

A Novel Depth based Segmentation Approach for Offline Signature Verification

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ABSTRACT

Signature verification is one of the most widely used biometrics for authentication. The objective of the signature verification system is to discriminate between two classes: the original and the forgery, which are related to intrapersonal and interpersonal variability. Firstly, there exists great variation even between two signatures of the same person. They never start from the same position and neither do they terminate at the same position. Also, the angle of inclination of the signatures, the relative spacing between letters of the signatures, height of letters, all vary even for the same person. Hence it becomes a challenging task to compare between two signatures of the same person. The proposed an offline signature verification system to take care of that, which is based on depth for segmentation of signature image into different parts, after that geometric center of the each segment is find out as the feature point of that segment. The number of feature points extracted from signature image is equivalent to the number segment of the signature image that is produce by specifying value of depth. The classification of the feature points utilizes two statistical parameters like mean and variance. Our proposed model has three stages: image pre-processing, feature point's extraction and classification & verification. The user introduces into the computer through scanned signature images, our technique modifies their quality by image enhancement and noise reduction techniques, to be followed by feature extraction and finally used Euclidean distance model to classification of signature either genuine or forgery. The proposed offline signature verification system used "GPDS360 signature database".

General Terms

Euclidean distance model, signature verification and recognition,

Keywords

Offline signature verification, geometric centre, feature point, forgeries, FAR(False Acceptance Rate), FRR (False Rejection Rate), CCR (Correct Classification Rate), image processing.

1. INTRODUCTION

Signatures are composed of special characters and flourishes and therefore most of the time they can be unreadable. Also intrapersonal variations and interpersonal differences make it necessary to analyze them as complete images and not as letters and words put together [1]. As signatures are the primary mechanism both for authentication and authorization in legal transactions, the need for research in efficient automated solutions for signature recognition and verification has increased in recent years. Recognition is the identification of the signature owner. Verification is the decision about whether the signature is genuine or forgery [9]. In this

decision phase the forgery images can be classified in three groups:

(i) Random Forgery (ii) Unskilled Forgery (iii) Skilled Forgery [2].

(1) Random Forgery: This is also known as simple forgery and is very easy to detect. The signer creates a signature in his own style by just knowing the name of an individual whose sign is to be made.

(2) Unskilled Forgery: The signer creates a signature after observing the signature once or twice without any prior experience.

(3) Skilled Forgery: The signer may be a professional in copying signatures. He creates a signature after having a good practice over it. Such signatures are most difficult to detect [1].

It is due to the fact that biometric characteristics of every person are unique and cannot be lost, stolen or broken. There are two types of biometrics: Behavioral and Physiological. Handwriting, speech etc. come under behavioral biometrics. Iris pattern, fingerprint etc. are part of physiological biometrics. Distinguish in two different categories of verification systems depending on acquisition of signatures: online signature verification, for which the signature is captured during the writing process and making the dynamic information available, and offline, for which the signature is captured once the writing process is over and thus, only static information is available. The objective of the signature verification system is to discriminate between two signature classes: the genuine and forgery signature is called Inter Personal Variation [2]. A lot of work has been done in the field of off-line signature verification [6], [7], [8]. Although a large number of works is focused on random and simple forgery detection, more efforts are still needed to address the problem of skilled forgery detection [3].

The proposed offline signature system is automated method for recognition and verification of signature by extracting feature points that characterizes the signature. This approach starts by scanning images into the computer, then modifying their quality through image enhancement and noise reduction, followed by feature point's extraction, threshold selection and finally verifies whether a signature is original or fake.

In this paper, all experiments have been performed on skilled forgeries. The paper is organized as: Section-2 describes signature database, Section-3 describes the proposed idea of this paper which includes signature acquisition, signature preprocessing, feature point's extraction and verification technique. In Section IV, experimental results have been presented including the results of the proposed technique and comparison with existing techniques. Section V concludes the technique discussed in the paper.

2. SIGNATURE DATABASE

This research has been conducted using then GPDS360 signature database” offered for those doing research in the field of signature recognition at the *Universidad de Las Palmas de Gran Canaria*, Spain. The database contains data from 300 individuals, including 24 genuine signatures from individuals, and 30 forgeries. The 24 genuine specimens were collected in a single day of writing sessions. The forgeries were produced from the static images of the genuine signatures. Each forger was allowed to practice the signature for as long as she/he wished. Each forger imitated 3 signatures of 5 signers in a single day writing session. The genuine signatures were shown to each forger and were chosen randomly from the 24 genuine ones. Therefore, for each genuine signature, 30 skilled forgeries were produced by 10 forgers, from 10 different genuine specimens. Access to the mentioned database was authorized after a document of compliance was signed, that ensures the use of these signatures for research and academic work only, and not for commercial use [7].

3. PROPOSED SYSTEM

From previous studies, it has been observed that an Offline signature verification process consists of following Steps:

1. Signature Acquisition
2. Signature Preprocessing
3. Feature Point's Extraction
4. Signature Verification

3.1 Signature Acquisition

Signature made on A4 paper were acquired by scanner having 300dpi and stored in Portable Network Graphics (PNG) format. Fig.1 shows some sample signatures from database on which proposed technique has been tested.



Fig 1: Original signature



Fig 2: Forgery signature

3.2 Signature Preprocessing

To verify a signature correctly, preprocessing of acquired signature is required. The acquired signature image as shown in Fig.1 may sometimes contain noise (extra pen dots other than signature). It is necessary to remove these extra pixels from acquired image to verify the signature correctly. This can be done by using median filters. Following are the preprocessing steps:

A) Threshold & Binarization: In computer vision and image processing, Otsu's method is used to automatically perform histogram shape-based image thresholding or the reduction of a gray level image to a binary image. The algorithm assumes that the image to be threshold contains two classes of pixels (e.g. foreground and background) then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. Binarization means black and white version of the input (RGB) signature [11].

B) Thinning: Thinning is basically a morphological operation which is applied to binary image to obtain one pixel run of signature or skeleton of a signature shown in Fig 5.

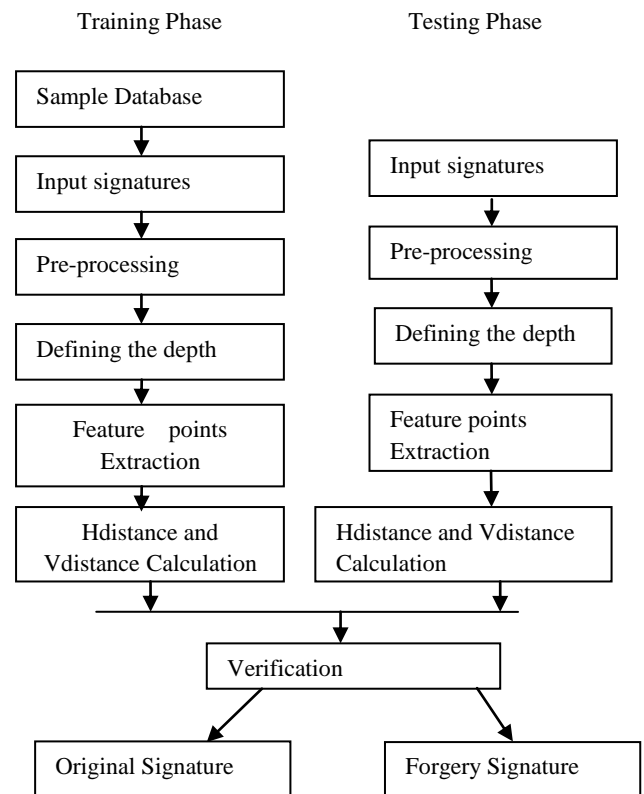


Fig 3: Flow Diagram of Offline Signature verification

C) Resizing image: Pre-processing is to resize the acquired signature to a standard size (300x500).The result of preprocessing phase is noise free, resized, binarized, thinned image as shown in fig 5.

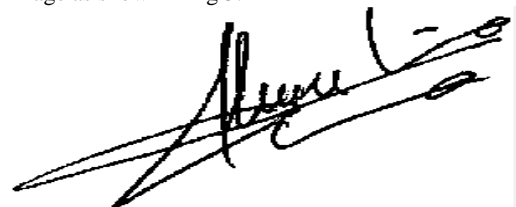


Fig 4: Original Signature image



Fig 5: Binarization, thinning, resize operation

3.3 Feature Point's Extraction

In feature extraction step, the necessary features points are extracted from the sample preprocessed signature. The numbers of feature point's to be extracted are based on the

application and vary from system to system. The number of feature point's selection is depends upon the depth as per value of depth the number of feature point get selected.

Determine the number of feature points: In proposed method extraction of total number feature points from the signature is based upon the depth as value of depth changes the total number of feature point's changes. The more number of feature points extraction improve the accuracy of forgery signature detection.

- a) Depth=1(4 feature points)
- b) Depth=2(4fp+4*2fp=12fp)
- c) Depth=3 (4fp+4*2fp+8*2fp=28fp)
- d) Depth=4(4fp+4*2fp+8*2fp+16*2 fp=60fp)
- e) Depth=5(4fp+4*2fp+8*2fp+16*2fp+32*2fp =124fp)

The geometric features are based on two sets of points in 2-dimensional plane. If depth is specified as 4 the vertical splitting of the image results thirty feature points (v1, v2, v3, ..., v30) and the horizontal splitting results thirty feature points (h1, h2, h3, ..., h30). These feature points are obtained with relative to a central geometric point of the image. Here the centered image is scanned from left to right and calculate the total number of black pixels. Then again from top to bottom and calculate the total number of black pixels. Then divide the image into two halves w.r.t. the number of black pixels by two lines vertically and horizontally which intersects at a point called the geometric centre. With reference to this point 60 features are extracted. 30 vertical and 30 horizontal feature points of each signature image.

Processing of the Signature: The geometric feature points of proposed system based on two sets of points in two dimensional planes. Each set having thirty feature points which represent the stroke distribution of signature pixels in image. These 60 feature points are calculated by considering the geometric center of each segment. Vertical Splitting and Horizontal Splitting are two main steps to retrieve these feature points.

3.3.1 Feature points based on vertical Splitting:

Thirty feature points are obtained based on vertical splitting w.r.t. the central feature point. The procedure for finding vertical feature points are given below

Algorithm:

Input: Static signature image, depth=4.

Output: Vertical feature points: v1, v2, v3, v4 ...v29, v30.

The steps are:

1. Input the value of depth =4
2. Split the image with a vertical line passing through the geometric centre (v0) which divides the image into two halves: Left part and Right part.
3. Find geometric centers v1 and v2 for left and right parts correspondingly.
4. 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.
5. We again split each part of the image through their geometric centers to obtain feature points v7, v8, v9...v13, v14.
6. Then we split each of the parts once again to obtain all the thirty vertical feature point's v15, v16, v17, ...,v29, v30.

3.3.2 Feature points based on Horizontal Splitting:

Thirty feature points are obtained based on horizontal splitting w.r.t. the central feature point. The

procedures for finding horizontal feature points are given below.

Algorithm:

Input: Preprocessed signature image, depth=4.

Output: Horizontal feature points: h1, h2, h3, h4, ..., h29, h30.

The steps are:

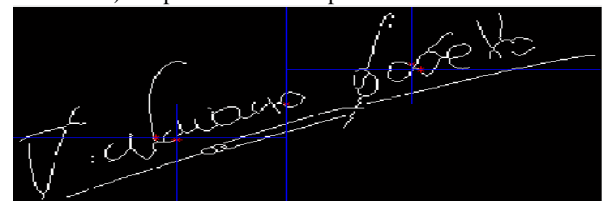
1. Input the value of depth =4
2. Split the image with a horizontal line passing through the geometric centre (h0) which divides the image into two halves: Top part and Bottom part.
3. Find geometric centers h1 and h2 for top and bottom parts correspondingly.
4. Split the top and bottom part with vertical 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.
5. Then we split each of the parts once again to obtain all the thirty horizontal feature points h15, h16, h17, ..., h29, h30.

Observations:-

a)

i) Input: Depth =1, preprocessed signature image

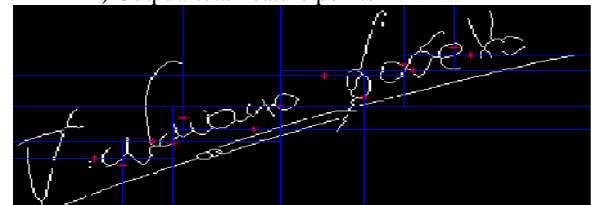
ii) Output: total feature points=4



b)

i) Input: Depth =2, preprocessed signature image

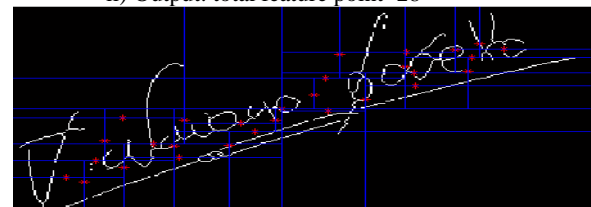
ii) Output: total feature points=12



c)

i) Input: Depth =3, preprocessed signature image

ii) Output: total feature point=28



d)

i) Input: Depth =4, preprocessed signature image

ii) Output: total feature point=60 point

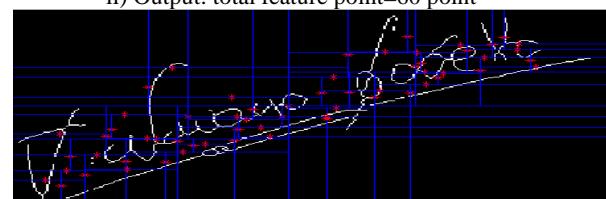


Fig 6: Feature points extraction by specifying the depth value

4. SIGNATURE VERIFICATION

In this study features are based on geometric properties. So we use Euclidean distance model for classification [12]. This is the simple distance between a pair of vectors of size n. Here vectors are nothing but feature points, How to calculate distance between the training and testing sample using Euclidean distance model is described in the following Section.

Euclidean distance model:

Let A (p₁, p₂.....p_n) and B(q₁,q₂....q_n) are two vectors. In threshold calculation these distances are useful.

In our application, vectors are the feature points on plane. So d is simple distance between points. Here p₁,p₂,p₃,.....,p_n are the mean feature points of the multiple training signatures and q₁,q₂,q₃,.....,q_n are the feature points of the test signature.

Let n signatures are training signature from each person. There are 60 feature points from each original signature, 30 are taken by vertical splitting and 30 are taken by horizontal splitting. Mean vertical feature points based on vertical splitting is calculated as shown below:

$$V_{mean,1} = \text{mean}(v_{1,1}, v_{2,1}, \dots, v_{n,1})$$

$$V_{mean,2} = \text{mean}(v_{1,2}, v_{2,2}, \dots, v_{n,2})$$

$$V_{mean,3} = \text{mean}(v_{1,3}, v_{2,3}, \dots, v_{n,3})$$

$$V_{mean,4} = \text{mean}(v_{1,4}, v_{2,4}, \dots, v_{n,4})$$

$$\dots\dots\dots$$

$$\dots\dots\dots$$

$$V_{mean,30} = \text{mean}(v_{1,30}, v_{2,30}, \dots, v_{n,30})$$

Where v_{i,1},v_{i,2},.....,v_{i,14} are vertical splitting features points of ith training signature sample. Now the same procedure applied to calculate the mean horizontal feature points using the horizontal splitting.

$$H_{mean,1} = \text{mean}(h_{1,1}, h_{2,1}, \dots, h_{n,1})$$

$$H_{mean,2} = \text{mean}(h_{1,2}, h_{2,2}, \dots, h_{n,2})$$

$$H_{mean,3} = \text{mean}(h_{1,3}, h_{2,3}, \dots, h_{n,3})$$

$$H_{mean,4} = \text{mean}(h_{1,4}, h_{2,4}, \dots, h_{n,4})$$

$$\dots\dots\dots$$

$$\dots\dots\dots$$

$$H_{mean,14} = \text{mean}(h_{1,30}, h_{2,30}, \dots, h_{n,30})$$

Where, h_{i,1}, h_{i,2},....., h_{i,14} are horizontal splitting features of ith training signature sample. Feature points based on vertical splitting are v₁,v₂,v₃,v₄...v₁₄, v₂₈ and feature points based horizontal splitting are h₁,h₂,h₃,h₄,..... h₁₃, h₁₄.

Distance between mean feature points of training signatures and test signature features points are shown below:

Depending upon the value of Distance, identification of signature is performed as original or forgery.

5. RESULT

To train the system, a subset of GPDS database was taken comprising of 5 genuine samples taken from each of the 5 different individuals and to test the system 10 genuine samples taken from each of the 5 different individuals. The following table 1 shows the result of system in the form of Correct Classification Rate (CCR) and False Rejection Rate

(FRR) for original signatures. The CCR and FRR calculated as.

Table 1: CCR and FRR for Original signature

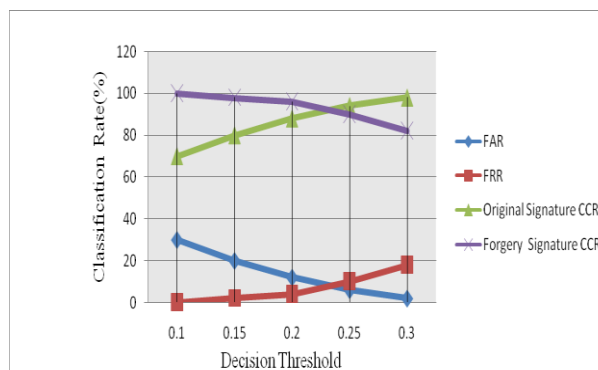
Training Signatures	Testing Original Signatures	Threshold	CCR (%)	FRR (%)
25	50	0.1	70	30
		0.15	80	20
		0.2	88	12
		0.25	94	06
		0.3	98	02
		Average	86	14

The following table 2 shows the result of system in the form of Correct Classification Rate (CCR) and False Acceptance Rate (FAR) for forgery signatures. The CCR and FAR calculated as.

Table 2: CCR and FAR for Forgery signature

Training Signatures	Testing Forgery Signatures	Threshold	CCR (%)	FAR (%)
25	50	0.1	100	00
		0.15	98	02
		0.2	96	04
		0.25	90	10
		0.3	82	18
		Average	93.2	6.8

The Following graph 1 shows the FRR, CCR for original signature and the FAR, CCR for forgery signature at different threshold levels.



Graph 1: FAR, FRR, CCR for different threshold in depth-4

Comparing the result of proposed method with other signature verification method such as Grid feature extraction & Signature Verification using Neural Network. The result is shown in Table 3.

Table 3: Comparative performance of system

Classification Rate	Grid Feature Extraction	Neural Network	Proposed Method (60FP)
FRR (%)	17.9	20	14
FAR (%)	9.7	14.66	6.8

6. CONCLUSION

This research was taken up with an objective of developing depth based signature segmentation algorithms for verification of Genuine and Forgery signatures. Signature verification in offline systems is completely based on the images of the signatures. It contains less discriminative information as it is often contaminated with noise either due to scanning hardware or paper background. A novel approach for off-line signature verification is proposed and implemented so that preprocessed signature i.e. resized, binarized and thinned signature is segmented into different parts specifying the depth value. From each individual segment, value of feature point is extracted by considering the signature pixels values. For verification, feature points of training signature images and test images have been compared using the Euclidean classification model and the test signature is then classified accordingly. So, the proposed system provides better result in terms of FRR, CCR for genuine signature and FAR, CCR for skilled forgery in different depth levels. The proposed algorithm result the FAR which is very much less as compared to the FAR of the previously existing techniques. So it is important for a user to sign his signature with at most care so that there is not a large variation of his signature. Otherwise there is a probability of rejection of an original signature.

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