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Image Processing Techniques for Fingerprint Identification and Classification – A Review

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ABSTRACT

The major contributing factor to biometric technological advancements is fingerprints. Biometric authentication technology works completely for worker time management combined with the ability to acknowledge distinctive behavioral features. The growing popularity for period and enrollment of biometrics-based platforms provides several advantages. These terminals can not only display fingerprints, but also some are intended to display the distinctive speech style, finger pattern, head form, or iris of a person. Image processing methods were the finest option for human administration to define fingerprint images. This article provides a study of present image processing research by reviewing methods used to distinguish fingerprints and computer training models used to classify fingerprints. The paper's primary objective is to demonstrate the present suggested feature extraction duties for image processing and fingerprint identification computer training methods. This evaluation document will be essential to other fingerprint identification scientists operating in the field of image processing.

KEYWORDS: *Fingerprint classification; Image processing; biometric technology; machine learning techniques; Features extraction*

1. INTRODUCTION

Behavioral and physiological factors have been played important roles for person identification. According to this fact, biometric information is focused for this approach.

The examples of biometric information are face, iris, signature, voice and fingerprint. Among these biometric information, fingerprint is one of the unique biometric information for human identification. Even identical face with identical voice, have different fingerprint pattern. Today, image processing techniques are developed for automatic biometric systems by applying machine learning and deep learning techniques.

Many researches in this area propose the use of an Expert system based on convolutional neural network with different feature extraction methods [1], [2]. Because early identification of fingerprint used different machine learning techniques in an expert system based on fingerprint image and feature extraction methods. This review paper focuses on showing the current state of the art in this field, by surveying the paper which deals with image processing for classification of fingerprint and show the advantages and disadvantages of these proposed approaches.

This paper is structured in five sections, section one is an introduction, section two is related work, section three is stages of image processing, section four is a literature review and section five is the conclusion.

2. RELATED WORK

This section describes review work which deals with image processing for fingerprint identification and classification. Galar, Mikel, et al. proposed a survey of fingerprint classification which clearly reviewed different feature extraction and different learning model for fingerprint classification from 1975 to 2015. The feature, leaning model and different datasets used by previous author from 1975 to 2015 are clearly presented and it had completed survey for fingerprint classification [3].

In 2014, Sharma, Monika surveyed fingerprint biometric system according to feature types, different machine learning methods and feature matching techniques. Fingerprint recognition system using minutia extraction technique was clearly explained in this paper with step by step [4].

In 2016, Ali, Mouad MH, et al. proposed an article for an overview of a current research based on fingerprint recognition system. The concepts and structure of fingerprint recognition was presented which are mainly based on image processing and machine learning techniques. The main stages of fingerprint recognition system were clearly discussed according to state of art proposed methodologies. The more information for different fingerprint database was also reviewed to know the challenge of fingerprint recognition. The different type of preprocessing, feature extraction, feature matching techniques and different learning methods are also highlighted to know the development of fingerprint recognition [5].

There are four main steps in fingerprint recognition system. These steps are: fingerprint capturing, pre-processing, feature extraction and matching (identification). In capturing step, the sensor had to use to record fingerprint image. And then in pre-processing, background subtraction or foreground extraction is performed to get modified version of fingerprint image. After pre-processing step, the pre-processed image is used as an input for feature extraction step to extract distinct feature for fingerprint. Finally, the matching or identification is performed by using extracted feature. In matching, the extracted feature is compare with the templates in the database [5]. In identification, the extracted feature is identified by trained model.

3. IMAGE PROCESSING TECHNIQUES AND MACHINE LEARNING TECHNIQUES IN FINGERPRINT IMAGE IDENFICATION AND CLASSIFICATION

This section shows the current state of the art in the field of image processing for fingerprint identification and classification. Image processing plays important role in fingerprint identification and classification and mainly applied in pre-processing and feature extraction steps. The identification rate of fingerprint mainly depends on pre-processing and feature extraction step. This allows a strategy comparatively complex and time-consuming as the existence of distortion in the image can lower the performance of the function and the precision of the model to acknowledge the fingerprint. Image processing techniques can be applied in these following steps:

Image Acquisition: Sensor is used to capture the fingerprint image. Different capturing of fingerprint for one person is performed to create fingerprint database. Fingerprint scanner is also used to generate fingerprint image. Most of generated image are 8 bit bmp type image file.

Image preprocessing: Image scaling, image filtering and other morphological techniques are used to remove unwanted noise. Binarizing image, thinning image and image enhancement techniques are used to get the perfect pattern of an image.

Image Segmentation: The separation of foreground and background is performed by using various clustering method or threads holding methods based on different type of color space such as RGB, LAB, HSV/HIS, CMYK and YCbCr etc. In most fingerprint images, the pre-processed fingerprint image is binary image. In this binary image, the background color is white and the foreground is black.

Feature Extraction: Corner detection methods, edge detection method, keypoints detection methods are used to extract the feature of a fingerprint image. Gray Level Co-Occurrence Matrix (GLCM), Local binary pattern (LBP) and statistical methods are commonly used to extract feature of a fingerprint image.

Classification: Most of machine learning such as Support Vector Machine (SVM), Linear Discriminant Analysis (LDA), Decision Tree (DT), K-Nearest Neighbors (KNN) and Naive Bayes classifier are commonly used for fingerprint classification and identification. Neural Network classification of deep learning is the most popular and powerful classifier in fingerprint classification and identification.

Image processing techniques influenced in fingerprint image identification and classification system. Most of researchers proposed feature extraction methods, image enhancement methods and segmentation methods to boot the identification rate or recognition rate of fingerprint image. The machine learning techniques are also essential in fingerprint classification and identification system.

4. LITERATURE REVIEW

Most of researches tried to improve the image quality before performing the fingerprint feature extraction. Fingerprint enhancement methods improve the fingerprint pattern and structure and remove unwanted noise or part form an image. In order to improve classification accuracy, most researches proposed feature extraction methodology and approaches with different image processing techniques. In this section, the pre-processing, feature and classification of different previous researches for fingerprint identification and classification are briefly explained.

In 2000, Cho, Byoung-Ho, et al. proposed fingerprint classification algorithm based on core points of fingerprint image. In this algorithm, core points are detected and adjusted to get modification version of fingerprint image. The analyzed core point's information is applied in classification step. The proposed classification method used the curvature and the orientation of core and its classification accuracy reach 92.3% for four labels of fingerprint called arch, left-loop, right-loop and whorl [6].
In 2002, Sujan, Vivek A., and Michael P. Mulqueen proposed to use a HAusdorff– Voronoi NETwork (HAVNET), an artificial neural network designed for two-dimensional binary pattern recognition. In pre-processing, Fourier–Mellin transform was used to get highlighted versions of fingerprint image [7].

In 2005, Xia, Tao, et al. proposed methodology for automated fingerprint identification system. In proposed methodology histogram transform, fast smoothing and enhancement were used in pre-processing; Orientation thinning method was used for fingerprint feature extraction. For matching and registration, Hough transform was used [8].

In 2010, Lourde, M., & Khosla, D. proposed an optimal algorithm for fingerprint matching to increase performance and accuracy in fingerprint identification. A Minutiae-Based Matcher and filter-based algorithm are compare in terms of Security and Convenience measurement. The fingerprint images form NIST database was used in experiment. Designers are very concerned about the problem of selecting an ideal algorithm for fingerprint identification to construct a scheme that meets efficiency and accuracy standards. It is vital to first comprehend a biometric-based security system's fundamental architecture and then continue to find out how a typical fingerprint authentication system operates [9].

In 2016, Magi, Aleksander proposed an algorithm for fingerprint identification with different fingerprint databases. According to this algorithm, there are four main steps in this algorithm: Acquisition, Pre-processing, Feature Extraction and Fingerprint recognition. In pre-processing, ridge segment, histogram equitation, FFT enhancement and binarization were used. In feature extraction, thinning image, minutiae detection and real minutiae were used. In

recognition, there are three main parts: enrollment or training, verification and identification. In enrollment, feature set temple of fingerprint images are save to match with incoming fingerprint image. In verification and identification, minutiae matching were used. Neural network and fuzzy logic needed to be used in order to enhance and evaluate the best performance of fingerprint recognition system. The experiments are tested on two FVC2000 and FVC2002 fingerprint databases [10].

In 2017, Ali, Mouad MH, et al. proposed to use convolutional neural networks for fingerprint classification. In their works, the classification of convolutional neural networks is compare with SVM, KNN and Decision Tree to show the advantages of convolutional neural networks. In experiment, different size of images are used with different models of convolutional neural networks are used for fingerprint classification. The architecture of proposed neural network with different layers size is test to show resistance of neural network classification for fingerprint image. Different machine learning classifiers have been compared with two different CNN architectures with different fingerprint database in experiment. The accuracy and robustness of neural network were mainly focused for fingerprint classification [11].

In 2018, Borra, Subba Reddy, G. Jagadeeswar Reddy, and E. Sreenivasa Reddy proposed Adaptive Genetic Neural Network (AGNN) with morphological operation for fingerprint classification. the direction-oriented pattern consists of ridges and valleys of fingerprint. The fingerprint image's reputation affects a fingerprint authentication scheme's reliability. The augmentation approaches were proposed for image enhancement. To remove noise from fingerprint image, Wave atom transform was used to boot the classification accuracy of AGNN. To augment the image, the morphological methods were used to affect the classification accuracy of AGNN efficiently [12].

In 2019, Mishra, Annapurna, and Satchidananda Dehuri proposed Filter Bank approach using Evolution Artificial Neural Network (ANN). The Gabor filter is used to extract fingerprint feature and Principal Component Analysis (PCA) was used for feature selection for ANN. The proposed EANN classification has no rotation invariant.

According to literature review, Neural Network is the powerful classifier for fingerprint image and image enhancement and feature extraction are also important for construction of better fingerprint clasfiier.

Table1: Summary of Literature Review

Pre-processing	Feature extraction	Classification Method	Dataset	Issue
- proposed image enhancing method that increases the distinction between ridges and valleys	- Mean and the variance, - Local mean and local variance for four directions - minimum variance - desired variance	Proposed Core Based Classification	6283 fingerprint images of adults in South Korea (4 labels)	The more advanced techniques are required for the noise-tolerant classification method to eliminate the fake key point [6].
- Fourier–Mellin transform	- No feature extraction and fingerprint image is used as input for artificial neural network.	Artificial neural network HAusdorff–Voronoi NETwork (HAVNET),	15 labels of fingerprint images	The training time of neural network is long and parameters of neural network are carefully defined [7].
- histogram transform, fast - smoothing and enhancement	- Wavelet-enhanced method - Orientation thinning - Minutiae Extraction	-Matching Score Computing	fingerprint images from a fingerprint Sensor /reader	Detail explanation of proposed methodology is clearly described but experimental results are not presented [8].
- Gabor filters of fingerprint enhancement algorithm	- Extract a reference point for the fingerprint image - Extract the region around the reference point - Filter the region of interest in different directions	Feature Matching (Minutiae-based, Correlation-based and Euclidean distance-based)	NIST-DB4	It is essential to know an application's safety demands and the amount of comfort that fingerprint system need [9].
- ridge segment - histogram equitation - FFT enhancement - binarization	- thinning image - minutiae detection - real minutiae	minutiae matching	- FVC2000 - FVC2002	High correct rate but comparison needed long time for identification and verification. [10]
- Image resize	- No feature extraction - Gray scale image	Convolutional Neural Network	- SFinGe databases - NIST-DB4	The issue of biometric detection introduced some peculiarities that should be considered when evaluating new technology [11].

- Wave atom transform	- Morphological operation - Dilated image - Opened image	Adaptive Genetic Neural Network (AGNN	- FVC2000	The training and testing approaches in proposed approach took very minimum time but preprocessing time took long time [12].
No pre-processing	- Gabor filter - Principal Component Analysis (PCA)	Evolutionary Artificial Neural Network	- NIST-9 database	The proposed EANN classification has no rotation invariant.

5. CONCLUSION

A useful alternative for administration is the use of image processing methods to identify and classify fingerprints. Image processing incorporated with a smart expert framework to support real-time identification and categorization of fingerprint. In this paper, multiple algorithms have already been suggested, but a convolutional neural network shows that it can identify the fingerprint. As a result, it can be used to produce real-time fingerprint identification instruments that assist community; devices will be more precise in fingerprint classification because CNNs give elevated classification quality most of the time. When interacting with one sort of fingerprint image, conventional techniques worked well. But in its pipeline detection and ranking of fingerprints, the strategy requires a ton of trial and error. Based on this research, it demonstrates that using convolutional neural network using scratch learning provides optimum identification precision in potential work meets to evaluate the highest classification necessity to create the identification model for fingerprint identification.

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