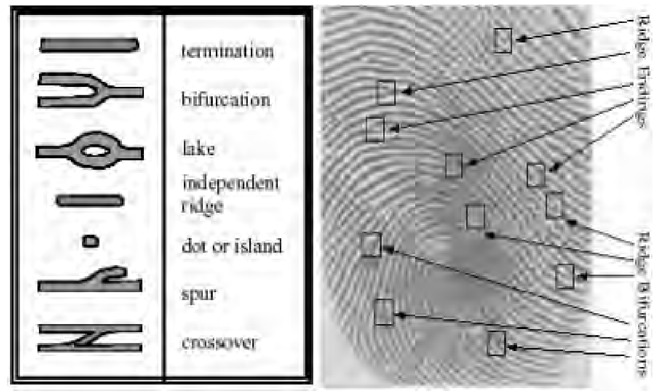

Figure 1. (a) Different minutiae types, (b) Ridge ending & Bifurcation

Many known algorithms have been developed for minutiae extraction based on orientation and gradients of the orientation fields of the ridges. In this project we will adopt the method used by Leung where minutiae are extracted using feed-forward artificial neural networks.

The building blocks of a fingerprint recognition system are: Image acquisition, Edge detection, Thinning, Feature extractor, Classifier. Figure 2 shows the building blocks.

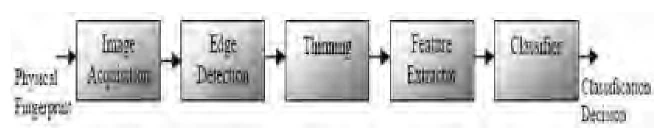

Figure 2. Fingerprint recognition system

a) *Image Acquisition*

The first stage of any vision system is the image acquisition stage. Image acquisition is hardware dependent. A number of methods are used to acquire fingerprints. Among them, the inked impression method remains the most popular one. Inkless fingerprint scanners are also present eliminating the intermediate digitization process [6].

i. *2D Image Input*

The basic two-dimensional image is a monochrome (grayscale) image which has been digitized. Describe image as a two-dimensional light intensity function f(x,y) where x and y are spatial coordinates and the value of f at any point (x, y) is proportional to the brightness or grey value of the image at that point.

A digitized image is one where
- spatial and grayscale values have been made discrete
- intensity measured across a regularly spaced grid in x and y directions
- intensities sampled to 8 bits (256 values)

Figure 3 shows a grayscale image.

Figure 3: Grayscale fingerprint image.

For computational purposes, we may think of a digital image as a two-dimensional array where x and y index an image point. Each element in the array is called a pixel (pictureelement).

99	71	61	51	49	40	35	53	56	99
93	74	53	56	45	45	48	72	55	102
101	69	57	53	54	52	64	62	68	101
107	82	64	63	59	60	81	90	93	100
114	93	76	59	72	85	84	99	95	99
117	109	94	92	97	101	100	106	105	99
118	114	109	106	105	108	108	102	107	110
115	113	109	114	111	121	113	105	111	115
110	113	111	109	106	108	110	115	120	122
103	107	105	108	109	114	120	124	124	132

Figure: Pixel values in highlighted region

ii. *3D Image Input*

A 3D image containing has many advantages over its 2D counterpart:
- 2D images give only limited information the physical shape and size of an object in a scene.
- 3D images express the geometry in terms of three-dimensional coordinates.

e.g Size (and shape) of an object in a scene can be straightforwardly computed from its three-dimensional coordinates.

b) *Edge Detection*

An edge is the boundary between two regions with relatively distinct gray level properties. The idea underlying most edge-detection techniques is on the computation of a local derivative operator such as „Sobel" operators [7]. In practice, the set of pixels obtained from the edge detection algorithm seldom characterizes a boundary completely because of noise,breaks in the boundary and other effects that introduce spurious intensity discontinuities. Thus, edge detection algorithms typically are followed by linking and other boundary detection procedures designed to assemble edge pixels into meaningful boundaries.

c) *Thinning*

Thinning [8] is a morphological operation that successively erodes away the foreground pixels until they are one pixel wide. A standard thinning algorithm is employed, which performs the thinning operation using two sub-iterations. This algorithm is accessible in MATLAB via the `thin' operation under the bwmorph function. Each sub-iteration begins by examining the neighbourhood of each pixel in the binary image, and based on a particular set of pixel-deletion criteria, it checks whether the pixel can be deleted or not. These sub-iterations continue until no more pixels can be deleted. The application of the thinning algorithm to a fingerprint image preserves the connectivity of the ridge structures while forming a skeletonised version of the binary image. This skeleton image is then used in the subsequent extraction of minutiae. An important approach to representing the structural shape of a plane region is to reduce it to a graph. This reduction may be accomplished by obtaining the skeleton of the region via thinning (also called skeletonizing) algorithm.
The thinning algorithm while deleting unwanted edge points should not:
- Remove end points.
- Break connectedness.
- Cause excessive erosion of the region

d) *Feature Extraction*

Extraction of appropriate features is one of the most important tasks for a recognition system. The feature extraction method used in will be explained below. A multilayer perceptron [9] (MLP) [10] of three layers is trained to detect the minutiae in the thinned fingerprint image of size 300x300. The first layer of the network has nine neurons associated with the components of the input vector. The hidden layer has five neurons and the output layer has one neuron. The network is trained to output a "1" when the input window in centered on a minutiae and a "0" when it is not. Figure 3 shows the initial training patterns which are composed of 16 samples of bifurcations in eight different orientations and 36 samples of non-bifurcations.

State the number of epochs needed for convergence as well as the training time for the two methods. Once the network is trained, the next step is to input the prototype fingerprint images to extract the minutiae. The fingerprint image is scanned using a 3x3 window given

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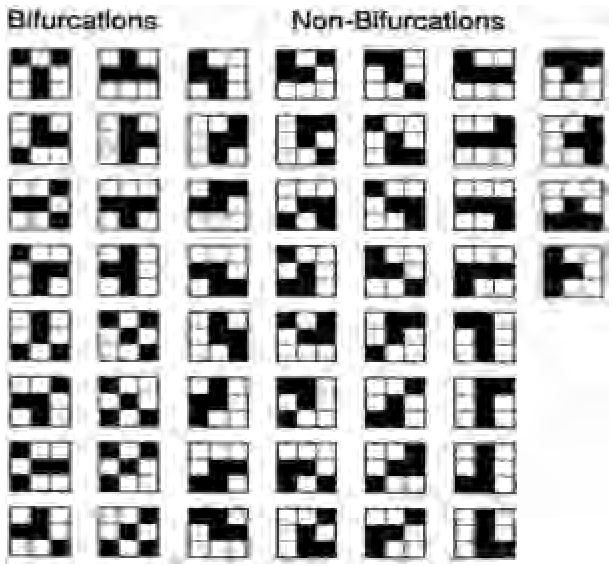

Figure 4: *Training set*

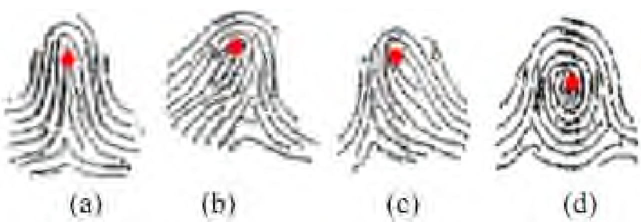

Figure 5. *Core points on different fingerprint patterns. (a) tented arch, (b) right loop, (c)left loop, (d) whorl.*

e) *Classifier*

After scanning the entire fingerprint image, the resulting output is a binary image revealing the location of minutiae. In order to prevent any falsely reported output and select "significant" minutiae, two more rules are added to enhance the robustness of the algorithm:

1) At those potential minutiae detected points, we re-examine them by increasing the window size by 5x5 and scanning the output image.

2) If two or more minutiae are to close together (few pixels away) we ignore all of them.

To insure translation, rotation and scale-invariance, the following operations will be performed:

• The Euclidean distance d(i) from each minutiae detected point to the center is calculated. The referencing of the distance data to the center point guarantees the property of positional invariance.

• The data will be sorted in ascending order from d(0) to d(N), where N is the number of detected minutiae points, assuring rotational invariance.

• The data is then normalized to unity by shortest distance d (0), i.e: dnorm(i) = d(0)/d(i); This will assure scale invariance property.

In the algorithm described above, the center of the fingerprint image was used to calculate the Euclidean distance between the center and the feature point. Usually, the center or reference point of the fingerprint image is what is called the "core" point. A core point, is located at the approximate center, is defined as the topmost point on the innermost upwardly curving ridgeline.

The human fingerprint is comprised of various types of ridge patterns, traditionally classified according to the decades-oldHenry system: left loop, right loop, arch, whorl, and tented arch. Loops make up nearly 2/3 of all fingerprints, whorls are nearly 1/3, and perhaps 5-10% are arches. Figure 5 shows some fingerprint patterns with the core point marked. Many singularity point detection algorithms were investigated to locate core points. For simplicity we will assume that the core point is located at the center of the fingerprint image.

After extracting the location of the minutiae for the prototype fingerprint images, the calculated distances will be stored in the database along with the ID or name of the person to whom each fingerprint belongs.

The last phase is the verification phase where testing fingerprint image:

1. is inputted to the system
2. minutiae are extracted
3. Minutiae matching: comparing the distances extracted minutiae to the one stored in the database
4. Identify the person: State the results obtained (i.e: recognition rate).

III. Conclusion

Our approach is based on minutiae located in a fingerprint. We further want to implement the fingerprint identification system based on a different approach, namely frequency content and ridge orientation of a fingerprint. The reliability of any automatic fingerprint recognition system strongly relies on the precision obtained in the minutiae extraction process. The minutiae based matching is highly sensible, as, if the finger is moved even a little bit that gives us a different set of minutiae.

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