Comprehensive Survey Based on 3D Fingerprint Matching Technique - Minutiae Cylindrical Code (MCC)

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Abstract : *Fingerprints are the most common authentic biometrics for personal identification, especially for forensic security. A 2D minutiae matching is widely used for fingerprint recognition and can be classified as ridge ending and bifurcation. This paper is survey of 3D Minutiae Matching Technique referred as Minutiae Cylindrical code (MCC). This technique is based on 3D data structures called as Cylinders. A lot of physical data has been exchanged in this digital age. Based on this reason, the purpose of this paper is to improve fingerprint matching efficiency. In the current state of the art liner solution, utilizing Minutiae Cylindrical Code Technique. False Acceptance Rate (FAR), False Rejection Rate (FRR), Execution Time, Matching Time, Enrollment Time will be increased.*

Keywords- FINGERPRINT MATCHING; MCC; FAR; FRR;MATCHING TIME; EXECUTION TIME; ENROLMENT TIME.

1. INTRODUCTION

The recognition of fingerprints is an interesting issue of pattern recognition and this has been researched for more than 40 years. While very successful solutions are currently available, it is not reasonable to consider fingerprint recognition as a completely solved problem, and the design of precise, extensible and lightweight algorithms is still an open problem.

Fingerprints are the designs of the fingertip epidermis. Three types of fingerprints are: arch, circle, and whorl. The fingerprint consists of valleys and ridges. The more obvious structural feature of a fingerprint is the interleaved pattern of ridges and valleys. There are two key features of the fingerprint: a) Global Ridge Pattern b) Detail of Local Ridge.[1]

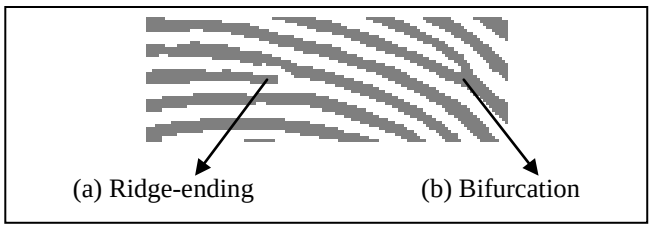

Fig 1. Fingerprint Ridge ending and Bifurcation

The fingerprint is a smooth pattern with alternating ridges and valleys. The ridges do not flow continuously but rather display various types of imperfections known as minutiae. At the time of registration in the fingerprint system, essential minutiae information (usually ridge and bifurcation positions and related orientations) is extracted and stored in the database in the form of a template.

By comparing the diligent distribution of two fingerprints using advanced point pattern matching techniques, fingerprint matching is accomplished. Minutiae have been extensively studied, especially in the context of fingerprint individuality modelsin forensic literature. [2],

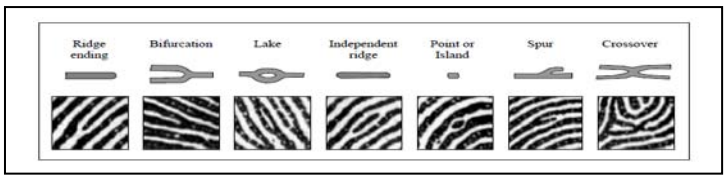

Fig 2. Seven most common Types of minutiae

The rapid growth of the use of digital systems has led to technological advances. In this modern era, a lot of physical data has been turned into digital data. An example of the use of digital data is digital fingerprint data on an electronic identity card. To identify a person Fingerprint matching can be used. There are three Approaches for fingerprint matching:

i) Correlation-based-matching
ii) Minutiae-based-matching
iii) Ridge feature-based matching.

Minutia-based fingerprint matching is one of the most common techniques. [1][2]

2. FINGERPRINT MATCHING

In fingerprint matching, there are 3 approaches: matching based on correlation, matching based on minutiae, and matching based on ridge features. In this study, we concentrate on the Minutia Cylinder-Code.[3]

2.1. Minutia-Based Matching

The minutiae is either a bifurcation of the ridge or the end of the ridge. The bifurcation of the Ridge is a point where the ridge splits into two ridges, while the ends of the ridge are a point where a dead end is reached by the ridge. Its position, angle, and shape define the minutiae. For minutiae-based matching, there are two algorithms in general.[2].

2.1.1 Nearest neighbor Fixed Radius - The proximity of the given minutiae is defined as K nearest minutiae in the nearest neighbor-based algorithm. Thus, in this algorithm, the number of neighbours is set such that fingerprint matching can be achieved quickly and effectively. The downside of this algorithm is that incomplete and spurious minutiae are unbearable.

2.2.2 Fixed radius-based algorithm- The proximity of a given minutiae in a fixed radius-based algorithm is defined as all the minutiae that its distance is within a circle radius of R. Depending on the density of the detail, the number of neighbours in this algorithm will differ. So, it's harder to match this algorithm with the fingerprint than with the previous one. This algorithm, however, gives more forgiveness to incomplete and spurious minutiae [2].

2.2 . Minutia Cylinder-Code

One of the highest performing fingerprint matching algorithms is Minutia Cylinder-Code (MCC) [3]. Without its drawbacks, it combines the benefits of both the nearest neighbor-based and fixed radius-based algorithms. As fixed radius-based algorithms, effective reliability as nearest neighbor-based algorithms and high tolerance to minute deformation.

By using standard features in detail, MCC aims to increase high accuracy while maintaining interconnection with other algorithms. It utilises the position and orientation of the minutiae, but not the product's shape and consistency. That is because the type is not a robust function and the continuity of the criteria is not semantically apparent.

The local representation of minutiae introduced in this paper is based on 3D data structures (called cylinders) built in the vicinity of each minutiae from invarian distances and angles. The combination of local similarities with a unique global score denoting the overall similarity between two fingerprints is then suggested by four global scoring strategies.. The key advantages of the new approach, the Minutia Cylinder-Code (MCC), are:

- MCC is a fixed-radius approach and thus better tolerates missing and spurious minutiae than nearest neighbor-based approaches.
- Unlike conventional fixed-radius techniques, MCC relies on fixed-length invariant coding for each minutiae, rendering the estimation of local structure similarities very easy.
- Boundary issues are gracefully handled without unnecessary pressure in the coding and matching phases.
- Local distortion and small feature extraction errors are tolerated by the adoption of smoothed (i.e. error-tolerant) functions at the coding level.
- MCC effectively deals with noisy fingerprint regions where minutiae extraction algorithms appear to position multiple spurious minutiae (close to each other); this is made possible by the saturation effect created by the limitation feature.
- Bit-oriented coding (one of the potential MCC implementations) makes the cylinder fit. Extremely simple and quick, reducing it to a bit-wise sequence of operations (e.g. AND, XOR) that can be efficiently implemented even on very simple CPUs[3],[4].

3. LITURATURE SURVEY

In Minutiae based 2-D approach, the ridge features called minutiae are extracted and stored in a matching prototype. Translation, rotation and scale shifts are invariant. It is, however, prone to error in low-quality images. The method based on minutiae is applied. Usually, pre-processing of the image is done prior to minutiae extraction. Before applying a minutiae-based approach, we should be at the pre-processing and extraction point. Fingerprint enhancement techniques are used to minimise noise and increase the visibility of valley ridges [2].

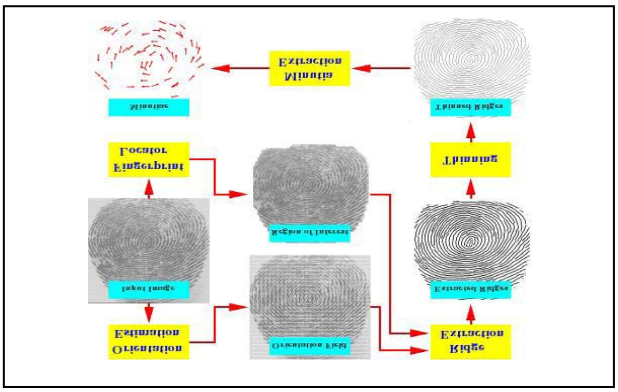

Fig.3 Typical 2-D Minutiae extraction process [2]

In Minutiae Cylinder Code (MCC) based 3-D Approach MCC representation, the local structure is associated with each minutiae. This structure encodes the spatial and directional relationship between the minutiae and its (fixed-radius) neighborhood, and can be conveniently represented as a cylinder whose base and height are connected to spatial and directional information [3][4][5].

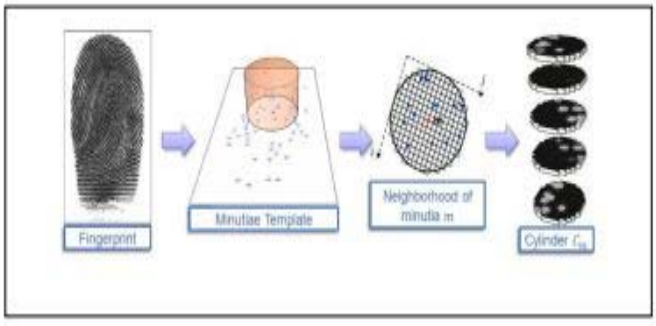

Fig 4. Minutiae Cylindrical code (MCC) Representation [3].

Dr. Anil K. Jain et al. (2009) thoroughly explains all the aspects of Fingerprints and Fingerprint Recognition in their book “Handbook of Fingerprint recognition”. [1]

David Maltoni (2005) presented Fingerprint matching techniques in his paper “ A tutorial on fingerprint Recognition”. This tutorial introduces fingerprint recognition systems and their main components: sensing, feature extraction and matching. The basic technologies are surveyed and some state-of-the-art algorithms are discussed. [2]

Raffaele Cappelli et al. (2010) The Minutia Cylinder-Code (MCC): a new representation based on 3D data structures (called cylinders) built from distances and angles of minutiae was implemented. The cylinders can be produced from a subset of mandatory features defined by standards such as ISO / IEC 19794-2 (2005) (minutiae position and direction). They advise that in order to compute local similarities and aggregate those into a global score, some simple but very effective metrics can be defined.

Extensive tests in the FVC2006 databases display MCC’s dominance over three well-known techniques and demonstrate the feasibility of providing light architectures with very powerful (and interoperable) fingerprint recognition. [3].

Matteo Ferrara et al. (2011) A modern hash-based indexing approach is proposed to speed up fingerprint detection in large databases. In order to rely on Minutiae Cylinder-Code (MCC), a Locality-Sensitive Hashing (LSH) method was designed to be very effective in mapping a minutiae-based representation (position / angle only) into a set of binary vectors with fixed-length transformation-invariant.In addition to the numerical approximation of the similarity between the MCC vectors, a novel search algorithm was developed. In all of the benchmarks commonly

used for fingerprint indexing, detailed studies have been conducted to compare the proposed solution with 15 current approaches. The new approach outperforms current ones in almost all cases, considering the smaller set of features used (top performing approaches usually integrate more features). [4]

David Maltoni et al. (2012) Propose a two-factor authentication scheme that makes P-MCC templates revocable in order to prevent MCC templates from revealing confidential details about the location and angle of the minutiae, a secure MCC representation (called P-MCC) has recently been implemented. P-MCC templates cannot be revoked despite a satisfactory degree of accuracy and reversibility. [5]

M. Hamed Izadi et al. (2012) Propose an alternative method for the calculation directly from fingerprint quality maps of cylinder quality measurements, in particular ridge clarity maps, taking into account the amount of minutiae involved. Via experiments with the NIST SD27 Latent Fingerprint Database, the integration of MCC with the proposed cylinder quality measures was assessed. These tests demonstrate clear changes in the efficacy of ugly-quality latent fingerprint detection. [6]

Matteo Ferrara et al. (2012) Propose a novel protection technique for Minutia Cylinder-Code (MCC), a well-known local minutiae representation. A advanced algorithm is designed to reverse the MCC (i.e. to restore the initial minutiae positions and angles). Systematic tests show that the new methodology compares favorably with state-of-the-art approaches in terms of precision and, at the same time, offers reasonable protection for detailed information and is resilient against masquerade attacks. [7]

A.Pasha Hosseinbor et al. (2017) propose a minutia-based fingerprint matching algorithm that employs iterative global alignment on two minutia sets. The matcher considers all possible minutia pairings and iteratively aligns the two sets until the number of minutia pairs does not exceed the maximum number of allowable one to-one pairings. The optimal alignment parameters are derived analytically via linear least squares. [8]

WajihUllah Baig, et al. (2018) Apply a modification to the underlying details of the MCC descriptor and demonstrate that using different features, the precision of the matching is strongly affected by these changes. Originally, the MCC being a minutiae onlydescriptor is turned into a texture descriptor. Transformation is rendered from minutiae angular information to direction, frequency and energy information using the Short Time Fourier Transform (STFT) analysis. Minutia cylinder codes are translated into minutiae texture cylinder codes.(MTCC). Based on a fixed set of parameters, the proposed improvements to the MCC display enhanced performance of the 2002 and 2004 FVC data sets and exceed the conventional MCC performance. [9][10][11]

This paper proposes a pre-treatment algorithm for Matlab 3D fingerprint recognition. This paper , based on Matlab, provides an algorithm for implementation and an improved method. A fingerprint image was obtained from the background with the results of each fingerprint image processing module, including, in particular, the segmentation of the image that could be separated. Image filtering, burr elimination, cavity management and binarization processing (with the concept of self-adapted local threshold binarization), which explain the picture of the fingerprint, remove unwanted noises and are useful for further identification. First, the rapid thinning algorithm is used to thin the picture to handle the preliminary thinning of other languages, including C , C++ , C #, Java, FORTRAN, and Python. The data need not be structured, because a separate process on a different node takes care of each instance of the data.

The streak line after thinning has a certain width and, secondly, after the preliminary thinning, the advanced one-pass thinning algorithm (OPTA) is adopted for the use of the fingerprint image; this ensures that all regions remain one-pixel deep, except for the bifurcation point, correcting the streak line that has been thinned by the advanced OPTA. They then obtain a basic fingerprint image, extract this image from the fingerprint feature point (spurious minutiae); this feature point contains a lot of false features that take a lot of time and affect the accuracy of the matching.

The author adopts the elimination of false features by edge and distance in this article, reducing the number of false features by about one-third, and then extracts detailed details from the feature points and stores it in the prototype of the book building. Using the same process, we'll get a basic fingerprint image when matching a fingerprint and create a contrast template; finally, we'll compare the contrast template with the template of the book and then get the ideal results.

They were not able to do the simulation step by step with the fingerprint recognition pre-treatment algorithm based on Matlab, but also to see intuitively the performance of an image processing algorithm that cooperates effectively with the analysis of algorithms. Experimental findings show that the processing result is more optimal with this algorithm, which is based on Matlab, and this method is not only simple and fast, but also highly accurate and satisfies the applicability of identification.

4. CONCLUSION

This study paper provides a comprehensive survey of the work carried out in the field of 3D fingerprint recognition in the field of biometric protection or personal identification. MCC relies on a robust discretization of the vicinity of each minutiae into a 3D cell-based structure called a cylinder. Simple but efficient techniques for computing and consolidating the similarities of the cylinders are given to assess the global similarity between the two fingerprints.

After study , it is found that there is a need for some positive, robust protected method of fingerprint recognition in adverse circumstances where we might have partial images or environmentally impacted images that we will try to do in the future course of my dissertation work.

Citation	Approach	Method	Conclusion
Bazen Asker M. et al. (2000)	2-D	Correlation-based	The Correlation -based fingerprint authentication method is capable of dealing with low-quality images from which no minutiae can be derived accurately and with fingerprints that suffer from non-uniform shape distortions.
Dr. Jain Anil K et al. (2000)	2-D	Filter bank based	They proposed “Filter bank based fingerprint Matching Technique.
Tico Marius et al. (2003)	2-D	Orientation-Based Minutia Descriptor	This representation allows the derivation of a similarity function between minutiae used to classify the corresponding features and to determine the resemblance between two fingerprint impressions.
Koichi ITO et al. (2004)	2-D	Phase only correlation (POC) based	The proposed algorithm exhibits successful identification efficiency even for difficult fingerprint images that could not be identified by traditional matching algorithms.
Muhammad Umer Munir et al. (2004)	2-D	Gabor Filters based	The fingerprint matching is based on the Euclidean distance between two corresponding feature vectors.
Cappelli Raffaele et al. (2010)	3-D	Minutia Cylinder-Code (MCC) based	They advise that some basic yet very effective metrics can be established in order to compute local similarities and aggregate them into a global score.
Ferrara Matteo et al. (2011)	3-D	Minutia Cylinder-Code (MCC) based	They suggest a new hash-based indexing process to speed up the identification of fingerprints in large databases.
Maltoni David et al. (2012)	3-D	Minutia Cylinder-Code (MCC) based	They suggested a two-factor security scheme that makes P-MCC templates revocable so as to prevent MCC templates from revealing sensitive details on the location and angle of minutiae.
Ferrara Matteo et al. (2012)	3-D	Minutia Cylinder-Code (MCC) based	They suggested a novel Minutia Cylinder-Code (MCC) protection technique.
M. Hamed Izadi et al. (2013)	3-D	Minutia Cylinder-Code (MCC) based	They propose an alternative approach to directly estimate cylinder quality measurements from fingerprint quality maps, in particular ridge clarity maps, taking into account the number of minutes involved.
Hosseinbor A. Pasha et al. (2017	2-D	linear least square Method	They suggested a fingerprint matching algorithm based on minutia that uses iterative global alignment on two sets of minutia.
Baig Wajih Ullah, et al. (2018)	3-D	Minutia Cylinder-Code (MCC) based	Presents a switch to the MCC descriptor 's underlying specifics and illustrates that the quality of the matching is highly affected by these improvements by using different features.

Tab. 1 Summary table of literature Review

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