Fingerprint Feature Extractors Using Multiple Machine Learning: A Comparative In The Study

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Abstract: Using biometrics information of personal identification has recognized more and more attention in the last few years, due to the inevitability to improve the biometric information security and access restrictions of authentication systems. Fingerprint information is considered the most practical biometrics due to some specific features which make them extensively established. The most challenging problem in fingerprint recognition system is still challenging from extraction unreliable feature from poor quality fingerprint images. Basically it required necessary pre-processing steps to enhance the quality of biometrics images to extract some distinctive features. Various multi resolution transforms methods have been comprehensively used as a feature extractor in the era of biometric information recognition.

Index Terms: Fingerprint, Minutiae extraction, Convolution Neutral Network, Biometrics, Automatic Fingerprint Recognition Systems

I. INTRODUCTION

Most of the biometric authentication system use fingerprint identification system to get process by authentication [1], by good quality of the image attractive properties of fingerprints including distinctiveness, uniqueness and invariability. A large-scale fingerprints database consists of finding the template that corresponds to the identity of an input fingerprint images. Multiple fingerprint matching and identification methods have been make public along the past few years [2- 4]. Each fingerprint identification algorithms of them has different properties, which in twist yield different trade-offs between effectiveness and correctness [5]. On the other hand, in an essential fingerprint identification structure the key value of fingerprint images should be compared with every pattern in the database, a process that becomes unreasonable time-consuming when dealing with enormously large databases. Consequently, it is essential to combine these technique with additional processing steps aimed at reducing the so-called database penetration rate. Fingerprint classification is single objective of the common accepted ways to accomplish [6] methods. Several classes of fingerprints are started and the input fingerprint images is classified aforementioned its identification. Then, it is evaluated only to the fingerprint patterns feel right to the expected class [1]. Conventionally, a proficient expert's manually tags every template fingerprint in the database. Then using this fingerprint patterns is classified is trained on the acquired labeled existing fingerprint image dataset with the endeavor of conveying to each input fingerprint the similar tag that was physically started for the corresponding pattern. This is a protracted and human-dependent process to focus on the classification robustness, which we characterize as the capacity of assigning the same class to different impressions of the same fingerprint, independently of the manual label.

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This enables the opportunity of additional increasing the presentation for fingerprints that reduce close to the frontier between classes. The overall fingerprint classification process is composed of two main steps [6]: feature extraction and the classification itself. First step is to capture image of the fingerprint is processed to remove meaningful features that can show the way to a high discernibility between the classes. These features are repeatedly characterized in the structure of a numeric vector [6]. Another step is the feature vector is used to perform the classification either by a set of fixed policy or by training a model in a supervised manner.

II. PROBLEM STATEMENT

Complex pattern recognition problem is still available in biometric authentication use by fingerprint identification system. So the major principle of the finger print recognition system is to extend a precise biometric technology. But few years' lot of algorithms tries to improve the accuracy of recognition system. An automatic and standardized finger print model is developed to get entails removing the minutiae elements from the processed fingerprint image and then comparing them with the existing accumulated fingerprint patterns in the database but minutiae extraction process is calculating the crossing number or the half of sum of differences between pair of pixels in an eight connected neighborhood pixels. The cross number pixels give an exceptional recognition for each finger print features. The recognized image removed details are then evaluated with the existing features in the databases and recognize palm print records for matching and details match the person is acknowledged. The fingerprint recognition make available a list of the closest matching fingerprint images from the existing database and the outcomes are confirmed to determine identification is made. It is complicated to design a complete and robust fingerprint recognition system particularly when dealing with poor quality fingerprint images. Fingerprint identification problem occur due to following challenges:

1. The high displacement and rotation which make a have common characteristics between the query and the template fingerprint image.
2. Different difficulty of fingertips
3. Different skin circumstances of fingertips
4. Non-linear distortion caused by finger plasticity.
5. Wounds and cutting in fingertips caused by hard worker people.

III. FINGERPRINT RECOGNITION SYSTEM

It is one of the physiological distinctiveness of a human for authenticating and identifying for a human has other distinctive features: i.e. face, ear print, iris and retina, palm print, vein map, voice, signature. But the fingerprints have become the most well-liked and extensively used because of their uniqueness better outcomes in recognition tasks.

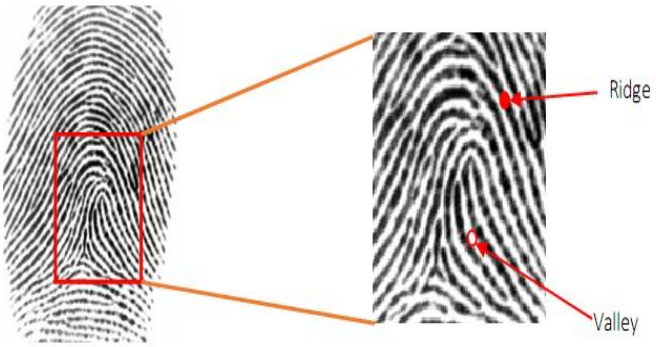

Figure: *Fingerprint image with marked ridge and valley.*

Fingerprints images need a set of pre-processing pace to improve their quality to find distinctive features. Usually pre-processing contains noise removing process, contrast enhancement and some morphological operations required [17, 18]. Human fingerprint is a black-white image where black lines called ridges and white called valleys. Union, intersection and other combinations of ridges produce distinguished feature of fingerprints i.e. minutiae's. Scientists recognize following minutiae (see Figure):

- Ridge ending - a place where the ridge line finishes.
- Ridge bifurcation - a place where the ridge divides into two new ridges.
- Lake - a valley inside a small closed boundary of ridges.
- Independent ridge - a small ridge line (bigger than an island).
- Island - a small ridge isolated by valleys.
- Spur - a small branch from the ridge.
- Crossover - an intersection of two ridges.

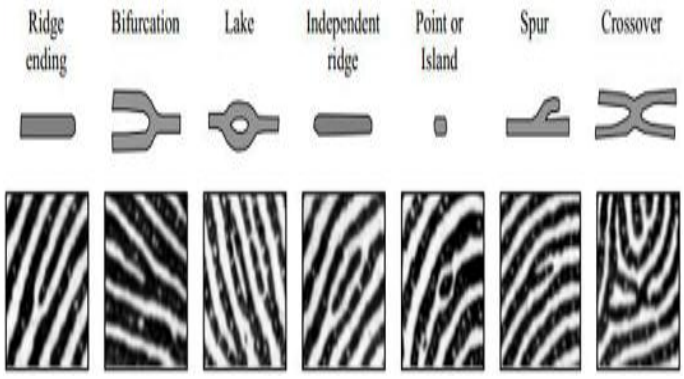

Figure: *The most common minutiae categories. Image is taken from [15].*

All distinctive features of a fingerprint can be divided into 3 main categories according to a level of details. See Figure.

- Level 1 (Global features). Defines singular points and the most important point of reference of ridges: arch, tented arch, left loop, right loop, and whorl.
- Level 2 (Local features). Defines minutiae's explained above.
- Level 3 (Fine details). Defines concrete details of ridges: width, shape, contours and sweat pores.

Level 2 and level 3 are used for fingerprint matching since they characterize individual unique fingerprints features to clearly understandable that level 3 features can be used only with very high-resolution images because of their size. The common scheme for fingerprint recognition is as follows: fingerprint image capturing, pre-processing, feature extraction, matching.

IV. FINGERPRINT MATCHING REGULARIZATION IN DEEP LEARNING ALGORITHMS

Simply, this algorithm returns a degree of correspondence pattern between two fingerprint images which is a number in a given interval (i.e. 0 to 1). There are mainly two classes of fingerprint matching algorithms: minutiae based and non-minutiae based [19]. There are also hybrid methods which are a combination of them [20, 21] and applied in a case when the quality of a fingerprint is not enough for matching. In turn, non-minutiae based class of algorithms can be divided into 4 categories: image based, ridge feature based, 3rd Level features based and feature-point based. Mainly minutia based algorithms which are logically divided in local minutiae matching methods and global minutiae matching methods.

Non-minutiae based approach: Image-based algorithms compare an input image and an image from a database to find a similarity between two of them. The weakest side of this way of matching is that it is extremely responsive to alignment and non-linear deformations. Ridge feature based techniques use ridge point of reference and ridge occurrence which describe topological information of ridge patterns to make fingerprint matching. From one side they solve a non-linear deformation problem of Image-based techniques but from another side, they have their own weakness ridge information for matching. People often use Level 3 features [19, 22] together with ridge features which add such ridge details as sweat pores and dots, ridge contours. But as it was mentioned before, to apply level 3 features we must have images of very high resolution. Feature-point based methods usually used for object recognition and image matching but some scientists use this approach for fingerprint matching as well.

Minutiae-based approach: The first stage of each minutiae-based matching algorithm is a minutiae extraction. Minutiae are presented by their spatial location coordinates and the angle of rotation. A minutiae of a given image is considered to be matched with minutiae of an image from a database. By tolerance box, we understand a permissible variation from both coordinates and direction of certain minutiae to compensate image distortions and limitations of minutiae extractors. Since in real-life tasks the correct alignment of two matched fingerprints is left unknown, it is obvious that they will vary in some way because of pose variations, scaling and physiological aspects. That is why to

reach the highest number of matched pairs of minutiae it is crucial to make rotational alignment, scaling and bias. As it was explained earlier, the minutia based techniques are classified as Local Minutiae Matching and Global Minutiae Matching.

- **Local Minutiae Matching** - These algorithms are taking into account confined arrangements of minutiae. By local structures, we should understand different relationships in groups of the closest minutiae. Such structures are invariant to global transformations of fingerprints which are undoubtedly the biggest advantage of using local matching. It also allows us to use only a part of information of a given fingerprint which is good for low-quality images and partial images which are usually not fully present in real-world tasks.
- **Global Minutiae Matching -** In opposite, these algorithms consider the set of minutiae's under the general scope. These are required to make a proper alignment and since nearby are three restrictions by which we should align (both coordinates and rotation) global matching may be computationally costly. Sometimes it is useful to apply so-called pre-alignment techniques which are based mainly on singular points and orientation maps to reduce the computing costs.

Recent years minutiae-based matching algorithms tend to local matching techniques because of their invariance to distortion, ease and low computational power required. **Convolution Neutral Network**: Convolution Neutral Network is also called as hierarchical neural network which modifies the convolutional layer with sub sampling layer. It has many other layers called.

1) Image processing layers.
2) Convolutional layers.
3) Max-pooling layers.
4) Classification layer.

Image Processing Layer: It is not obligatory preprocessing layer that has predefined filters which are reserved fixed in training process. To a certain extent than the unrefined effort the extra information can be making available to the network like edges, gradients. The contrast extracting layer improves the recognition rate.

Convolutional Layer: In this layer, here they found number of maps, skipping factors, kernel sizes and the association table. Each and every layer has maps of same size i.e. (Mx, My). Kernel is transferred over the suitable area of the input image. The pixels skipped by kernel in x and y direction is defined by skipping issues which are between the successive convolutions.

Max Pooling Layer: The main difference between the implementation and CNN is the use of maximum pooling layer instead of sub sampling layer. In this layer they leads to faster convergence, select better-quality invariant characteristics and recover simplification whereas the sub sampling layer hops the nearby pixels earlier to convolution as an alternative of pooling or averaging. Position invariance is permitted in max-pooling layer; it down illustrations the input fingerprint image by an aspect along each direction.

Classification Layer: In this layer convolutional filter max-pooling rectangles omitting features of kernel sizes are selected so that the output maps of the previous convolution layer are down illustration to 1 pixel per map, or an entirely connected layer unites the outputs of the highest convolution layer into a 1-Dimensional feature vector. One output unit per class label is joined with the top layer.

The drawbacks of existing system are:

- Accuracy is less.
- It takes the decimal value as whole value and process.
- All the ridges are not analyzed.

V. FEATURE EXTRACTORS AND CLASSIFIERS COMPARISON

In order to meaningfully evaluate the performance of the deep learning approaches studied in this paper, several other fingerprint classification techniques from the state-of-the-art will be tested. In particular, we selected the classifiers and feature extractors that obtained the best results in [25], selecting algorithms with a variety of different characteristics. A dynamic mask is applied for each class, producing a vector of size five. The orientations are also stored into the feature vector. Hong et al. [23] expand the FingerCode feature vector based on Gabor filters with the pseudo-ridges outlined from the midpoint of the fingerprint the number of singular points (cores and deltas) and the detachment and location between them. Liu's approach [24] extracts the singular points and builds a feature vector based on relative measures among them. Three general purpose classifiers will be applied to the vectors produced by the aforementioned feature extractors. Again, we selected classifiers with very different learning procedures so as to carry out a generic study:

• **SVM** [26]: the original feature space is mapped to a higher dimensional space by means of a kernel function to facilitate formulate it linearly separable. The separating hyper plane is computed by make best use of the boundary to the training instances in the target space.

• **Decision tree (C4.5)** [27]: classification rules are extracted by building a decision tree from the training set, which is built in a top-down approach. At each and every node of the tree are structured the attribute with maximum difference in entropy is used to split the data. C4.5 also involves a pruning procedure.

• **K-NN** [28]: the k nearest neighbors of a test instance is computed. Then, the most frequent class among these neighbors is returned for the test instance. Therefore, the distance metric and the assessment of k value strongly determine the behavior of this classifier.

VI. LITERATURE REVIEW

In [7] the performance of three models of image enhancement techniques was evaluated, and their impact in minutiae detection was compared. These minutiae detection techniques were: a) The Histogram Based Image Enhancement, b) The FFT filter Based Fingerprint Image Enhancement, and c) The Gabor filter Based Fingerprint Image Enhancement. These techniques were mainly very

much dissimilar in the method of enhancing the input image for minutiae detection. In this method they try to evaluate the performance of image enhancement algorithms using various minutiae extraction process in all the three cases with the assessment of a human observer. Using existing three methods, the Gabor filter based algorithm performed very well. It was performed 5 to 6 times better than the other two algorithms. Similarly, a comparative study between six different enhancement techniques was recommended in [8]. The first one was based on Histogram Equalization. The second one was based on 2D Fourier transform and Butterworth filter. The third one was based on Gabor filters. The forth one was based on Gabor filters combined with Wavelet transforms. The fifth one was based on directional filters. The last one was based on Laplacian-based pyramidal decomposition (LPD). They computed the peak signal-to-noise ratio and Equal Error Rate (EER) for all the testing algorithms. The result showed that the LPD method and Wavelet based enhancement have been given a slight better result. Another comparative study between three different enhancing algorithms was proposed in [9] to evaluate the effectiveness of fingerprint image enhancement. These algorithms included the use of FFT, smoothing on the spatial domain, and contextual filtering using Gabor filters. The result showed an improvement in enhancing reduced image quality fingerprint images in frequency domain. Although the FFT produced the best result in enhancing fingerprint images, it also introduced noise outside of the fingerprint representation as a side effect of the frequency domain process, which can be solved by using a better segmentation algorithm. The enhancement based on Gabor filters worked well in good and recoverable region of fingerprint image, but it leaved empty blocks in unrecoverable regions. Algorithms based on only the spatial domain could not enhance minutiae details in existing images. A three-stage enhancement algorithm was proposed in [10] to improve the feature of fingerprint images. The first-stage performed diffusion filter on the computed orientation field to connect broken ridges. Although it connected the broken ridges, it reduced the contrast of the image and failed to separate the falsely conglutinated ridges. In the second stage, filtering was applied to the enhanced image to remove the smears and scars, to separate the falsely ridges, and to improve the contrast of the image. Although the second stage overcomes the constraints of the first-stage, it produced black borders and created false minutiae in the enhanced image. In the third-stage, an angular filter was applied to defeat the inadequacy's of the second-stage, and this enhanced the low-quality fingerprint images to a large extent. The drawback of this solution is the complexity of its procedures, which needs to compute several pre-processing techniques in addition to their main process, such as normalization, orientation field estimation. Geometric distortion significantly reduces the match score value. These features prevent malicious users from hiding their identity, as well as reduce the inconvenience of using identification systems in authentication tasks. In this paper [11], here they try to extend existing work by a new rectification model based on a Deep Convolutional Neural Network (DCNN) to find accurate approximation distortion parameters from the input image. The experimental results shows that wide-ranging database of synthetic distorted models, the DCNN become skilled at precisely calculate approximately distortion bases ten times faster than the dictionary search techniques used to shown that the DCNN can estimate the non-linear distortions of samples more accurately from existing method. In view of the fact that the finger pore extraction method is a vital step for AFRS high precision is essential for extraction process. Adaptive pore extraction, it is difficult problem to remove the finger pore information in the approved manner for the reason that the finger pore character depends on the human being, area, and finger pore category. To solve such kind of difficulty have accessible [12] a pore extraction technique using Deep CNN and pore intensity alteration. The deep networks are utilized to become aware of pores in aspect using a huge region of a fingerprint image. They try to improve the finger pore information by discovering local maxima to recognize finger pores with unusual intensities in the fingerprint image. Finally the experimental results show that their finger pore extraction technique achieves enhanced than the state-of-the-art methods. In this paper [13] author has to present a CNN was used to differentiate the real and counterfeit fingerprint is significant for safety measures reason essentially for the apprehension of fingerprint protection in authentication arrangement. Using Ploy-Doh, silicon or other artifacts methods are used for constructing the counterfeit fingerprints. Using this fingerprint images but it is not rewarding the real world application problem. Using this CNN method they are providing the better optimization procedure for both feature extraction and classifier training. Local binary pattern and minutiae extractions are utilized as a quality descriptor. Using these texture descriptors is utilized to recognize the correctness in the fingerprint image. Local binary pattern is making use of to alter the grey scale image into a binary image. Using this technique it will check the accuracy of the fingerprint images based on the 3x3 matrices model. Minutiae check the ridge and bifurcation by subsequent the procedure of binarization and thinning process. Afterward the fusion algorithm is utilized to combine both LBP and minutiae. This model produces the good accuracy on training sets. No task specific hand engineered technique was used. The pre trained networks showed the stronger generalization capabilities in data sets. The histogram equalization technique was used to improve the correctness of the images. This paper mainly focuses on how to apply CNN [14] to the research field of fingerprint liveness detection for fingerprint images is paying attention on the structure of composite handcrafted characteristics but these techniques generally devastate or be unable to find spatial information between pixels. Various method has use convolutional neural network (CNN) can produce high-level semantic demonstrations by learning and concatenating low-level edge and shape features from a huge amount of labeled information. Consequently, CNN is discovered to resolve the exceeding setback and distinguish accurate fingerprints from fake individuals. Here author has reflected that the convolutional process is observed as procedure of feature extraction. Therefore, the extracted features based on CNN are fed into SVM classifier. PCA technique is also utilized to decrease the dimensionality structure of feature maps after each convolutional or pooling operation. Moreover, ROI preprocessing operation has been implemented in this paper to get rid of the impact of anomalous region. Using

above mentioned process they are utilized at high-level semantic features of fingerprint images without any human intervention to find out from basic preprocessing step of fingerprints images and then these feature extracted from using SVM classifier. In this paper [16], here author has to present the new geometric distortion crisis of fingerprint recognition structures by proposing a quick and efficient distortion estimator which confines the non- linear properties of geometric distortion of fingerprints. While in recent times various recommended techniques hold distortion using a glossary of indistinct patterns for this effort here they utilize a DCNN to calculate approximately the principal distortion parts of input samples. Our approach has the following contributions:

- There is no need to estimate the ridge frequency and orientation maps of input fingerprints.
- Distortion parameters are being calculated approximately continuously to accomplish extra precise alterations.
- A notable decrease in rectification time due to embedding distortion patterns in network considerations.

VII. Conclusion

The key objective of this research review work is to find better fingerprint matching technique to find accurate value. The reliability of automatic biometric recognition system robustly relies on the precision acquired in the minutia extraction procedure. The features extracted in the feature extraction process helps us to perform pattern matching process with existing fingerprint images this matching process is based on the Matchscore value. The best matchscore value is selected based on the threshold. If the match score value is higher than the specified threshold values, then the fingerprint belongs to the same person otherwise it belongs to different person. The fingerprint images from the crime scene can also be taken and using different classifier it can used to identify which person fingerprint. As a final point of attraction the algorithm was estimated to be better accuracy.

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