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A REVIEW ON HUMAN IDENTIFICATION SYSTEMS USING BIOMETRICS FINGERPRINT MATCHING

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Abstract:

Biometrics play an important role in solving security issues related to human identification system. Human recognition requires a robust feature set to discriminate individuals, for which, unique features are to be identified and processed. Fingerprint matching is the most sophisticated method of thedifferent biometric techniques because fingerprints are unique and reliable. Fingerprint matching systems are and validated through many applications. Most of the existing system is automated and provides acceptable performance. These systems address level 1, level 2 and level 3 features such as pores, ridge contoursand minutiae. Sometimesthey lack accuracy due to the poor quality of the images.This paper provides a review of various fingerprint matching systems and then discusses an automated, simple and robust fingerprint matching system with a hierarchical matching method.

Key words: Hierarchical matching, Ridge flow patterns, Galton features, Gabor filters, wavelet transform, ICP algorithm.

I. Introduction

Fingerprint identification is one of the most well-known and publicized biometrics. Because of their uniqueness and consistency over time, fingerprints have been used for identification for over a century, more recently becoming automated due to advancements in computing capabilities.The practice of using fingerprints as a method of identifying individuals has been in use since the late nineteenth century. Fingerprint identification began its transition to automation in the late 1960s along with the emergence of computing technologies. With the advent of computers, a subset of Galton points, referred to as minutiae, has been utilized to develop automated fingerprint technology (www.biometrics.gov, 2006). In 1969, NIST had started studying the process of automating fingerprint classification, searching and matching. In

1975, FBI funded the development of fingerprint scanners for automated classifiers and minutiae extraction technology, to the development of the prototype reader. Over the next few decades, the work at NIST led to the development of the M40 algorithm, the first operational matching algorithm used at the FBI for narrowing the human search. By 1981, five Automated Fingerprint Identification Systems had been deployed. The next stage in fingerprint automation occurred at the end of the Integrated Automated Fingerprint Identification System competition in 1994.

The architecture of a general-purpose fingerprint matching system is depicted in the Figure 1.

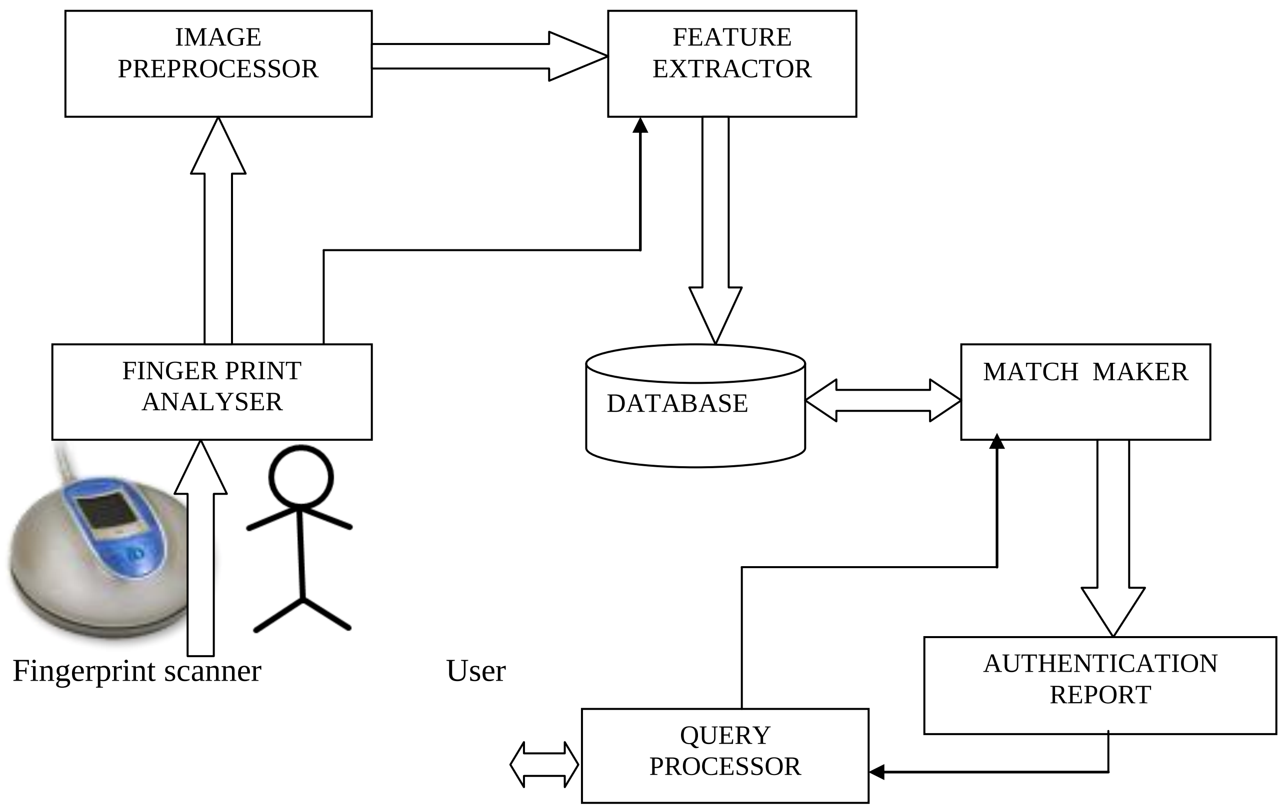

Figure 1: Architecture a general-purpose fingerprint matching system.

The input for the system- Fingerprint is obtained using a scanner and the image is subjected to analysis. The quality of the images is checked and is improved through the image enhancement procedures. From the enhanced images, sufficient number of features are extracted and stored in a database. As the query request is raised by the user, the query processor accepts the query and determines the type of services to be provided to the user. The processor issues the necessary triggers in the matchmaking process which in turn performs the hierarchical matching process to determine the level of authentication. Once the authentication is done, a report on the completed process is generated and is submitted to the user. All the features that are used in fingerprint matching are shown in Figue 2

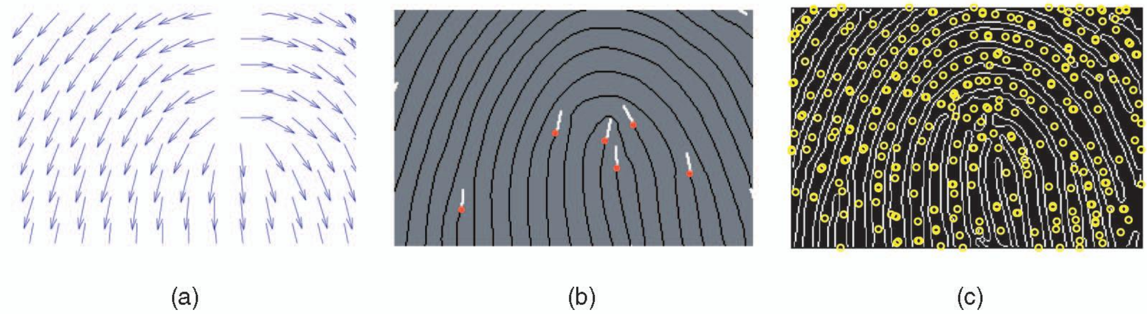

Figure 2: Feature set:Different levels of fingerprint features

(a) Orientation field (Level 1), (b) minutia points (Level 2), and (c) pores and ridge contours (Level 3).

II. Review of Literature:

Existing literature focuses on the extraction of different levels of features in high resolution fingerprint images to assist in fingerprint identification.

A skeletonization-based pore extraction and matching algorithm was proposed by Stosz and Alyea (1994). A multilevel identification technique combining the use of ridge and pore featureswas developed. But, the effectiveness of the process was observed only when the quality of images is good. As the image resolution decreases or the skin condition is not favorable, this method does not give reliable results.

Based on the skeletonization algorithm, later, a statistical analysis of pores was carried out and a model was presented by Roddy and Stosz(1997) to predict the performance of a pore-based automated fingerprint system. The analysis provided statistics about pores and demonstrated the efficacy of using pores, in addition to minutiae, for improving the fingerprint recognition performance. The method was dependent on intensity correlation, which was computationally expensive.

Similarly, L. Hong et al.,(1998) and C. Burrus et al., (1998) had suggested a pore extraction process which provided diversified methods of feature extraction through frequency domain processing. In parallel, a string matching procedure for level 1 and level 2 features developed by A.K. Jain et al., (1999) provided a good base for the matching process. Further D.R. Ashbaugh, 1999 suggested a method called edgeoscopy which extracted ridge contour details of the fingerprint.

To improve the accuracy of fingerprint feature extraction process, later in 2002, Sharath Pankanti et al. proposed a quantification method for minutiae points. Subsequently, A. Ross et al (2003) recommended a min-max normalization procedure for the score level fusion of level 2 and 3 features. Afterwards, two hypotheses pertaining to Level 3 features were presented by Kryszczuk (2004) by making a study on matching fragmentary fingerprints using minutiae and pores. It is found that Level 3 features are effective depending on certain conditions viz. fingerprint fragment size, number of minutiae.But the method suggested a small database only.

Michael Ray, Peter Meenen, and Reza Adhami (2005)presented a method to obtain additional discriminate information from fingerprint images. In this paper, a method was demonstratedto extract the locations of sweat pores from the grayscale fingerprint image. The disadvantage is that every fingerprint image obtained with a 500 dpi scanner does not have evident pores.

Initially in 1992, a modified Iterative Closest Point algorithm was suggested by P.J. Besl et al., When applied locally, ICP also provided an alignment correction to compensate for nonlinear deformation as mentioned by A. Ross et al.,(2006)**.** A similar approach using ICP had been adopted by A.K.Jain (2007) for level 3 feature matching.

Minutia based technique is not very efficient for recognizing the low quality fingerprints. Some researchers used correlation-based methods to get better results. Deepak Kumar Karna et al., (2008) proposed normalized cross-correlation technique for fingerprint matching to minimize error rate as well as reducethe computational effort than the minutiae matching method. Subsequently, Abhishek Rawat (2009) proposed hierarchical matcher that utilized level 3 features in conjunction with level 2 features for matching. The method reduced the error rates False Acceptance Rate and False Rejection Rateconsiderably.

K. Caoet al., (2010) developed an algorithm for distorted fingerprints. In which, finger placement direction and ridge compatibility are used to deal with nonlinear distortion in fingerprints. Fingerplacement direction is extracted from fingerprint foreground and the ridge compatibility is determined by some matched minutiae and their associated ridges. Thesetwo features are combined with orientation descriptor and local minutiae structure. Minimal error rates are proved by experiments. Successively the algorithm is refined by H. Choiet al., (2011) to improve the matching performance against nonlinear deformation in fingerprints. The ridge features are used in conjunction with minutiae features and the matching process used a breadth-first search algorithm.

Madhuri and Richa Mishra(2012) proposed to use local features for fingerprint representation and matching. The authors proved that their technique is rotation-invariant and is able to apply it for partial fingerprints, which was missing in the previous works. Later, Chandana et al., (2015) stated about how minutiae points are important to recognize fingerprint and the Region Of Interest (ROI) to minimize errors and time complexity.

After having a detailed study of fingerprint matching techniques, a summary is devised and written in Table 1.

Table 1: Summary of different fingerprint matching techniques.

Fingerprint Matching Technique	Remarks
Skeletonization based pore extraction and matching algorithm Multilevel identification technique that combines the use of ridge and pore features	Effective only when the image quality is good If the skin condition is not favorable, the results are not reliable
Another skeletonization approach applying a statistical analysis of pores	Performance improved as the approach uses pores in addition to minutiae More computational complexity
Frequency domain processing used for feature (pore) extraction	Reduced computational complexity
Stringmatching procedure for level 1 and level 2 features	Created a goodbase for the matching process
Edgeoscopy method used for fingerprint matching	Ridgecont our details extracted as one of the features
Quantification method for minutiae points introduced	Accuracyof the fingerprint feature extraction process improved
A min-max normalization procedure for the score level fusion of level 2 and 3 features introduced	Improved performance
Two hypotheses pertaining to Level 3 features presented Matching process using minutiae and pores	Level 3 features found to be effective Verified for a small database only
Additional feature i.e. locations of sweat pores from the grayscale fingerprint image extracted and used in the matching process	Additional feature becomes difficult for lower resolution fingerprint images
Iterative Closest Point(ICP) algorithm modified for matching level 3 features	Provided alignment correction to compensate for nonlinear deformation
A cross-correlation technique used for fingerprint matching	Error rate minimized Less computational complexity
Level 3 features used in conjunction with level 2 features	Error rate, False Acceptance Rate and False Rejection Rate considerably
Nonlineardistortion dealt finger placement direction and ridge compatibility Features derived from minutiae and their associated ridges and combined with orientation descriptor	Error rate minimization improved
The previous algorithm modified by using breadth-first search algorithm for the matching process	Matching performance improved against nonlinear deformation in fingerprints
A rotation-invariant method using local features for fingerprint matching	Could be used for partial fingerprints
Importance of minutiae points for the recognition of fingerprint and the Region Of Interest (ROI)	Errors and time complexity reduced much

Conclusion:

The summary shows the review of different fingerprint matching techniques and their applicability for human identification. A detailed review on the merits and demerits of fingerprint matching techniques is presented. Recognition of people based on their physiological and/or behavioral characteristics is called biometric recognition or simply biometrics. Fingerprint authentication is a pattern recognition system that recognizes a person via the individual information extracted from the raw scanned fingerprint image.

In order to devise a simple, reliable and fully automated framework for identifying human beings through finger prints, the effectiveness of a system for matching ridges and iteratively calculating the registration error need to be considered. Therecognition performance may further be improved using three different levels of featureshierarchically. Thus, they can be applied on a larger scale on fingerprints.

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