International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Study of Altered Fingerprint Detection Using Artificial Neural Network

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Abstract: ***Fingerprint Identification has been the most widely used measure for biometric identification. But as there have been techniques to counter every technology, altered fingerprinting has also emerged as the way to counter the AFIS which is a system to identify the fingerprints. The currently used fingerprint quality assessment software is unable to detect most of the altered fingerprints since the image quality does not always degrade due to alteration. This paper discusses: 1) Types of fingerprint alterations 2) Techniques for detection of altered fingerprints 3) Implementation of artificial neural network in fingerprint identification 4) Minutiae extraction using neural network. The use of the suggested techniques can help to mitigate the incidents of altered fingerprints and can detect them to an increased extent.***

Keywords: Obliteration, Distortion, Imitation, Binarization, Skeletonization, Artificial Neural Network, Back Propagation, Minutiae, Scar, Ridge.

1. Introduction

Law enforcement agencies have been using Fingerprint Identification technique for biometric recognition. But due to successful utilization of this system, there have been extreme activities to circumvent this system. One of such activities is altered fingerprinting. Altered fingerprints are different from fake fingerprints. These are prints of real fingers that are used to hide one's identity in order to escape identification by a biometric system. This phenomenon is referred to as biometric obfuscation. This has been a prime center for concern for many because fingerprint alteration is much easier than alterations of other biometric trait. The characteristics of fingers whose proper analysis can help to identify the aforementioned alterations include: 1) Orientation field 2) Minutiae extraction 3) Ridge discontinuity 4) Scars. This paper includes the overview of these characteristics. Also, one of these characteristics can be associated with artificial neural networks. Hence, the use of neural networks in fingerprint identification and consequently in detection of altered fingerprint along with the implementation of back-propagation algorithm is briefly discussed.

2. Types of Fingerprint Alterations

On the basis of the ridge patterns observed in fingerprint samples, we can categorize the alterations into two main characteristics:

2.1 Obliteration

Obliteration [2] refers to the complete destruction or wiping out of something. The obliteration of fingerprints can be caused due to various factors such as skin-burns, chemical action, cuts, abrasion, etc. In obliteration, the friction ridge structure is completely destroyed and it is comparatively much easier to perform. Yet, obliterated fingerprints can be matched by AFIS to the original prints if the area of obliteration is small; but this will not happen in case of largely affected area.

Figure 1: Obliteration

2.2 Distortion

Distortion [2] can be referred to as being out of order. The friction ridge pattern on the fingers can be distorted by replacing a particular area on the skin with skin from a different area, either from palm or sole. For instance, a particular small portion of skin on finger can be removed and can be replaced with the skin from a different region. This can change the ridge structure drastically. It should be noted that this doesn't affect the local ridge structure due to which it can pass the fingerprint test but the overall structure is affected drastically.

Figure 2: Distortion

2.3 Imitation

Imitation [2] refers to the action of giving the same look as original. In distortion, the global friction ridge pattern gets abruptly changed on a global level. In distortion, the friction ridge patterns on fingertips can retain their fingerprint-like pattern even after the process of fingerprint alteration. Imitation can be done in two ways – 1) a particular part of the skin is peeled off and the remaining skin is pulled together and stitched or 2) skin from other part of the body can be used to replace the peeled off skin

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Figure 3: Imitation

3. Automatic Detection of Altered Fingerprint

In this section, we consider the problem of automatic detection of alterations based on analyzing orientation field, minutiae distribution, ridge discontinuity and scars.

3.1 Analysis of Orientation Field

Orientation [2] field describes the ridge pattern and its flow in fingerprints. The cleaner fingerprints have a smooth orientation field except near the singular points like core and delta. Orientation field flow curves (OFFC) are generated based on the observed orientation field. There are two advantages of using OFFCs for fingerprint classification: (i) breaks and discontinuities in the OFCCs are avoided, and (ii) the OFFCs are free from small scale ridge oscillations. After the generation of OFFC, labeling of each OFFC is done into the four classes: left- and right-loops, whorl and arch and then an overall classification of the fingerprint image is made into one of the four classes based on syntactic rules.

3.2 Minutiae Distortion

A minutia [2] in the fingerprint indicates ridge characteristics such as ridge ending or ridge bifurcation. For instance, if there is a scar is encountered then a large number of ridge endings are generated. These tend to form clusters in the altered region as observed in the fingerprints, while the natural minutiae are distributed uniformly. Hence, this helps in detection of altered fingerprints. First of all enhancement of fingerprint is done for directional smoothening of ridges. Secondly, image Binarization is a process which transforms the 8bit gray image to a 1-bit image with 0-value for ridges and 1 value for furrows. In a 3 x 3 window, if the central pixel is 0 and has exactly 3 neighbors with zero-values, then the central pixel is a ridge bifurcation. If it has only one zero-neighbor, then the central pixel is a ridge ending.

3.3 Ridge Discontinuity

Ridge orientation [3] of altered fingerprint is discontinuous in the altered region. This is referred to as ridge discontinuity. Ridges are also discontinuous at the boundary of the altered region in case of distortion and imitation. As discussed in the first part, the orientation field is computed. After finding the ridge orientation field, the altered image is enhanced by FFT. After this, the ridge orientation field of the FFT enhanced image is obtained. The difference between observed orientation field and orientation field of FFT enhanced image gives the orientation discontinuity map or error map.

3.4 Analysis of Scars

Long cuts, absence of ridges and valleys can be referred to as scars. [3] Scars often appear along the cuts on the ridges and it gives important information about alteration. Scar is present in obliteration and distortion type of alteration. The scar in the distortion alteration should cover a comparatively smaller area than obliteration type of alteration. First and foremost, we need to perform normalization of the fingerprint image. The averaging filter preserves the sharp edges in the image. Thus the second step is that the image is convolved with average filter in the spatial domain to accentuate the present scars. After this, thresholding is done for segmenting the scars from the filtered fingerprint image.

4. Altered Fingerprint Identification using Artificial Neural Network

The fingerprint identification using artificial neural network is divided into main three stages:

Preprocessing stage
Preprocessing stage involves enhancement of image by using histogram equlization, binarization and morphological operations after applying this enhancement algorithm a binarized thinned image has been obtained.

Post processing stage
In this stage, minutiae are extracted from the enhanced fingerprint by using the optimization technique

Final minutiae matching stage
This stage is the recognition of the fingerprint which has been done with the help of neural network.

We can achieve more fruitful results from this technique if we associate the Neural Networks along with the Genetic Algorithm. After acquiring the fingerprint image, the contrast of the image is adjusted by changing the intensities of the various modules of the image for obtaining a uniform histogram. The further enhancement of the image is discussed below.

4.1 Histogram Equalization

This is the first step which is used for the image enhancement process [3] . It basically performs the intensity adjustment processes to manipulate the contrast of the image. This method is used to adjust the pixel intensities of the acquired fingerprint image to enhance the contrast of the image. As a result of this adjustment, the intensities can be better distributed on the histogram, which is the main aim of equalization. This allows the lower contrast region of the fingerprint image to gain a higher contrast

4.2 Binarizaiton

The operation that converts the gray scale image into binary image is known as Binarization. It is used to transform 8-bit gray fingerprint image into 1-bit image with 0 values for ridges and 1 value for furrows.[3]

4.3 Morphological Erosion

Morphological techniques are used as pre-processing and post-processing such as filtering and thinning. There are two fundamental morphological operations, dilation and erosion, in terms of union (or intersection) of an image with a translated shape (structuring element).[3]

4.4 Morphological Thinning

The final enhancement method prior the minutiae extraction is thinning. Thinning is a morphological operation that erodes the pixels. Thinned image helps minutiae extraction. The thinning of the image is to reduce the ridges till the ridges one pixel wide. [3]

5. Role of Artificial Neural Network in Altered Fingerprint Detection

One of the important steps involved in altered fingerprint detection is Minutiae extraction. The extracted minutiae can be broadly classified in following categories:

- Termination
- Bifurcation

The binarized image obtained during fingerprint recognition using Genetic algorithm and Arificial Neural Network plays a very important role in detecting fingerprint alterations using artificial meural network [4] . The bianrized image can be further skeletonized. Skeltonization represents the binarized image into 1 pixel wide lines form, forming a skeleton of image. This will help in preserving the minutiae using the least amount of details. The minutiae extraction process is performed on skeleton of the image. The extracted details can be given as an input to the artificial neural network. The neural network is then trained to classify the extracted minutiae into one of the two categories mentioned above. One of the well known algorithms used to train the artificial neural network is Back Propagation [5]. Once the neural network is trained it is then examined against unknown skeleton image so that it is able to give appropriate results. Thus the task of applying neural network in altered fingerprint detection is accomplished.

6. Conclusion

The problem of fingerprint alteration is quite different from fingerprint spoofing. While the latter has received substantial attention and concern, the former has not been addressed in the biometric literature despite of numerous incidents of alteration for escaping from the identification process. Hence, the various steps applied for identifying altered fingerprints help to detect the hidden identity are elaborated. Also, the extension of Artificial Neural Networks in the fingerprint identification and consequently altered fingerprint detection is discussed. Also the use of genetic algorithm to associate with the artificial neural network is introduced.

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