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

Sunil M. Wanjari[1], S.R.Tandan[2]

[1]St. Vincent Pallotti College of Engineering and Technology, Nagpur (M.S.) India.

[2]Dr. C.V. Raman University, Bilaspur (C.G.) India.

ABSTRACT

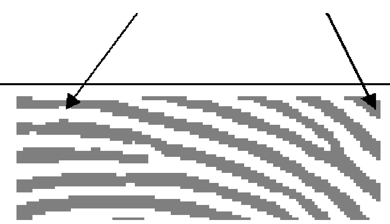
Fingerprints are the most common authenticbiometrics for personal identification, especially for forensic security. A 2D minutiae matching is widely used for fingerprint recognition and can be classified as ridge ending and bifurcation. This paper is survey of 3D Minutiae Matching Technique referred as Minutiae Cylindrical code (MCC). This technique is based on 3D data structures called as Cylinders. In this digital era lots of physical data has been transferred. Based on this rationale, this paper this paper aims to improve the fingerprint matching performance. In the current state of art liner solution, by using Minutiae cylindrical Code Technique. False acceptance rate (FAR), False rejection rate(FRR), Execution Time, Matching Time, Enrollment Time is being going to improved.

Keywords—Fingerprint Matching; MCC; FAR; FRR; Matching Time; Execution Time; Enrolment Time.

I INTRODUCTION

Fingerprint recognition is an intriguing pattern recognition problem that has been studied for more than 40 years. Although very effective solutions are currently available, fingerprint recognition cannot be considered a fully solved problem, and the design of accurate, interoperable, and computationally light algorithms is still an open issue.

Fingerprints are the patterns formed on the epidermis of the fingertip. The fingerprints are of three types: arch, loop and whorl. The fingerprint is composed of ridges and valleys. The interleaved pattern of ridges and valleys are the most evident structural characteristic of a fingerprint. There are two main fingerprint -a) Global Ridge Pattern b) Local Ridge Detail.



(a) Ridge-ending (b) Bifurcation

Fig. 1 Fingerprint Ridge ending and Bifurcation

A fingerprint is a smoothly owing pattern of alternating ridges and valleys. The ridges do not flow continuously but rather display various types of imperfections known as minutiae (minor details in fingerprints). At the time of enrollment in a fingerprint system, important minutiae information (typically, positions of ridge endings and bifurcations, and the associated orientations) is extracted and stored in the database in the form of a template. Fingerprint matching is accomplished by comparing the minutiae distribution of two fingerprints via sophisticated point pattern matching techniques. Minutiae have been studied extensively in the forensic literature specifically in the context of fingerprint individuality models.

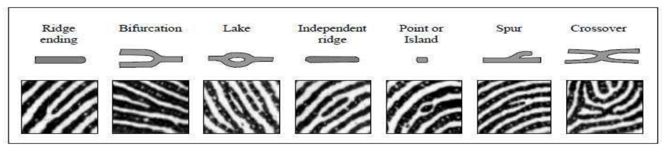


Fig. 2 Seven most common Types of minutiae

The advancement of technology has given contributions to the rapid growth of the use of digital data. In this digital era, lots of physical data have been transformed into the digital ones. 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 3 approaches in fingerprint matching:

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

One of popular technique is minutia-based fingerprint matching.

II FINGERPRINT MACTCHING

There are 2 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.

(i) Nearest neighbor Fixed Radius

In nearest neighbor-based algorithm, the neighbourhood 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 minutia is defined as all minutiae that its distance is within a circle radius R. The number of neighbours 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.

(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 neighbour-based and fixed radius-based algorithms without having their drawbacks. It has an efficient performance as nearest neighbour-based algorithms and high tolerance to minutiae deformations as fixed radius-based algorithms.

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 introduced in this paper 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. The main advantages of the new method, called Minutia Cylinder-Code (MCC), are:

MCC is a fixed-radius approach and therefore it tolerates missing and spurious minutiae better than nearest neighbor-based approaches.

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.

Border problems are gracefully managed without extra burden in the coding and matching stages.

Local distortion and small feature extraction errors are tolerated thanks to the adoption of smoothed functions (i.e., error tolerant) in the coding stage.

MCC effectively deals with noisy fingerprint regions where minutiae extraction algorithms tend to place numerous spurious minutiae (close to each other); this is made possible by the saturation effect produced by a limiting function.

The bit-oriented coding (one of the possible implementations of MCC) makes cylinder matching extremely simple and fast, reducing it to a sequence of bit-wise operations (e.g., AND, XOR) that can be efficiently implemented even on very simple CPUs.

III LITERATURE SURVEY

In Minutiae based 2-D approach the ridge features called minutiae are extracted and stored in a template for matching. It is invariant to translation, rotation and scale changes. It is however error prone in low quality images. The minutiae based approach is applied. Usually before minutiae extraction, image preprocessing is performed. Before applying minutiae-based approach we should do the preprocessing and extraction stage. Fingerprint enhancements techniques are used to reduce the noise and improve the clarity of ridges against valleys.

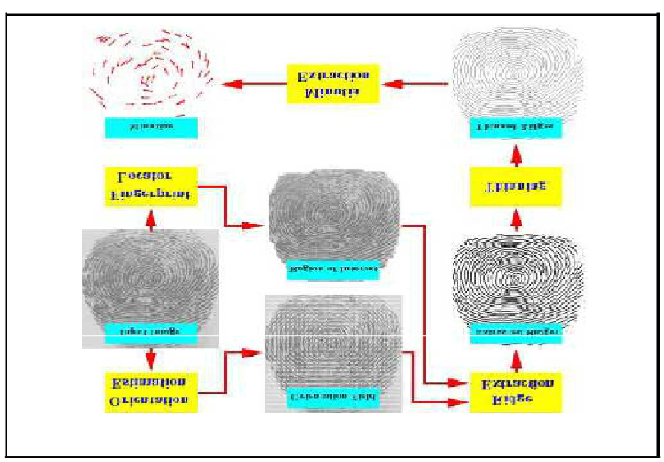


Fig.3 Typical 2-D Minutiae extraction process

In Minutiae Cylinder code (MCC) based 3-D Approach MCC representation associates a local structure to each minutia. This structure encodes spatial and directional relationships between the minutia and its (fixed-radius) neighborhood and can be conveniently represented as a cylinder whose base and height are related to the spatial and directional information, respectively.

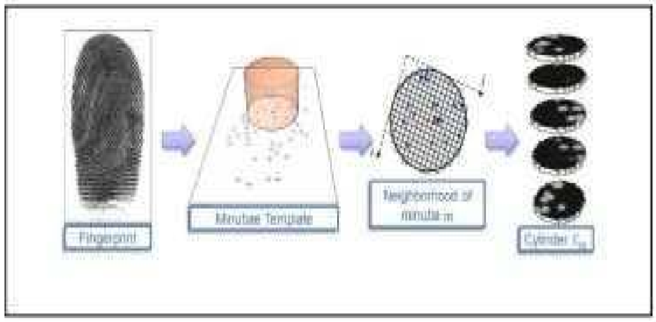


Fig. 4 Minutiae Cylindrical code (MCC) Representation.

Dr. Anil K. Jain et al. (2003) thoroughly explains allthe aspects of Fingerprints and Fingerprint Recognition in their book “Handbook of Fingerprint recognition”.

David Maltoni (2005) presented Fingerprint matching techniques in his paper “ A tutorial on fi ngerprint 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.

Raffaele Cappelli et al. (2010) introduce the MinutiaCylinder-Code (MCC): a novel representation based on 3D data structures (called cylinders), built from minutiae distances and angles. The cylinders can be created starting from a subset of the mandatory features (minutiae position and direction) defined by standards like ISO/IEC 19794-2 (2005). They advice that some simple but very effective metrics can be defined to compute local similarities and to consolidate them into a global score. Extensive experiments over FVC2006 databases prove the superiority of MCC with respect to three well-known techniques and demonstrate the feasibility of obtaining a very effective (and interoperable) fingerprint recognition implementation for light architectures.

Matteo Ferrara et al. (2011) proposes a new hash-based indexing method to speed up fingerprint identification in large databases. A Locality-Sensitive Hashing (LSH) scheme has been designed relying on Minutiae Cylinder-Code (MCC), which proved to be very effective in mapping a minutiae-based representation (position/angle only) into a set of fixed-length transformation-invariant binary vectors. A novel search algorithm has been designed thanks to the derivation of a numerical approximation for the similarity between MCC vectors. Extensive experimentations have been carried out to compare the proposed approach against 15 existing methods over all the benchmarks typically used for fingerprint indexing. In spite of the smaller set of features used (top performing methods usually combine more features), the new approach outperforms existing ones in almost all of the cases.

David Maltoni et al. (2012) propose a two factorprotection scheme that makes P-MCC templates revocable to avoid that MCC templates can disclose sensitive information about position and angle of minutiae, a protected MCC representation was recently introduced (called P-MCC).Inspite of a satisfactory level of accuracy and reversibility, P-MCC templates cannot be revoked. [5]

M. Hamed Izadi et al. (2012) propose an alternativemethod to estimate the cylinder quality measures directly from fingerprint quality maps, in particular ridge clarity maps, by taking into account the number of involving minutiae as well. Integration of MCC with the proposed cylinder quality measures was evaluated through experiments on the latent fingerprint database NIST SD27. These experiments show clear improvements in the identification performance of latent fingerprints of ugly quality.

Matteo Ferrara et al. (2012) propose a novelprotection technique for Minutia Cylinder-Code (MCC), which is a well-known local minutiae representation. A sophisticate algorithm is designed to reverse MCC (i.e., recovering original minutiae positions and angles). Systematic experimentations show that the new approach compares favorably with state-of-the-art methods in terms of accuracy and, at the same time, provides a good protection of minutiae information and is robust against masquerade attacks.

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.

WajihUllah Baig, et al. (2018) present a modificationto the underlying information of the MCC descriptor and show that using different features, the accuracy of matching is highly affected by such changes. MCC originally being a minutia only descriptor is transformed into a texture descriptor. The transformation is from minutiae angular information to orientation, frequency and energy information using Short Time Fourier Transform (STFT) analysis. The minutia cylinder codes are converted to minutiae texture cylinder codes (MTCC). Based on a fixed set of parameters, the proposed changes to MCC show improved performance on FVC 2002 and 2004 data sets and surpass the traditional MCC performance.

This Paper proposes a 3D fingerprint identification pre-treatment algorithm in Matlab. Based on Matlab, this article provides an algorithm implementation, and an improved method. The results of each fingerprint picture processing module, mainly including image segmentation which could be separated, obtained a fingerprint image from a background area. Image filtering, removing burr, cavity management and binarization processing (with the thought of self-adapted local threshold binariztion) which make the fingerprint image clearer, eliminate unnecessary noises and are beneficial 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, Fortran 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 a lot of time and influences the matching precision. In this paper, the author adopt eliminating the false features by edge and distance, lessening the false feature points by approximately a third, and then next extract reliable information of the feature points and store in the book building template. When matching a fingerprint, we get clear 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. Experimental results show that with this algorithm, which is on the basis of 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.

IV CONCLUSION

This survey paper gives the detail survey of the work carried out in 3D fingerprint recognition in biometric security or personal identification. 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 similarities are provided to determine the global similarity between two fingerprints.

It is found after analysis that there is need of some constructive, robust secured method of fingerprint recognition in adverse situation where we may have partial images or environmentally affected images which we would be trying in future course of my dissertation work.

REFERENCES

[1] Baig Wajih Ullah, Umar Munir, Waqas Ellahi, Adeel Ejaz, Kashif Sardar, (2018),” Minutia Texture Cylin der Codes for fingerprint Matching”, arXiv:1807.02251v1 [cs.CV] 6 Jul 2018,pp 1-12.

[2] Biometric System Laboratory, DISI University of Bologna, ITALY, Web site : http://bias.csr.unibo.it

[3] Cappelli R., Ferrara M. and Maltoni D. (2011) , ”Fingerprint Indexing Based on Minutia Cylinder-Cod e”, IEEE Transactions on Pattern Analysis Machine Intelligence, vol.33,No.,5,pp 1051-1057 , May 2011, pp 1051-1057

[4] Dario Maio, Cappelli R., Maltoni Davide, Wayman James L., and Jain Anil K., (2004) ”FVC 2004: Third Fingerprint Verification Competition”, Internationa l Conference on Biometric Authentication, ICBA 2004, pp 1-7.

[5] Ferrara M. and Maltoni D. (2010), " Minutia Cylinder - Code: a new representation and matching technique for fingerprint recognition", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.32, no.12, pp.2128-2141, December 2010, pp 2128-2141.

[6] Ferrara Matteo, Maltoni, Davide Cappelli ,Raffaele

[7] (2012),“Noninvertible Minutia Cylinder-Code Representation”,IEEE Transactions on Information Forensics and Security, Vol 7, No. 6, December 2012,pp 1727-1737.

[8] Ferrara M., Maltoni D. and Cappelli R, (2014), "Two-Factor Protection Scheme for MCC Fingerprint Templates", IEEE ,2nd International Conference of the Biometrics Special Interest Group (BIOSIG), 2014, pp 171-178.

[9] FVC2004 web site: http://bias.csr.unibo.it/fvc2004.

[10] Hamed Izadi M., Drygajlo Andrzej (2013),” Estimatio n of cylinder quality measures from quality maps for Minutia-Cylinder Code based latent fingerprint matching”, Biometric Technologies in Forensic Science (BTFS-2013), 2013,pp 6-10

[11] Maltoni D., Maio D., Jain A.K., Prabhakar S (2003)., “Handbook of Fingerprint Recognition”, Springer, Ne w York (2003) pp 1-55, 97-232.

[12] Maltoni Davide (2005),”A Tutorial on Fingerprint Recognition”, Advanced Studies in Biometrics Lectur e Notes in Computer Science Volume 3161, Springer US 2005, pp 43-68.

[13] Maio Dario,Raffaele Cappelli,Davide Maltoni,James L. Wayman, and Anil K. Jain, (2000) ” FVC 2000: Fingerprint Verification Competition”, IEEE Transac tions on Pattern Analysis Machine Intelligence, vol.23, no.3, March 2002, pp 402-412.

[14] Maio Dario, Raffaele Cappelli,Davide Maltoni,James L. Wayman, and Anil K. Jain, (2002),”FVC 2002:Second Fingerprint Verification Competition”, Published in : Object recognition supported by user interaction for service robots, Aug. 2002.

[15] Pasha Hosseinbor A., Zhdanov Renat, and Alexander Ushveridze,(2017), ”A New Point-set Registration Algorithm for Fingerprint Matching”, arXiv: 1702.01870 v1 [cs.CV] 7 Feb 2017 pp.1-6.