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Off-line Signature Verification Using Artificial Neural Network & Error Detection

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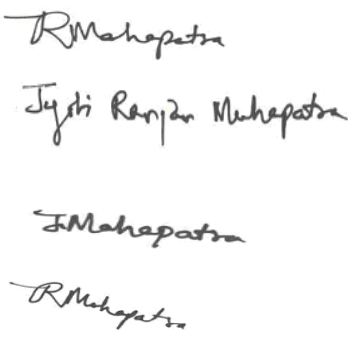
***Abstract*— This paper off-line signature verification and classification using a new approach that depends on a artificial neural network and Euclidean distance model which discriminate between two classes (i) genuine and (ii) forgery signature. The proposed system is based on the technique that includes pre-processing on the signature, weighted feature point extraction and neural network training and finally verifies the authenticity of the signature using trained neural network & error detection methodology. The objective of the proposed scheme is to reduce two vital parameters False Acceptance Rate (FAR) and False Rejection Rate (FRR). That means results are expressed in terms of FAR and FRR. The Proposed technique give more efficient result than most of the existing techniques.**

***Keywords*— Preprocessing, Feature extraction, Neural network, Ecludian Distance Model, FAR (False Acceptance Rate), FRR (False Rejection Rate).**

Introduction

Signature verification is one of the Biometric system which is based on non-vision. Signature verification recognition is an important research area in the field of authentication & authorization. The recognition of human handwriting is important concerning about the improvement of the interface between human beings and computers. If the computer is intelligent enough to understand human handwriting it will provide a more attractive and economic man-computer interface [5]. Approaches to signature verification fall into two categories according to the acquisition of the data: On-line and Off-line. Online data records the motion of the stylus while the signature is produced, and includes location, and possibly velocity, acceleration and pen pressure, as functions of time [4]. Online systems use this information captured during acquisition. These dynamic characteristics are specific to each individual and sufficiently stable as well as repetitive. Off-line data is a 2-D image of the signature. Processing Off-line is complex due to the absence of stable dynamic characteristics. Difficulty also lies in the fact that it is hard to segment signature strokes due to highly stylish and unconventional writing styles. The non-repetitive nature of variation of the signatures, because of age, illness, geographic location and perhaps to some extent the emotional state of the person, accentuates the problem. All these coupled together cause large intra-personal variation. A robust system has to be designed which should not only be able to consider these factors but also detect various types of forgeries. In this area signature is a special case that provides secure means for authentication, attestation authorization in many high security environment. The objective of the signature verification system is to discriminate between two classes: the original and the forgery, which are related to intra and interpersonal variability. The variation among signatures of same person is called Intra Personal Variation. The variation between originals and forgeries is called Inter Personal Variation [4].Problems of signature verification are addressed by taking into account three different types of forgeries: random forgeries, produced without knowing either the name of the signer nor the shape of its signature; simple forgeries, produced knowing the name of the signer but without having an example of his signature; and skilled forgeries, produced by people who, after studying an original instance of the signature, attempt to imitate it as closely as possible. Clearly, the problem of signature verification becomes more and more difficult when passing from random to simple and skilled forgeries, the latter being so difficult a task that even human beings make errors in several cases. The method takes care of simple and random forgeries and the skilled forgeries are also eliminated in greater extent. The threshold used in the proposed technique can be dynamically changed according to the target application. Basically, the threshold here is the security level which the user can input as per his requirement. The objective of the work is to reduce two vital parameters, False Acceptance Rate (FAR) and False Rejection Rate (FRR). So the results are expressed in terms of FAR and FRR and subsequently comparative analysis has been made with standard existing techniques. Results obtained by our proposed algorithm will more efficient than most of the existing techniques [8].



(a) Original Signature

(b) Random Forgery

(c) Simple Forgery

(d) Skilled Forgery

Fig. (i) : Types of Forgery

SIGNATURE IMAGE DATABASE

This research has been conducted using the "GPDS300signature database" offered for those doing research in the field of signature recognition at the Universidad de Las Palmas de Gran Canaria, Spain [7].

PROPOSED SYSTEM

Any signature verification process consist of pre-processing on signature to get standard image. It is necessary to pre-process on signature because it helps to verify a signature correctly. Proposed system consists of following steps:

A. Signature Image Pre-processing
B. Weighted Feature Point Extraction
C. Neural Network Training & Error Detection
D. Testing
E. Recognition

Signature Image Pre-processing: Proposed system verify signature in off-line mode so acquire signature made on paper and then scan it. The scanned image then fed to pre-processing phase. Fig(ii) is the sample scanned signature image. To verify signature correctly, pre-processing phase is required. After signature acquisition, image may contain noise (extra pen dots), blurriness. It is necessary to remove these extra pixel or blurriness. Noise can be removed by using median filter. The pre-processing stage includes five steps: Gray Scale, Threshold and invert, Thinning, Boundary Detection and Auto cropping [5].

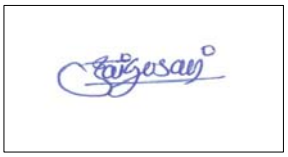


Fig. (ii) : Sample Signature

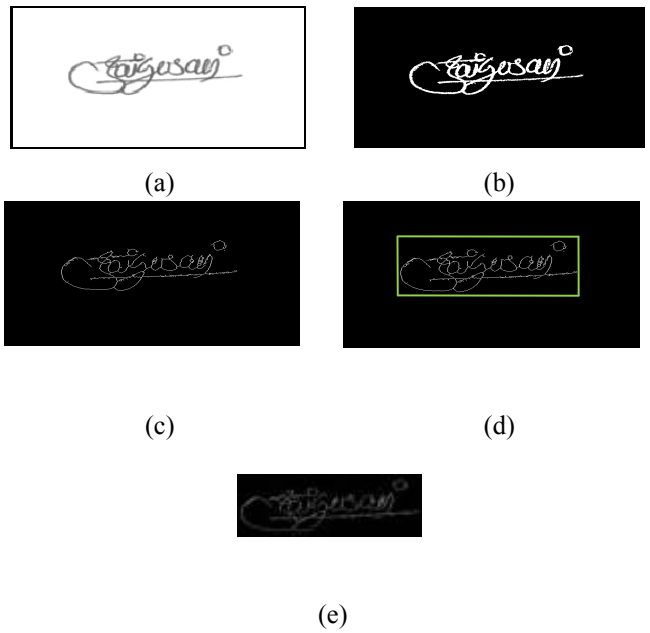


Fig. (iii) : (a) Gray scale (b) Threshold and invert (c) Thinning (d) Boundary Detection (e) Cropping [5]

(a) Gray Scale

In signature verification, scanned image is converted in gray scale. It also called as monochromatic image in which each pixel carries only intensity information.

(b) Threshold and invert

Thresholding is the method of converting gray scale image to binary image. i.e. image with only black or white colours. Threshold image is used for feature extraction.

(c) Thinning

Thinning eliminate the thickness differences of pen Due to the nature of variation of the signatures, because of age, illness, geographic location etc. by making the image one pixel thick.

(d) Boundary Detection

It helps to get scanned image with necessary part of signature.

(e) Cropping

Cropping is the method of removing outer part of an image to get well bordered thin image. This image is ready for feature extraction [5].

Feature Extraction: This is the most important phase in any signature verification system since it is the key to identifying and differentiating a user's signature from another. Features extracted in proposed system are based on geometric centre of signature image. Geometric features are based on dimensions of the signature image, shape and depth of signature image. Here geometric features are based on two set of points in 2 dimensional planes. The vertical splitting of the image results thirty features points (v1,v2,v3,……,v30) and the horizontal splitting results thirty features points (h1,h2,h3,……,h30) [2]. Geometric centre of image split image in two halve left and right portion of image. Then again find out geometric centre of left and right part of image and calculate the total number of black pixel. Then divide the two parts in four parts with respect to the black pixel. This process gives 30 features in vertical splitting and 30 features in horizontal splitting.

Horizontal splitting of signature image: Horizontal feature points give thirty feature points by splitting image horizontally w. r. t. geometric centre point (h0). Here the geometric centre plays important role. After finding geometric centre of signature image, split the image with horizontal line passing through the geometric centre (h0). Splitting gives two part top and bottom. Find geometric centre point of top and bottom portion say h1 and h2 correspondingly. Split the top and bottom portion with vertical lines through h1 and h2 to divide the two parts into four parts: Left-top, Right-top and Left-bottom, Right bottom parts from which we obtain h3, h4 and h5, h6. We again split each part of the image through their geometric centers to obtain feature points h7, h8, h9,…, h13, h14. Then we split each of the parts once again to obtain all the thirty vertical feature points (as shown in Fig. (iv) [2]).

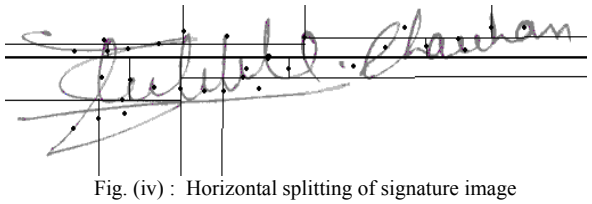


Fig. (iv) : Horizontal splitting of signature image

Vertical splitting of signature image: Vertical feature points give thirty feature points by splitting image vertically w. r. t. geometric centre point (v0). After finding geometric centre of signature image, split the image with vertical line passing through the geometric centre (v0). Splitting gives two part left and right. Find geometric centers v1 and v2 for left and right parts correspondingly. Split the left and right part with horizontal lines through v1 and v2 to divide the two parts into four parts: Top-left, Bottom-left and Top-right, Bottom right parts from which we obtain v3, v4 and v5, v6. Again split each part of the image through their geometric centers to obtain feature points v7, v8, v9,….,v13, v14. Then split each of the parts once again to obtain all the thirty vertical feature points (as shown in Fig. (v) [2]).

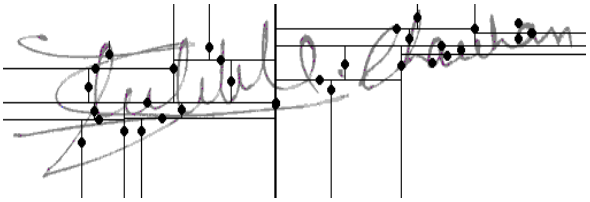


Fig. (v) : Vertical splitting of signature image

Neural Network Training& Error Detection: original signature's extracted 60 features points. Among 60 features points, first 12 feature point fed to neural network using back propagation algorithm and 48 features points are used to find error rate using Euclidean Distance Model.

Testing: The signature to be tested is firstly go through pre-processing. After pre-processing feature extraction is performed to obtain 60 feature points. First 12 feature points are then fed to trained neural network using multiple layer feed forward algorithm and remaining used to find difference.

Recognition: In proposed system, we get total 60 features based on vertical splitting and horizontal splitting. These features helps to classify signature is original or fake. Here geometric centre plays vital role to obtain features. So we use Euclidean distance model for classification. This model states that distance between a pair of feature points. Following Eq. 1 is used to find out distance between pair of feature points. Let V (v1, v2, v3,…., v30) and H (h1,h2,h3,…..,h30) are two set of features points based on vertical and horizontal features point respectively. Here x and y is horizontal and vertical coordinator of pixel [5].

$$\text{Distance (d)} = \sqrt{(y_2 - y_1)^2 + (x_2 - x_1)^2} * \text{Depth}$$

$$\text{Total Error} = \sum d \qquad (1)$$

Calculate weighted average by multiplying with depth of feature point. Here in proposed system depth is set to maximum 4 i.e. geometric centers calculate upto depth 4 in horizontal and vertical splitting. This calculated average will help to classify the signature. Let d1, d2, d3 & d4 are distances calculated by Euclidean distance model based on depth. Individual weighted average (wa) is calculated for horizontal splitting and vertical splitting. Weighted distance average is given by following Eq. 2.

$$\text{Weighted Average (wa)} = d1*4+d2*3+d3*2+d4*1 \qquad (2)$$

PERFORMANCE EVALUATION

False Acceptance Rate (FAR) and False Rejection Rate (FRR) are the two parameters used for measuring performance of any signature verification method. FAR and FRR are calculated by the equations given below:

False Acceptance Rate (FAR): False acceptance ratio is the total number of fake signature accepted by the system with respect to the total number of comparison made.

$$\text{FAR} = \frac{\textit{Number of forgeries accepted}}{\textit{Number of forgeries} \text{ tested}} \times 100$$

False Rejection Rate (FRR): False rejection ratio is the total number of original signature rejected by the system with respect to the total number of comparison made.

$$\text{FRR} = \frac{\textit{Number of originals rejected}}{\textit{Number of originals tested}} \times 100$$

RESULT AND ACCURACY

The proposed system will give better result in terms of FAR and FRR than existing techniques. In training section, ANN is trained by original signature's 60 features based on horizontal and vertical splitting. As mentioned earlier Euclidean distance model help to calculate the distance between pair of feature point of original signature and testing signature. In testing section, weighted average calculated in vertical and horizontal features compare with threshold value. If weighted average of horizontal splitting is less than or equal to threshold then new signature is acceptable by horizontal splitting. Same process will follow by vertical splitting. New signature i.e. test signature have to satisfy both horizontal splitting and vertical splitting thresholds.

Sample Presented	Genuine	Forged	FAR	FRR
40 Genuine	37	03		7.5%
40 Forged	02	38	5 %	

Table (i): Result of proposed system

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