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Fingerprint authentication using graph theory

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ABSTRACT

In this paper we have tried to implement the idea to classify fingerprints through identifying the core of the fingerprint. The fingerprint is taken as an input via an image. The image is then transformed for necessary preprocessing. Then we make a graph with ridges' ending and bifurcations all around the Centre, acting as vertices. Then we compare the graph constructed using the connection of vertices. The idea is to calculate distance between neighbouring vertices for each vertex. Our aim is to increase the efficiency of fingerprint identification in different orientation.

Introduction

Fingerprint identification is the process of identifying a person based on the patterns of his fingerprint denoted by the patterns of the ridges on the surface of his finger. The ridges in the image of a fingerprint are denoted by the black lines and the spaces between them known as valleys and are denoted by white spaces. Also one or more ridges in a fingerprint pattern are connected[1].The unique factors of a fingerprint are: crossover, core, bifurcation, ridge ending, island, delta and pore.

The two fundamental principles of fingerprints identification are:

Immutability: The fingerprint pattern remains consistent for a particular person throughout his life. They only change by accident, skin disease or change of size.

Uniqueness: Fingerprint pattern develops in a purely random manner during foetal development in the womb. There is sufficient variability in the arrangement that no two patterns match each other even the patterns of two different fingers of the same person are unique.

The current research only matches fingerprints using neighbor of a particular ridge to match the patterns or by reducing the ridges to a smaller pixel value. These algorithms are not able to overcome the problem of identification when there is some noise in the image of the fingerprint because of dirt, scar etc[2]/.

This paper proposes a solution to overcome the problems of orientation and noise of a fingerprint image during the process of matching. The algorithm considers the image as a whole and compares using minutiae.

Related Work

One of the papers by Honglei Wei[1] has proposed a fingerprint matching algorithm which can withstand the elastic distortion produced while taking a fingerprint. For fingerprint matching they have used the ridge line which connects the minutia point with the associated ridge point. Basically, algorithm is divided into two stages based on the ridge lines.

In first stage, estimation of transformation is done by matching the input with local quadrilateral sets. Here, the quadrilateral is formed by connecting two ridges' minutia point and ridge points respectively. Input graph and quadrilateral sets are matched by comparing their respective parameters.

In second stage, a coarse pair set is achieved by matching two aligned ridge line sets in relatively slack matching qualifications, and then graph matching algorithm is applied again to match those coarse pair set again to remove the false matched ridge lines which might be present due to slack matching qualifications. The coarse pair set is represented as graph of input image and quadrilateral template graph respectively. Each node in the graph corresponds to a ridge line and each edge corresponds to a quadrilaterals. A similarity graph can be achieved by matching the two graphs, in which an edge between two nodes corresponds to the matching score of corresponding quadrilaterals composed with the corresponding ridge lines. Final matching score is then calculated on the basis of both the matching score of ridge line sets and the matching score of orientation fields.

One another paper[2] has proposed core based algorithm for Fingerprint verification. Most of the non-core based matching algorithm is time consuming. Therefore, they are not suitable for online application. So to increase the efficiency of algorithm, firstly, they used core detection algorithm to get the core position, and then defined some local structure of the core area. Using this local Structure, we find some correspondent points of the two fingerprint image. Secondly, we use the correspondent points in the first stage to march the global feature of the fingerprint. Experimental results showed that the performance of the proposed algorithm is good but not the best.

Another paper[3] proposed a fingerprint minutia matching technique, in which matching is done by using both the local and global structures of fingerprint minutiae. The local structure of a minutia describes a rotation and translation invariant feature of the minutia in its neighborhood. It is used to find the correspondence of two minutiae sets and increase the reliability of the global matching. While the global structure of minutiae reliably determines the uniqueness of fingerprint. Therefore, the local and global structures of minutiae together provide a solid basis for reliable and robust minutiae matching. The scheme is

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suitable for an on line processing due to its high processing speed.

Proposed Solution

Given an image of fingerprint take the higher and the lower pixel values from it and then recognize the friction ridges pattern. We are using binary grey values for the image. Here we mark each and every ridge by a set of nodes for every pixel value. The ridges having nodes will be connected by ensuring the connectedness of the graph and we traverse in bottom up fashion. When the graph begins to be disconnected then we start making the new graph by taking nodes from its one end point to other[6]. Now, each ridge has become the connected path of the fingerprint graph.

$$K_G(v) = 1 - \frac{\deg v}{2} + \sum_{f \sim v} \frac{1}{|f|}$$

Then we determine the curvature of the ridges using combinatorial curvature[7].The connected path and circuits where f ~v indicates that vertex v is on the boundary of face f, and |f| isthe number of vertices on the boundary of face f[7] Find the combinatorial curvature of the graph from the last graph constructed. The least curvature value for the set of graphs is nearest to center. So, in order to find the center of the fingerprint we take the lowest curvature ridge and below it on the one grey value patch are marked as center. Then after finding the center point we make a wheel graph around it with the help of surrounding ridges. Then for matching purposes we use graceful labeling to label each and every ridge's node uniquely based on the direction and distance from the center point[5]. A graceful labeling is one in which labeling is done with distinct integers from the set {0, 1, 2, ..., m} (where m is the number of edges) such that when each edge vertex u to vertex is given the value | f (u)-f (v) | the edges are uniquely labeled from set of numbers {1, 2,… m}[7].Then the similar labeling is done in the graph after angle of 20° and by this can get distance measure and direction of ridges of fingerprint graph. Use the planarity of graphs to detect the crossover. The graph are said to be planar if edges in the plane do not intersect each other. The graph in non-planar if edges intersect but they can be made non-intersecting with the given edges and vertices. So with this if we detect intersecting edges i.e. their non-planar we can say that there is a cross-over for the two edges we store their labels. The node in the path having highest eccentricity is known as ridge ending. As eccentricity is labeled relative to distance from a particular vertex to the others is maximum. Then we get the end points as their eccentricity is maximum.

$$E(v) = \max_{v_i \in G} d(v, v_i)$$

where, d(v,vi) is the distance of from farthest vertex vi[4].

These end points of the ridges at each 20° and note their graph label and edge labels. The lake is other important component of minutiae of fingerprint. Lake can be determined by using concept of multiple edges. The two adjacent edges having deg(3) are considered. Then check their edge connectivity is two then there is lake formed by these to vertices. The edge connectivity gives the minimal number of edges required to make graph disconnected. Degree of a node can be done by finding the incident vertices on a vertex. The incidence can be calculated by the number of non-parallel edges which ends up on the same vertex. The number of incident vertices on a graph gives the degree of that graph.

Figure 1

For detection the stored edge labels of each parameter is taken. Then the labels are compared with labels of test images[8]. The noises on the image as discussed can be removed by comparing matching each parameters' edge labels up to 80% only so that even off there is noise the test image nearly matches the stored image based on basic parameters. The parameters are weighted based on their uniqueness from person to person. There are three major types of minutiae features: the ridge ending, the bifurcation, and the dot (also called short ridge). The ridge ending is, as indicated by the name, the spot where a ridge ends. A bifurcation is the spot where a ridge splits into two ridges. Spots are those fingerprint ridges that are significantly shorter than other ridges. Also, the ridges in the fingerprint have a specific grey value of 0 which will help distinguish from noises like scars, ink and dust.

Figure 2

Conclusion

This study described a new fingerprint matching technique based on identifying the core of a fingerprint. To find out the core of the fingerprint we are finding the curvature of the ridges. Since the finger print matching technique is based on core of a fingerprint so it can efficiently recognize the fingerprint even if the fingerprint is taken at different orientations. Now after finding the core of a fingerprint the wheel graph will be formed around the core and labeling of each vertex will be done. This step will help us to uniquely identify fingerprint of the respective person. Since the presence of noises in the image is possible so 80% match could be considered. Therefore it can be concluded that the proposed algorithm is efficient way of fingerprint matching.

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