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Minutiae Cylindrical Code (MCC) for Fingerprint Matching - A Survey

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***Abstract*: In this paper, introduction minutiae cylindrical code (MCC) for fingerprint matching based on 3D data structures called cylinders. In this digital era, lots of physical data have been transformed into the digital ones. A survey of minutiae cylindrical code (MCC) is done using various papers to find out the problem or drawback in various models, methods, algorithm. This paper aims to improve the fingerprint matching performance, by using Minutiae Cylinder-Code (MCC) algorithm. With the help of MATLAB tool false acceptance rate (FAR), false rejection rate (FRR), execution time, matching time, enrolment time is going to be improved.**

***Keywords*: fingerprint matching; MCC; FAR; FRR; matching time; execution time; enrolment time.**

1. Introduction

A fingerprint matching algorithm analyze two given fingerprints and returns either a degree of similarity or a binary decision. Only a few matching algorithms engage directly on grayscale fingerprint images; most of them require that transitional fingerprint portrayal be proved through a feature extraction stage. Matching fingerprint images is a very difficult problem, mainly due to the large variability in different impressions of the same finger.

Fingerprint matching can be roughly classified into three types.

- *Correlation-based matching:* Two fingerprint images are overlapped and the interaction between the analogous pixels are calculated for different alignments.
- *Minutiae-based matching:* This is the most prominent and widely used technique, being the basis of the fingerprint contrast made by fingerprint investigators. Minutiae are derived from the two fingerprints and saved as sets of points in the two dimensional plane. Minutiae-based matching essentially consists of finding the adjustment between the template and the input minutiae feature sets that decision in the maximum number of minutiae pairings.
- *Non-Minutiae feature-based matching:* minutiae deriving is crucial in extremely low-quality fingerprint images. While some other features of the fingerprint ridge arrangement may be selected more accurately than minutiae, their uniqueness as well as persistence is generally lower. The path belonging to this family analyze fingerprints in term of features separated from the ridge arrangement. In principle, correlation-based matching could be conceived of as a subfamily of non-minutiae feature-based matching, in as much as the pixel intensity are themselves features of the finger pattern.

Fingerprint recognition is an intriguing pattern recognition problem that has been studied for more than 40 years. Although very impressive results are presently available, fingerprint recognition can't be considered a fully clarified problem, and the design of accurate, intolerable, and computationally light algorithms is still an open issue [1].

2. Literature survey

This paper demonstrates the advancement of technology that has given contributions to the rapid growth of the use of digital data. One example of the use of digital data is the digital biometric fingerprint data on the Electronic Identity Card (KTP-el). To identify a person, fingerprint matching can be used. There are some techniques to do fingerprint matching. One of popular technique is minutia-based fingerprint matching a 2D approach. A new method of minutiae based fingerprint using 3D cells called cylinders is used to implement the fingerprint matching on a large scale.

The technique can be classified into two categories, nearest neighbor-based and fixed radius-based. Each category has their own advantages and disadvantages. However, there is a technique that combines their advantages without having their drawbacks, i.e. Minutia Cylinder-Code (MCC). The process of analyzing their fingerprints data could take extremely long time if it done linearly, which is what is currently happening. Thus, there is a need for a parallel fingerprint matching. Parallel processing can be done with multicore CPU, multicore GPU, or multicomputer. The difference between CPU and GPU is how they process task [2].

This paper demonstrates the new method called minutiae cylindrical code (MCC) for fingerprint matching using 3D data structures called cylinders, built from minutiae distances and angles. Hough transform is a common solution Unfortunately, most of the global minutiae matching algorithms are computationally demanding and lack robustness with respect to nonlinear fingerprint distortion.

Local minutiae structures can be classified into nearest neighbor-based and fixed radius-based. Matching fingerprints based only on local minutiae arrangements relaxes global spatial relationships, which are highly distinctive, and therefore reduces the amount of information available for discriminating fingerprints. However, the profit of both local and global matching can be sustain by completing hybrid strategies that perform a local structure matching followed by a consolidation stage.

The main improvement of the new method, called Minutia Cylinder-Code, are:

1. MCC is a fixed-radius approach and therefore it tolerates missing and spurious minutiae better than nearest neighbor-based approaches.
2. Unlike traditional fixed-radius techniques, MCC relies on a fixed-length invariant coding for each minutia and this makes the computation of local structure similarities very simple.
3. Border problems are gracefully managed without extra burden in the coding and matching stages.
4. Local distortion and small feature extraction errors are tolerated thanks to the adoption of smoothed functions (i.e., error tolerant) in the coding stage.
5. MCC effectively deals with noisy fingerprint regions where minutiae extraction algorithms tend to place numerous false minutiae; this is made possible by the saturation effect produced by a limiting function.
6. The bit-oriented coding (one of the possible implementations of MCC) makes cylinder matching highly simple and fast, reducing it to an arrangement of bit-wise operations (e.g., AND, XOR) that can be efficiently implemented even on very simple CPUs [3].

In this paper highlights on the quality of fingerprint pictures is the key to fingerprint identification, but in actual practice, the pictures we obtained often have all kinds of noise such as scars, perspiration, and stains, as well as some noise caused by uniform contact with fingerprint collecting devices. Based on work of forebear, a proposed a fingerprint identification pre-treatment algorithm in MATLAB. Based on MATLAB, it provides an algorithm for implementation, and an improved method. The results of each fingerprint picture processing module, includes image segmentation which could be removed, by obtaining a fingerprint image from a framework area. Filtering image, removing blur, and binarization processing which make the fingerprint image fair, to eliminate unnecessary noise and are helpful to further identification. To thin the image, we first, adopt the quick thinning algorithm to handle the preliminary thinning other languages, including C, C++, C#, JAVA, Fortan, and Python. The data doesn’t have to be in structured form or uniform because each instance of data is taken care by separate process on a different node.

The streakline after thinning has a certain width, and secondly, the advanced one-pass thinning algorithm (OPTA) is adopted for use the fingerprint image that after preliminary thinning; this makes all areas, except the bifurcation point, remain a single-pixel wide, correcting the streakline that has

been thinned by advanced OPTA. Then we get a clear fingerprint picture, extract the fingerprint feature point (spurious minutiae) from this picture; this feature point contains a lot of false features that take most of time and influences the matching exactness. The authors approve removing the false features by edge and distance, removing the false feature points by generally a third, and then next extract reliable information of the feature points and store in the book building template. When matching a print, get exact fingerprint image using the same method, and build a contrast template; at last, we compare the contrast template with book building template and then get ideal results. Based on MATLAB, with this method we are unable to do the simulation step-by step with the fingerprint identification pre-treatment algorithm, but also see the result of image processing algorithm intuitively, which cooperates with the algorithm research effectively. Results shows that, which are based on the MATLAB, the processing result is more ideal, and this method is not only simple and quick, but also has a high precision, and satisfy the identification applicability [4].

This paper describes a well-known fingerprint matching algorithm that uses an orientation-based minutia descriptor. It introduced a set of advancements to the algorithm that increase the accuracy and speed, using the same features. The most important advancement is in the global minutiae matching method, is to reduce the number of local matching minutiae and using multiple minutiae pairs for fingerprint positioning. Fingerprint recognition has become one of the most active research areas nowadays. It plays an important role in forensic applications, but its increasing popularity is perhaps due to its integration into civilian systems. A key point in most of its applications is the fingerprint matching algorithm. Most of the authors distinguish two types of fingerprint matching algorithms: correlation-based matching and minutiae-based matching. As it is seen in the Fingerprint Verification Competitions (FVC), the minutia-based matching is the most popular approach. This approach essentially consists on finding the maximum number of matching minutiae pairs given two fingerprints represented by their minutiae.

It introduces a novel fingerprint template protection scheme, evaluates its accuracy and security according to well-defined criteria [Si12], and tests its robustness against various types of attack. the new method markedly outperforms most of the state-of-the-art techniques and is robust against different attack scenarios. P-MCC representation guarantees irreversibility and accuracy but not diversity and unlink ability [Si12]. In some preliminary studies a random

projection transform [TY07] was combined to the P-MCC representation to fulfill diversity and unlink ability requirements: although such solution showed better results in

terms of accuracy, but it was not robust enough against token-stolen attacks. The two-factor method proposed in this work (called 2P-MCC) is simple but proved to allow a good trade-off between accuracy and security [5].

In this paper it has been studied that, template protection techniques have gained interest in the biometric system, due to the worldwide diffusion of new biometric applications and the consequent growing of security issues. The development of effective techniques to protect fingerprint templates is a very big challenge for the researchers.

In general, template protection methods are designed to assure: i) the infeasibility to reconstruct the original pattern from the protected template (non reversibility), ii) the probability to create different protected templates starting from the same unprotected pattern (diversity), iii) the preservation of the recognition accuracy when the matching is carried out on protected templates (accuracy), and iv) the possibility to revoke a a settle dispute and reissue a new one based on the same biometric data (revocability).

Fingerprint template protection in not fully solved problem, since enforcing non reversibility tends to produce an

excessive drop in accuracy. This is primary due to the large intra class variability of fingerprint patterns: different acquisitions of the same finger can be very dissimilar and consequently the protected templates may be very different.

P-MCC advances the state-of-the-art of fingerprint template protection techniques, we recognize that this approach is still far from being perfect and that relevant research efforts are still necessary in this field [6].

In this paper, a new hash-based indexing method is introduced to speed up fingerprint identification in large databases. A Locality-Sensitive Hashing scheme has been designed MCC, which derived to be very impressive in mapping a minutiae-based representation A search algorithm has been designed to the derive a numerical approx. for the similarity between MCC vectors. Experiment has been carried out to compare 15 existing methods over all the benchmarks typically used for fingerprint indexing. In spite of the smaller set of features used, the new approach outperforms existing ones in almost all of the cases. Two feature reduction methods in order to solve the problems of the original spectral minutiae algorithm: the Column Principal Component Analysis (Column-PCA) and the Line Discrete Fourier Transform (LineDFT) feature reduction algorithms. By applying Column-PCA and Line-DFT methods to the original spectral minutiae features, we can effectively compress the spectral minutiae templates and increase the matching speed as well.

For a large Automated Fingerprint Identification System (AFIS), the recognition accuracy, matching speed and its robustness to poor image quality are normally regarded as the most critical elements of system performance. For fingerprint identification systems with large databases, in which a fast comparison algorithm is required, most minutiae-based matching algorithms failed to meet the high speed requirement. To overcome the speed requirement, some AFIS vendors firstly used the global fingerprint characteristics as the first stage, and then use the minutiae matcher as the second stage [7].

3. Fingerprint matching

A fingerprint matching algorithm compares two given fingerprints and returns either a degree of similarity or similarity score. The main factors responsible for intra-class variations are:

1. *Displacement:* the same finger may be placed at different locations on a touch sensor during different acquisitions resulting in a (global) translation of the fingerprint area.A finger displacement of just 2 mm (imperceptible to the user) results in a translation of about 40 pixels in a fingerprint image scanned at a resolution of 500 dpi.
2. *Rotation:* The same fingerprint may be rotated at different angles with respect to the sensor surface during different acquisitions. In spite of the finger “guide” mounted in certain commercial scanners, involuntary finger rotations of up to ±20° with respect to vertical orientation can be observed in practice.
3. *Partial overlap:* finger displacement and rotation often cause part of the fingerprint area to fall outside the sensor’s “field of view,” resulting in a smaller overlap between the foreground areas of the template and the input fingerprints. This problem is particularly for small-area such as touch sensors.
4. *Non-linear distortion:* the act of sensing maps the three-dimensional shape of a finger onto the two-dimensional surface of the sensor. This mapping results in a non-linear distortion in successive acquisitions of the same finger due to skin plasticity. Often, fingerprint matching algorithms disregard the characteristic of such a mapping, and consider a fingerprint image as non-distorted by assuming that it was produced by a correct finger placement; a finger placement is correct when: (i) the trajectory of the fingerprint approaching the sensor is orthogonal to the sensor surface; (ii) once the finger to hes the sensor surface, the user doesn’t apply traction or torsion. However, due to skin plasticity, the components of the force that are non-orthogonal to the sensor surface produce compression or stretching in the acquired fingerprints.
5. *Pressure and skin condition:* The ridge structure of a fingerprint would be accurately captured if ridges of the part of the finger being imaged were in uniform contact with the sensor surface. However, finger pressure, dryness of the skin, skin disease, sweat, dirt, grease, and humidity in the air all confound the situation, resulting in a non-uniform contact. As a consequence, the acquired fingerprint images are very noisy and the noise strongly varies in successive acquisitions of the same finger depending on the magnitude of the above cited causes.
6. *Noise:* it is mainly introduced by the fingerprint sensing system; for example, residues are left over on the glass platen from the previous fingerprint capture.
7. *Feature extraction errors:* The feature extraction algorithms are not perfect and often introduce

measurement errors. Errors may be made during any of the feature extraction stages (e.g., estimation of orientation and frequency images, detection of the number, type, and position of the singularities, segmentation of the fingerprint area from the background, etc.). In low-quality fingerprint images, the minutiae extraction process may introduce a large number of spurious minutiae and may not be able to detect all the true minutiae [8], [9].

There are 3 approaches in fingerprint matching: correlation based matching, minutiae-based matching, and ridge feature based matching. In this we focus on Minutia Cylinder-Code.

A. Minutia-Based Matching

A minutia is either a ridge bifurcation or a ridge ending. Ridge bifurcation is a point where a ridge splits into two ridges, meanwhile ridge ending is a point where a ridge meets a dead-end. A minutia is represented by its position, angle, and type. In general, there are two algorithms in minutiae-based matching.

1. Nearest neighbor
2. Fixed Radius

In nearest neighbor-based algorithm, the neighborhood of a given minutia is defined as K nearest minutiae. Thus, the number of neighbors in this algorithm is fixed so fingerprint matching can be performed fast efficient. Disadvantage of this algorithm is it is intolerant to missing and spurious minutiae.

In fixed radius-based algorithm, the neighbourhood of a given is defined as all minutiae that its distance is within a circle radius R. The number of neighbors in this algorithm can vary, depends on the density of a minutia. Thus, fingerprint matching with this algorithm is harder than the former one. However, this algorithm is more tolerant to missing and spurious minutiae [10].

B. Minutia Cylinder-Code

Minutia Cylinder-Code (MCC) is one of the best performing algorithms in minutia-based fingerprint matching. It combines the advantages of both nearest neighbor-based and fixed radius-based algorithms without having their drawbacks. It has an efficient performance as nearest neighbor-based algorithms and high tolerance to minutiae deformations as fixed radius-based algorithms [11].

MCC aims to achieve high accuracy while maintaining interoperability with other algorithms by using standard features in minutiae. It uses the position and direction of the minutiae but not the type and quality. It is due to the type is not a robust feature and the quality is not semantically clear in the standards.

The local minutiae representation is based on 3D data structures (called cylinders), built from invariant distances and angles in a neighborhood of each minutia. Four global-scoring techniques are then proposed to combine local similarities into a unique global score denoting the overall similarity between two fingerprints. [12], [13].

4. Proposed plan of work

The aim of proposed work is to find the fast way to recognize the fingerprint from large database by using minutiae cylindrical code with the use MATLAB (image processing toolbox). The main work of the project is work on the false acceptance rate (FAR), false rejection rate (FRR), execution time, matching time, enrolment time.

1. *False acceptance rate:* The FAR is defined as the ratio of the number of false acceptances divided by the number of identification attempts. The system will incorrectly accept access by unauthorized user.
2. *The false recognition rate:* The FRR is the measure of system will incorrectly reject an access attempt by an authorized user. A system's FRR defined as the ratio of the number of false recognitions divided by the number of identification attempts.
3. *Execution Time:* Execution or run time is the time during which a program is running, in contrast to other program lifecycle phases such as compile time, link time load time.
4. *Matching time:* Matching time is finding a small part of image which is matched with the other image template.
5. *Enrolment time:* The enrolment time is the time taken to enroll ones fingerprint in database.

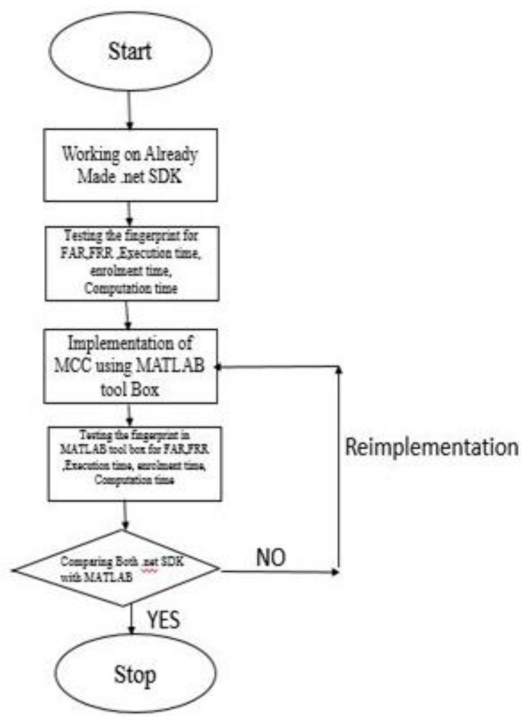

Fig. 1. Flow of the Proposed System

Matrix Laboratory-MATLAB is a multi-paradigm numerical computing environment developed by MathsWork. MATLAB allows different languages such as C, C++, JAVA, Fortan, Python to use for various purpose. The data doesn't have to be in structured form or uniform because each instance of data is taken care by separate process on a different node.

In this paper, introduction to Minutia Cylinder-Code (MCC) a novel minutiae-only representation and matching technique for fingerprint recognition. MCC relies on a robust discretization of the neighborhood of each minutia into a 3D cell-based structure named cylinder. Simple but effective techniques for the computation and consolidation of cylinder to determine the global similarity between two fingerprints.

5. Conclusion

The system will be more accurate with the results like FAR, FRR, execution time, matching time, and enrolment time. More accurate than the MCC .net SDK. The MATLAB version to be used MATLAB 9.1 [14]. The datasets are taken from FVC2000 [15].

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