FINGERPRINT RECOGNITION USING MACHINE LEARNING APPROACHES

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EEL 6825 Pattern Recognition

Fall 2022

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Abstract:

Fingerprint recognition is one of the most widely used biometrics since it is low-cost, easy-to-use, highly secure, and widely accepted. Fingerprint image enhancement, feature extraction, feature matching, and fingerprint classification are only few of the phases of fingerprint identification systems that continue to face new obstacles as more and more people use them. The problems of fingerprint identification are addressed in different ways by machine learning approaches. This report consists of few fingerprint algorithms for identification and couple of machine learning techniques developed to encounter the false fingerprint detection problems.

Introduction:

Fingerprints provide a one-of-a-kind foundation for identity information. Online banking, locker rooms, mobile devices, and the security of classified data are just some of the areas where this authentication is being put to good use. In addition, many developed nations are adopting fully automated systems, including smart houses and ways of life. One of the most reliable ways to access or operate any smart device in the environment is through biometric authentication. No two people have the same fingerprint, and this pattern does not change as we age or develop. It has been reported that in despite of billions of comparisons, no two fingerprints have ever been found to be identical. However, this biometric method is encountering several difficulties as a result of technological advancements, such as detecting false fingerprints in the cybercrime industry.

Fingerprint Structure:

The ridge and valley pattern left on the fingertip is what makes up a fingerprint. It is built with regular intervals of ridge and valley, creating a harmonic structure.

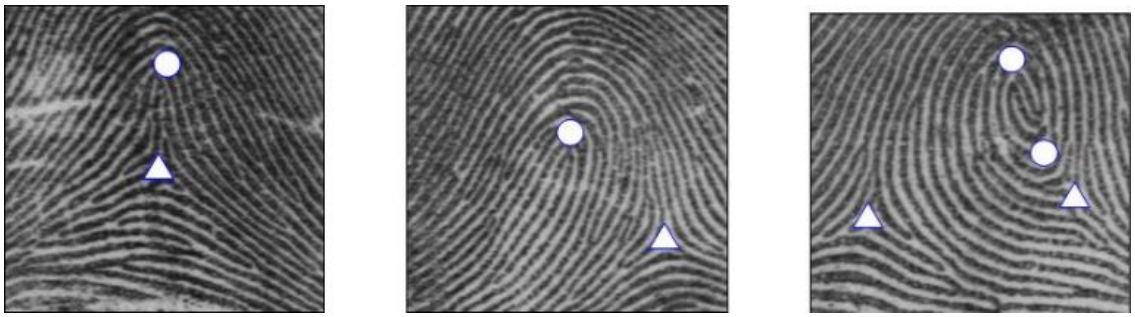

Fig.1 Shows three different examples of fingerprint images with ridges and valleys representations

Analysing the pattern of ridges and valleys on the fingerprint reveals different types of features which can be represented by three levels: (i) Global Structure (ii) Minutiae points or Local Structure (iii) Low level Structure.

(i) Global Structure:

The overall form of a fingerprint is conveyed by the global fingerprint representation. In global structure, the fingerprint picture can be represented by a single representation. Singular points also play a significant role in the overall global structure. Considering that singular points are exclusive to each fingerprint class, they are frequently utilized in coarse registration and classification.

(ii) Local Structure:

Specifically, the ridge and valley pattern found at the local significant location is reflected in the fingerprint structure. Both ridge terminating and ridge bifurcation are well-known characteristics of ridges (it is called Minutiae). Due to the high discriminant strength of fingerprint minutiae, fingerprint matching relies heavily on local structure.

(iii) Low Level Structure:

Sweat pores on fingerprint skin are considered by the low-level structure. Capturing the low-level structure is challenging because it requires a high-resolution sensor and a well-controlled environment, both of which are expensive.

Fingerprint Identification System:

The necessity for a human specialist in fingerprint identification and classification is mitigated by the availability of automatic fingerprint recognition systems. There are two main stages to authentication system: I) Enrolment phase and ii) Recognition phase. In the enrolment phase the fingerprints of an individual person is stored in a database for future purpose. While in the recognition phase is opposite, it compares the currently enrolled individual fingerprints with the data stored in database to authenticate the person.

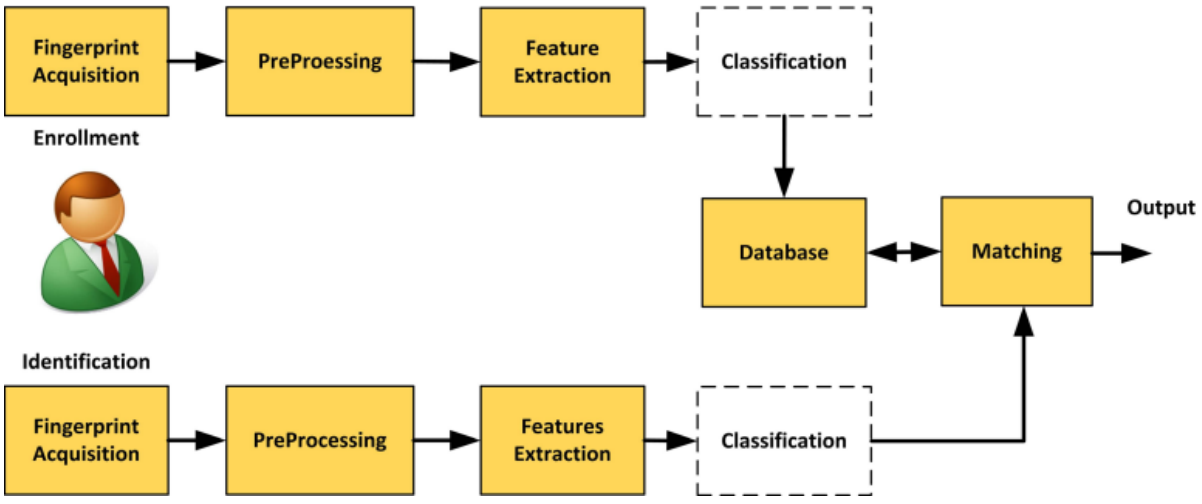

Fig.2 Flowchart of Fingerprint Identification System

- Fingerprint acquisition: In this step, sensors are used to capture the fingerprints. But sometimes the Images may be unusable for processing at times due to factors such as too much or little pressure, moisture, dust on the sensor.
- Pre-processing: This is the most needful step and it is used to enhance the quality of images.
- Feature Extraction: It serve as crucial milestones in the development of fingerprint recognition technology.
- Database: We can store the features of fingerprints in this database for future use.
- Matching: In these features of fingerprint are extracted and matches with the previous fingerprints which are stored in database for authorization and gives the output.

Fingerprint Recognition Algorithms:

The minutiae algorithm is commonly implemented in fingerprint verification procedures. Minutiae points, are local ridge characteristics that appear as ridge bifurcations. On average, a full fingerprint has 100 different, minutiae spots that make it unique. In a coordinate system, the swarm of dots represents these minutiae points. Due to high discriminant strength of this algorithm hybrid methods have been proposed.

1) The Spaced Frequency Transformation Algorithm (SFTA):

This follows the frequency of the ridge patterns and it utilizes the 2D Fourier transform to distinguish the two fingerprints. Moreover, this Fourier transform plays a vital role in altering the images from spatial domain to frequency domain.

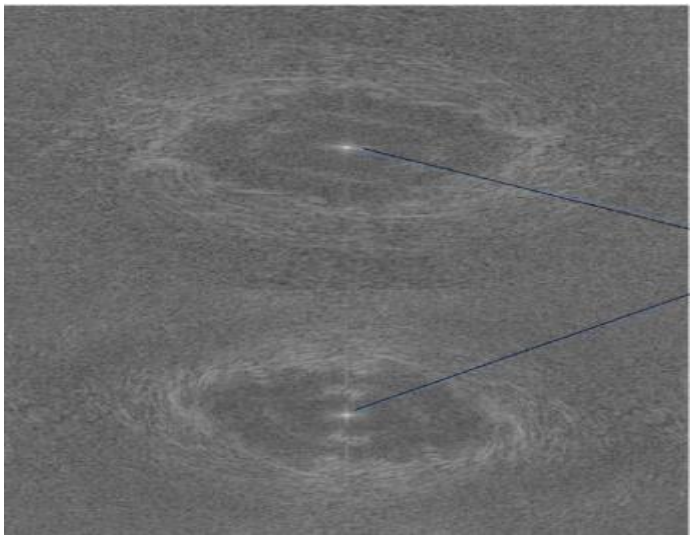

Fig.3 Fourier Transforms of two different fingerprints

This was developed to compare the partial fingerprints. Finding the match between fingerprints can be done by using threshold value, Firstly, the Fourier transform compare the similar elements in both images if it is higher than the threshold value the match is perfect. Otherwise, it is a mismatch.

2) Line Scan Algorithm:

The main purpose of enhancing this algorithm is to reduce the comparison time while using Fourier transform. This algorithm provides more benefits than the spaced frequency algorithm, and we can also find the partial matching between them using this algorithm. This has an accuracy rate of 95% which is more than the STFA algorithm discussed earlier.

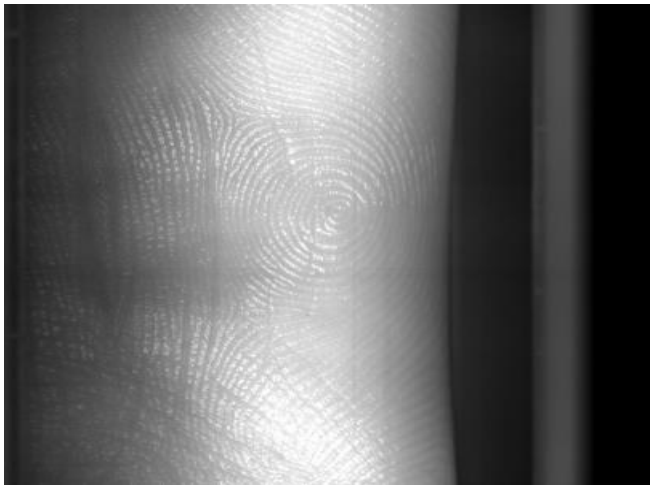

Fig.4 Desired portion of fingerprint

Machine Learning Techniques Used to Detect False Fingerprints:

Machine learning is the subset of artificial intelligence, it uses our previous data to enhance their predictions to give better output. Machine Learning is first trained by the user by giving known labelled data and then the system performs the required operations based on its experience. However, there are some techniques which are utilized to detect the false fingerprint recognitions.

1) Artificial neural network:

One of the most common types of machine learning algorithms used in fingerprint identification systems is the Artificial Neural Network (ANN). It has many applications, including quality control and fingerprint classification. The backpropagation algorithm is used to strengthen the skills of this Artificial Neural Network. In order to perform fingerprint matching, they build a new set of features and then extract those features from frames using a neural network classifier. The main goal of this method is to identify frames with clearly defined properties. The main disadvantage of this method is the amount of time required to perform the calculations.

2) Support vector machine:

It is an algorithm for supervised learning that can perform tasks including regression, classification (both linear and nonlinear), and outlier detection. By optimizing the hyperplane border, support vector machines may more accurately categorize data into different classes.

i) Fingerprint quality assessment method:

An accuracy of 96.03% was achieved while using this method to categorize fingerprint images as either high, medium, or low quality. The extra time required for processing is due to the feature extraction step. Segmenting fingerprints is an essential first step in processing fingerprint data.

ii) Fingerprint segmentation:

This technique consists of three stages: pre-processing, segmentation, and postprocessing. In the pre-processing phase, Gaussian Filter and Histogram Equalization are utilized, and in the segmentation phase, global mean, local mean, local variance, and coherence are determined by employing a split-and-merge technique. A linear support vector machine classifier is used for classification after the fill the gap technique has been used in the post-processing stage. To interpret these database fingerprint identifiers, a support vector machine is built and then trained.

3) Genetic Algorithm:

As a form of machine learning, Genetic Algorithms show great potential for addressing issues with fingerprints. Singular point extraction using a genetic algorithm was achieved by Professor Mao and colleagues. They created a unique concept of core point location and orientation to serve as the genetic algorithm's fitness function. A classification algorithm was created by Tan et al. that makes use of recently discovered features. Using the Genetic Programming method, they looked for unusual primitives in the orientation images with the proposed method. It is possible that people are incapable of conceiving of the traits that have been taught. Then, the actual categorization was carried out using a Bayesian classifier. NIST-4 data was used to test the proposed approach.

Results:

Over all, the fingerprint identification consists of different steps which are fingerprint acquisition, pre-processing, extraction, database and matching these are all used to identify the specific fingerprint. Moreover, few algorithms that are enhanced to compare the two fingerprints from the data stored in database to find its match. In addition, fingerprint is mostly used biometric algorithm due to its higher availability and acceptability because of that it encounters a lot of problems as more as people use them. To overcome this situation some machine learning techniques are discussed in this report and these techniques shows superiority than other algorithms to face fingerprint challenges.

Conclusion:

To sum up, this report provided a summary of how machine learning methods have been applied to date to address issues with fingerprint recognition. The research examined the application of four major machine learning approaches, including pre-processing, features extraction, classification, and matching, with a particular emphasis on Support Vector

Machines, Artificial Neural Networks, and Genetic Algorithms. This study also shown that when compared to conventional fingerprint identification algorithms, machine learning algorithms perform significantly better when confronted with fingerprint recognition difficulties. Both reducing processing time and improving accuracy in a fingerprint identification system remain open problems. Therefore, in the future, researchers will focus on creating algorithms that employ machine learning to address these issues.

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