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Fingerprint Detection and Matching using Deep Learning and Gabor Features

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Abstract

Purpose: Due to the increasing expansion of fingerprint databases, the Automatic Biometric Identification System (ABIS) has become more challenging than ever before. As a result, in order to meet both efficiency and accuracy criteria, fingerprint indexing must be quick and precise. This research compares and contrasts multiple deep learning algorithms for extracting fingerprint features for faster and more efficient authentication.
Design/Approach: Examining an analysis of the preliminary results, the researchers entertained the possibility that the provided aim would be better served by using deep learning techniques. Wavelet Transformation and Gabor Features are 2 of the most popular techniques to extract the features from an image. Traditionally, these, along with various other techniques, were utilised in producing noiseless features, that leads to an increase in accuracy of the model. In this work, deep learning models such as VGG-16, CNN and ResNet 50, are used for fingerprint recognition and matching.

Keywords: CBMCC, FVC, ResNet50, VGG16, CNN, MIH

1 Introduction

One application of a bio-metric system is to provide relevant results in optimal time during fingerprint identification. For relevant results in optimized time, fingerprint template generation and its indexing play an important role, and highest matching accuracy and fast response time [8, 7]. Fingerprint-based recognition is one of the oldest and popular modern methods to identify a person. Identification is based on the macro and micro features of the fingerprint. Fingerprints are made by the ridges that are the raised portion on the palms and the tip of the finger. Macro features of the fingerprint are ridge patterns like whorl, arc, loop, core and delta points that are originally used in identification processes [4]. The core is the central part of the fingerprint which looks like a whirl. There can be one or more core or there can be no core in a fingerprint. Delta is the region on the fingerprint where one ridge divides into two or more ridges that normally go in opposite directions. Micro features include minutiae, its orientation, and position. The local ridge discontinuities present on the fingerprint are minutiae points. These are of two types namely; terminations, which is the immediate ending of a ridge and bifurcations, which is the region where one ridge comes and divides into two parallel running ridges and moves forward.

1.1 Fingerprint matching

As discussed in the previous paragraph, image recognition and its indexing are an important part of fingerprint indexing.As shown in Figure.1, there are four phases in fingerprint recognition.

Image Acquisition: Image acquisition plays an important role in fingerprint identification and matching. In this process, images are captured in two ways: offline and online. The optical fingerprint readers are used to capture images of a fingerprint in online fingerprint recognition. Offline fingerprint identification can be done by inking the area of the finger, then placing a sheet of white paper over it, and scanning the paper to generate a digital image.

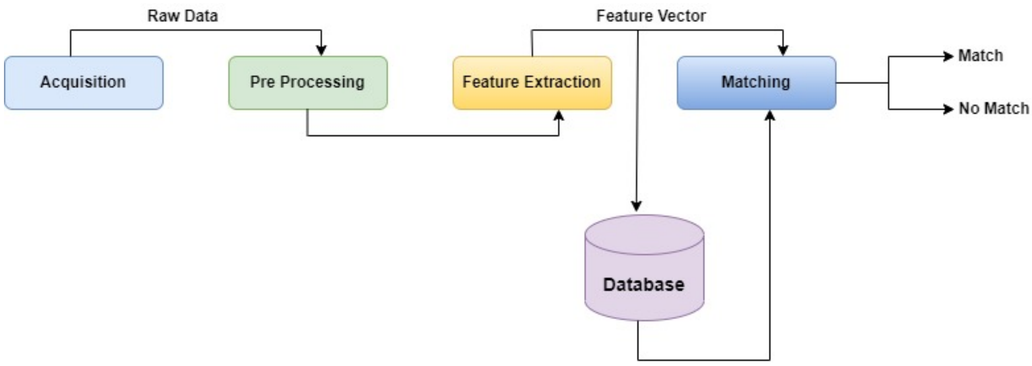

Figure 1: The Fundamentals of the Fingerprint Recognition [1]

Prepossessing: This process is used to remove undesirable data in fingerprint image such as reflection, noise removal, binarization, thinning, segmentation and smoothing. After completing the processes, it would improve the visibility of ridge structure.

Feature extraction: The fingerprint image's feature extraction is used to extract fingerprint features for identification and matching. In the past, various algorithms were proposed for fingerprint feature extraction. The basic task of fingerprint-based feature extraction algorithm is to locate, measure, and encode the fingerprint's ridge ends and bifurcations. The most well-known technique is the minutiae extraction algorithm, that locates and maps the minutiae spots mostly on fingerprint[2].

Matching: This stage is used to match fingerprints based on a feature extracted in the feature extraction phase. The matching step calculates the measure of similarity between both the input test image (used by the user to verify his/her identity) and a database training image (the template that was developed during the enrolment process). Matching can be accomplished in three ways: hierarchical, classification, or coding. The hierarchical technique increases the performance of matching at the expense of accuracy - not clear. Classification techniques, such as the KNN classifier, provide a class to every bio-metric in a database. Coding strategies that employ a single matching function to search through huge datasets[13].

1.2 Fingerprint Indexing

Better fingerprint matching in optimal time, its require better indexing approach. According to the authors of the paper[6], indexing schemes for fingerprints vary according to the features used to create the index. The Indexing has two critical facets: (1) Indexing characteristics and (2) Retrieval Approach. It is used to optimise database speed by reducing the number of matches required for identification. In this approach, a fingerprint is expressed as a feature vector.

The paper is organised into following sections: Section 2 discusses the recent contributions in the literature, machine learning and deep learning methods. Section **??** describes the pre-processing, vectorization, and model details used in the paper. Section **??** discusses analysis the results obtained. Section **??** compares the results of the proposed approach with recent state of art methods. Section **??** concludes the paper with final thoughts.

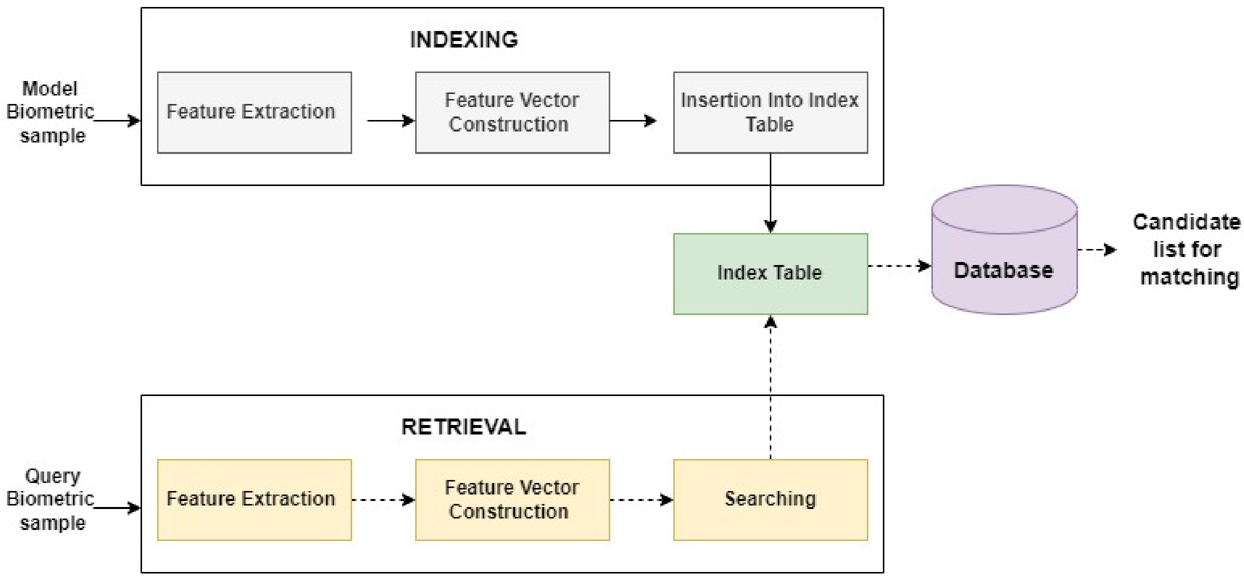

Figure 2: Enrolment and retrieval operations for fingerprint indexing

2 Literature survey

In introduction section, it is clearly shown that feature extraction process plays an important role in fingerprint matching and detection. This section describes the past work done in fingerprint matching, classification, indexing and detection, specially using deep learning approaches.

A fingerprint verification technique is proposed in the paper [11]. They proposed a representation and matching scheme for fingerprint using Scale Invariant Feature Transformation (SIFT). They proposed a strategy of applying SIFT to fingerprint images. They evaluated the proposed model using a public domain fingerprint database (FVC 2002), and reported that proposed approach complements the minutiae based fingerprint representation. Further, They reported that combination of SIFT and conventional minutiae based system achieves significantly better performance than either of the individual schemes. They reported EER of 8.44%(DB1)and 10.16%(DB2) using SIFT. In the paper [9], authors proposed fingerprint image post-processing algorithm based on generalization through a study on the errors. They evaluated the results on FVC2000 databases with average EER imprvement 18.42%.

Fingerprint Classification and Indexing This section describes the past work on fingerprint classification and indexing approaches. In the paper[14], authors discuss the fingerprint classification approach to classify the fingerprint using the directional image of fingerprints to increase the number of subclasses. They reported results on nine groups on the database consists of 168 fingerprints.In the paper[12],authors proposed a feedback path for the feature extraction stage, followed by a feature refinement stage for improving the matching performance. They show a minutia verification improve the matching performance by 4% on own database

After classification, fingerprints are needed to index based on micro feature[10]. Indexing schemes are popular in two working stages: off-line data insertion and on-line data search. A large portion of indexing strategies have been focused on the real valued feature representation. These indexing schemes are time and memory consuming. For example, index using sorted array takes time and as well as drains lots of storage [3, 5]. Later, researcher used hashing for indexing, they pointed out that it is a convenient choice for sequential(non-binary) search. The primitive implementation of the hash table uses a hash key (spawned by hash function),keyword along with document-id and location of keyword in the document.

After going through the studies on fingerprint matching and identification mentioned above, it is found that a lot of research has been done on fingerprint identification using various tools. However, a lot of gaps is present for improvement in fingerprint identification and matching. This survey has identified the following significant points. Firstly,most of the researchers used traditional feature extraction methods in the fingerprint. Second, some researchers used only a few evaluation metrics to report the results of fingerprint matching but they have not commented on reducing the matching error rate. Third, some observe that most of researcher used Gabor feature for feature extraction, and limited work has been done using deep learning methods for feature extraction in fingerprint matching. Based on these points, the following research points (RPs) have been defined:

- Is there any possibility to improve current architectures to achieve better fingerprint identification results?
- Is there any possibility of reducing the error rate of fingerprint matching?
- Is there any possibility of applying a deep learning model along with traditional feature extraction method to reduce the error rate?

Among all the existing models, CBMCC MIH (128) model was the best fit, but our model (ResNet 50) deals with the problems of CBMCC MIH (128) model and outperforms it in every aspect.
In Fig. **??**, the penetration rate of 10 refers to a 3% error rate in DB1, a 2% error rate in DB2, a 9% error rate in DB3, a 4% error rate in DB4.

3 Conclusion

The proposed model is better as compared to the state of art, as in previous works there was usage of cylindrical codes. Cylindrical codes increases the overlapping of features. Due to which , noise is created. So due to this, fingerprint indexing can not be done in an efficient manner . So for reduction of noise , we use Wavelet Transformation to convert the image into pixels so that we can extract the Gabor features of the fingerprint to minimize the overlapping of features and then ResNet50 is used So that, fingerprint indexing can be done in an efficient manner.

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