A Neural Network Based Analysis of Altered Fingerprints

P. Archana Lal

Abstract--- A fingerprint is an impression or mark made on a surface by a person's fingertip, able to be used for identifying individuals from the unique pattern of whorls and lines on the fingertips. Law enforcement have been using fingerprints to identify criminals from the latent impressions left behind at crime scenes. But some criminals escape from the cases by physically deforming their prints. With existing software, which searches through millions of fingerprints, spotting anomalies can be nearly impossible. Neural network is a nonlinear mapping system whose structure is loosely based on principles of real brain. The ability of the ANN to learn given patterns makes them suitable for applications like Fingerprint recognition. ANN can play a critical role. An ANN can be configured and trained to handle such variations observed in the texture of the fingerprint. The problem of automatic detection of alterations based on analyzing ridge orientation field and minutiae distribution is proposed here. Demonstration has been made in the MATLAB background. In the task of fingerprint recognition, the experiments conducted on various fingerprint images shows enhancement of performance

Keywords--- Altered Fingerprints, Minutiae, Orientation Field, ANN, MATLAB

I. INTRODUCTION

A fingerprint pattern will remain unchanged for the life of an individual. However, the print itself may change due to permanent scars and diseases. Fingerprints have general characteristic ridge patterns that allow them to be systematically identified. Dactyloscopy is the study of fingerprint identification. It is the process of comparing two instances of friction ridge skin impressions from human fingers or toes, or even the palm of the hand or sole of the foot, to determine whether these impressions could have come from the same individual

The Automated Fingerprint Identification System (AFIS) is a computerized system capable of reading, classifying, matching, and storing fingerprints for criminal justice agencies. Fingerprint alteration is a serious attack on Automated Fingerprint Identification Systems (AFIS) since it can reduce the similarity between fingerprint impressions from the same finger due to the loss of genuine minutiae, increase in spurious minutiae and distortion in spatial distribution of the minutiae. Orientation field describes the ridge flow of fingerprints. Good quality fingerprints have a smooth orientation field except near the singular points. A minutia in the fingerprint indicates ridge characteristics such as ridge ending or ridge bifurcation

Fig .1: An Image of a Fingerprint Created by the Friction Ridge Structure

II. FINGERPRINT ALTERATION

A fingerprint is the reproduction of a fingertip epidermis, produced when a finger is pressed against a smooth surface. The most evident structural characteristic of a fingerprint is a pattern of interleaved ridges and valleys; in a fingerprint

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image, ridges (also called ridge lines) are dark whereas valleys are bright. Ridges and valleys often run in parallel; sometimes they bifurcate and sometimes they terminate, of course, the simplest way for criminals to avoid leaving identifiable fingerprints is by wearing gloves Some criminals have actually deformed their fingerprints by surgery, burning, or the application of acid in an attempt to destroy the papillary ridges so law enforcement can't identify the criminals by their fingerprints. . Individuals will often cut a "Z" shape into their hands, burn it with acid, or even swap with another person. Altered fingerprints are different from fake fingerprints. Unlike normal prints, altered fingers have abrupt, discontinued lines which usually contain a high number of minutiae points.

In order to detect attacks based on fake fingers, many software and hardware solutions have been proposed. However, the problem of altered fingerprints has hitherto not been studied in the literature and there are no reported techniques to identify them. Furthermore, the lack of public databases comprised of altered fingerprint images has stymied research in this area. One of the goals of this paper is to highlight the importance of the problem, analyze altered fingerprints, and propose an automatic detection algorithm for them.

A. Types of altered fingerprints

The altered fingerprints can be divided into 3 types:

a. Obliteration
b. Distortion
c. Imitation

a. Obliteration

Friction ridge patterns on fingertips can be obliterated by abrading, cutting, burning, applying strong chemicals, and transplanting smooth skin. Further factors such as skin disease (such as leprosy) and side effects of a cancer drug can also obliterate fingerprints. Friction ridge structure is barely visible within the obliterated region

b. Distortion

Friction ridge patterns on fingertips can be turned into unnatural ridge patterns by removing portions of skin from a fingertip and either grafting them back in different positions or replacing them with friction ridge skin from the palm or sole. Distorted fingerprints have unusual ridge patterns which are not found in natural fingerprints. These abnormalities include abnormal spatial distribution of singular points or abrupt changes in orientation field along the scars

c. Imitation

Friction ridge patterns on fingertips can still preserve fingerprint-like pattern after an elaborate procedure of fingerprint alteration: 1) a portion of skin is removed and the remaining skin is pulled and stitched together, 2) Friction ridge skin from other parts of the body is used to fill the removed part of the fingertip to reconcile with the remaining ridge structure, or 3) transplantation of the entire fingertip. simply swapping the skin on fingertips between the left and right hands

Obliterated fingerprints can evade fingerprint quality control software, depending on the area of the damage. Distorted fingerprints can also successfully pass the fingerprint quality test since their local ridge structure remains similar to natural fingerprints while their global ridge pattern is abnormal. Imitated fingerprints can not only successfully pass the fingerprint quality assessment software; they can also confound human examiners.

B. Fingerprint processing

The image processing is a visual task, starting from obtaining an image i.e. image acquisition then enhancement and finally to process. Image pre-processing stage is to increase both the accuracy and the interpretability of the digital data during the image processing stage.

The main steps for pre-processing include image enhancement, binarization, fourier transform, and segmentation.

Image enhancement: Image enhancement is basically improving the digital image quality. The histogram in the context of image processing is the operation by which the occurrences of each intensity value in the image is shown and Histogram equalization is done for distribution of the intensities of the image of the entire range of possible intensities.

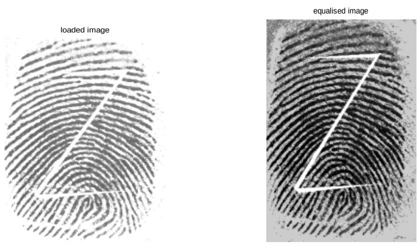


Fig. 2: Histogram Enhancement Original Image(Left) Enhanced Image (Right)

Fourier transform: The image was divided into small processing blocks (32*32 pixels) & fourier transform was performed .In order to enhance a specific block by its dominant frequencies, the FFT of the block was multiplied by its magnitude a set of times. The enhanced image after FFT has the improvements to connect some falsely broken points on ridges and to remove some spurious connections between ridges.

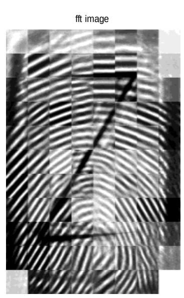


Fig. 3: Fingerprint Enhancement by FFT

Fig. 4: Binarized Image

Binarization: Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white.

Region of interest:. The image area without effective ridges and furrows is first discarded since it only holds background information. Then the bound of the remaining effective area is sketched out since the minutia in the bound region is confusing with those spurious minutias that are generated when the ridges are out of the sensor. To extract the ROI, a two-step method is used. The first step is block direction estimation and direction variety check, while the second is intrigued from some Morphological methods

Local orientation direction: Orientation field describes the ridge flow of fingerprints and is defined as the local ridge orientation in the range 0 to pi. A fingerprint is thus defined by the uniqueness of the local ridge characteristics and their relationships.

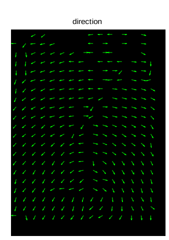


Fig. 5: Orientation Direction

Minutiae extraction: Minutiae points are the local ridge characteristics that occur either at a ridge ending or a ridge bifurcation. A ridge ending is defined as the point where the ridge ends abruptly and the ridge bifurcation is the point where the ridge splits into two or more branches. Automatic minutiae detection becomes a difficult task in low quality fingerprint images where noise and contrast deficiency result in pixel configurations similar to that of minutiae. This is an important aspect that has been taken into consideration in this project for extraction of the minutiae with a minimum error in a particular location

Artificial neural network: Neural network is a nonlinear mapping system whose structure is loosely based on principles of the real brain. The whole network is build up with simple processing units. Of the different types of the neural networks, we are using only so called feed forward neural networks. The neurons are structured in layers and connections are drawn only from the previous layer to the next one.

III. PROCEDURE

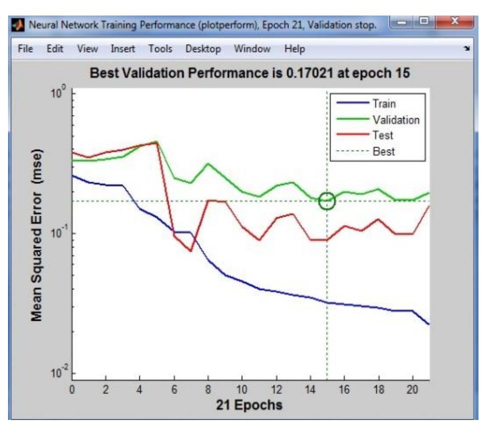
After completing the enhancement and segmentation process now our job is to extract the minutia of the fingerprint image. Then the orientation field direction is estimated. Using both the feature vectors, neural network should be trained.. Extracted features of all the images in the data set are the input of the neural network. With the help of these inputs the network has been trained and the network should be trained till then we get the minimum MSE value so that the desired number of true results can be obtained. Retrain the network at least twenty times. For training the network, MATLAB neural network toolbox can be used. Testing is the final step of the work. To test or recognize the fingerprint, first take any image from the data set and fed that image to the trained network then it gives the result by showing whether it matches to the given condition or not

A. *Algorithm*

- Initially read the first image from the database, and train that image by applying histogram equalization, Fast Fourier transforms by dividing the image into small processing blocks (32 by 32 pixels) and perform thresholding techniques
- To enhance a specific block by its dominant frequencies, multiply the FFT of the block by its magnitude a set of times. Get the enhanced block accordingly.
- Extract the Region of interest
- Orientation direction is estimated & minutiae are extracted
- Repeat steps 1-4 on rest of the image. Generate and Store the statistical value after training.
- Give a fingerprint image from outside, in testing phase and repeat steps 1-4 on that image.
- Generate the statistical value out of that image.
- Compare both trained and Testing phase's statistical values
- Generate a report and display the case as belonging to altered or non altered, for any of the case.

The trained neural network can now be tested with the testing samples This will give us a sense of how well the network will do when applied to data from the real world.

To see how the network's performance improved during training, we can either click the "Performance" button in the training tool, or call PLOTPERFORM. Performance is measured in terms of mean squared error, and shown in log scale. Performance is shown for each of the training, validation and test sets. The version of the network that did best on the validation set is was after training It rapidly decreased as the network was trained. Validation performance curve is a plot of mean squared error against number of epochs. It gives an idea on the value of epoch at which the validation stops

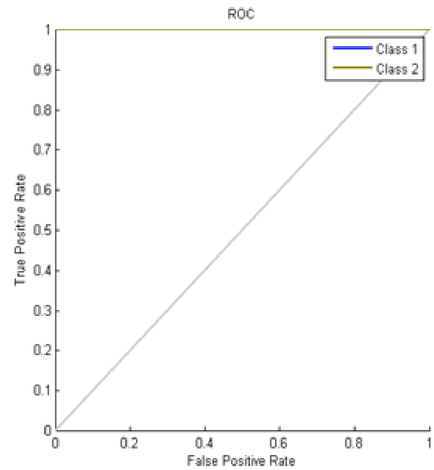


One measure of how well the neural network has fit the data is the confusion plot. Here the confusion matrix is plotted across all samples. The confusion matrix shows the percentages of correct and incorrect classifications. Correct classifications are the green squares on the matrices diagonal. Incorrect classifications form the red squares.

If the network has learned to classify properly, the percentages in the red squares should be very small, indicating few misclassifications.

Fig. 6: Performance Plot of an Altered Image

Another measure of how well the neural network has fit data is the receiver operating characteristic plot. This shows how the false positive and true positive rates relate as the thresholding of outputs is varied from 0 to 1.The farther left and up the line is, the fewer false positives need to be accepted in order to get a high true positive rate. The best classifiers will have a line going from the bottom left corner, to the top left corner, to the top right corner, or close to that



IV. Conclusion

The success of automated fingerprint identification systems has prompted some criminals to take extreme measures to evade identification by altering their fingerprints. It is necessary to develop a method that can automatically detect altered fingerprints. Available fingerprint quality control software modules were not designed to distinguish altered from natural fingerprints.

We have developed an algorithm to automatically detect altered fingerprints. The underlying idea is that altered fingerprints often show unusual ridge patterns.

A set of features is extracted from the ridge orientation field and minutiae, then a classifier is used to classify the fingerprint as natural or altered.

V. Future Works

The success of automated Neural network enable solutions to be found to problems where algorithmic methods are too computationally intensive or do not exist.The problem of feature extraction and classification seems to be a suitable application for neural nets.They offer significant speed advantages over conventional techniques.we can also use minutiae features along with orientation field for detection of various types of altered fingerprints.

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