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Research Paper on Fingerprint Identification

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Abstract: *Fingerprint identification is one of the most popular and reliable personal biometric identification methods. This paper describes an on-line fingerprint identification system consisting of image acquisition, edge detection, thinning, feature extractor, and classifier. The preprocessing part includes steps to acquire binarized and skeletonized ridges, which are needed for feature point extraction. Feature points (minutia) such as endpoints, bifurcations, and core points are then extracted, followed by false minutia elimination. Human fingerprints are rich in details called minutiae, which can be used as identification marks for fingerprint verification. The goal of this project is to develop a complete system for fingerprint identification.*

Keywords: Fingerprint, Minutia, Thinning, Edge Detection, Ridge, Bifurcation

I. INTRODUCTION

Two like fingerprints would be found only once every 10^48years" — Scientific American, 1911.

A fingerprint is defined by a set of ridge lines and they run parallel and sometimes terminate and sometimes intersect. Thepoints are known as Minutiae where the ridge lines are terminatedwhereas according to Galton, each ridge is characterized by numerous minute peculiarities called Minutiae, which may divideand almost immediately reunite, enclosing a small circular or elliptical space or sometimes the independent beginning or endingof ridges.

In a fingerprint image, ridges area unit dark whereas valleys area unit bright.Ridges and valleys usually run in parallel; typically they bifurcate and typically they terminate. Minutiae-based mostly fingerprint identification system approaches towards extraction of the ridge patterns properly.A goodquality fingerprint contains 25-80 numbers of minutiae depending on the sensor resolution and fingerplacement on the sensor.However, fingerprint images captured through poor scanners, are found to possess a lower range of trivia points.In order to ensure the minutiae extraction procedure images as input, this gives a reason to the fingerprint images forenhancement.Unlike face and voice patterns, fingerprints are persistent with age and can't be easily changed. We can say that fingerprinting is one of the most researched and matured field of biometric authentication.They have long been used for identification because of theirimmutability 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 it 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 ATMs. 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 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 minutiae types are used in fingerprint recognition.

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, and Classifier. The building blocks of fingerprint detection system:

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.

i. 2D Image Input

The basic two-dimensional image is a monochrome (grayscale) image that has been digitized. Describe the 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).

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 (picture element).

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 the computation of a local derivative operator such as Sobel "operators". 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 is a morphological operation that successively erodes 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 (MLP) 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 is centered on a minutiae and a "0" when it does not show 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

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 thefingerprint 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-old Henry 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. 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 into 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).

Five advantages of Fingerprint Recognition

- Security – security-wise, it is a vast improvement on passwords and identity cards. Fingerprints are much harder to fake, they also change very little over a lifetime, so the data remains current for much longer than photos and passwords.
- Ease of use – for the user they are simple and easy to use. No more struggling to remember your last password or being locked out due to leaving your photo ID at home. Your fingerprints are always with you.
- Non-transferable – fingerprints are non-transferrable, ruling out the sharing of passwords or 'clocking in' on behalf of another colleague. This allows for more accurate tracking of workforce and provides additional security against the theft of sensitive materials.
- Accountability – using fingerprint recognition also provides a higher level of accountability at work. Biometric proof you have been present when a situation or incident has occurred is hard to refute and can be used as evidence if required.
- Cost effective – from a technology management perspective, fingerprint recognition is now a cost-effective security solution. Small hand-held scanners are easy to set up and benefit from a high level of accuracy.

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Three disadvantages of Fingerprint Recognition

- System failures – scanners are subject to the same technical failures and limitations as all other electronic identification systems such as power outages, errors and environmental factors.
- Cost – it is true that fingerprint recognition systems are more cost effective than ever, but for smaller organisations the cost of implementation and maintenance can still be a barrier to implementation. This disadvantage is lessening as devices become more cost effective and affordable.
- Exclusions – while fingerprints remain relatively stable over a person's lifetime there are sections of the population that will be excluded from using the system. For example, older people with a history of manual work may struggle to register worn prints into a system or people who have suffered the loss of fingers or hands would be excluded.

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.Future research work can be carried out toimprove the quality of the image by improving the image enhancement technique and develop a better matching technique.

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