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Offline Signature Verification Using Contour Tracing

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Abstract: ***The paper proposed a centroid based method for offline signature verification. The signatures are acquired by the individuals on sheet of paper within boxes of pre-determined size. These sheets are then scanned to produce reference signature images. After pre-processing, the global and local features of the signature images are extracted. The authenticity of the signer is determined by comparing the features of the input signature and features of the stored reference signatures. The similarity between the features of input signature and reference signatures is calculated and compared with a threshold. If this similarity value exceeds the threshold, the input signature is authenticated as original signature otherwise they are considered as a forgery. The results are produced focusing on two vital parameters: False Acceptance Rate(FAR) and False Rejection Rate(FRR).***

Keywords: Authenticity, Biometric, Pre-processing, Signature verification, Threshold

1. Introduction

In the era of growing technology security is in a great menace due to increasing rate of fakes and forgeries. With the traditional security systems the user may need to carry their identity cards, remember passwords or use some other means of authentication but with biometric systems there is no need to carry or remember anything because these systems are based on physiological and behavioral features of the individuals. Thus, keeping in mind the conveniences of biometric systems there is a rapid growth in development of these systems to control forgeries.

Biometric systems are mainly based on face recognition, iris scanning, fingerprint ECG and DNA analysis etc. Although attributes associated with iris, fingerprint, and retina do not change overtime, but they require special and relatively expensive instrument to acquire the image. Thus, all these systems provide better security than traditional systems but with expensive instruments and processing systems. Signature verification is one of the authentication methods which can provide security at low cost and maintenance because the device for signature acquisition is much cheaper. Signature verification systems are authentication method which determines whether a particular signature is authenticated or forged.

The signature verification systems can be categorized into two depending upon the process of data acquisition: Online signature Verification systems and Offline Signature Verification systems. In online systems the signature are done on digital pads or electronic tablets thus capturing and analyzing the signature in real time, as the person is signing it. The dynamic information about writing activity such as speed of writing, pressure applied, numbers of strokes, acceleration, trajectory and time taken are acquired in these systems. Where as in off-line systems, signatures are signed on paper and are converted to electronic form with the help of a scanner. The real time data is not available in offline system unlike online systems. Due to availability of dynamic features online systems are more accurate than offline systems.

2. Literature Survey

From the literature it may be noted that the work has been done to improve the accuracy of offline-systems. Bradley Schafer [] proposed an Offline verification system based on geometrical features. Sepideh Afsardoost [1] proposed an approach based on geometric center features. Vu Nguyen [2] reported that encouraging results can be obtained by using 24-dimensional compact size feature set. Sargur N. Srihari [3] concluded that in the one-class scenario distance methods are superior while in the two-class ,SVM based method outperforms the other methods. Debashish Jena [4] proposed a method that extracts 60 feature points and concluded that these feature points are highly sensitive to even small variations in signature. Ramachandra C [5] proposed an approach which was based on global features and observed that the FAR and FRR obtained are much better than previously existing feature extraction method .

3. Our Approach

A. Database Design

Signature of every individual is considered unique. Whenever the self-signatures are signed by signer they may not always be same but they will be similar, these variations are intra-personal variations. The difference between the signatures of different individuals is called inter-personal variations. There is a need to minimize the intra-personal variations and maximize inter-personal variations, which means there should be least variance between the different signatures of same individual. To manage these variations a signature database is created by collecting signatures from 20 different persons. Each person signed 20 signatures. The signature were done very carefully with black/blue ink on A4 size sheets, further, these sheets were scanned at 300 dpi resolution for the purpose of clarity in binary image format.

The database consisted of original signatures and forged signatures. An original signature means the actual

signatures signed by individual. Forged signatures can be of two types [4] Simple and Skilled forgery. Simple forgeries are signed by the forgers who have not practiced the signature before signing. Skilled forgeries are the signatures signed by the forgers after practicing.

In total, 20 signatures were taken from each individual. 15 signatures were used for training and rest for testing. In addition to this, 10 forged signatures were also taken from each person, out of which 5 were unskilled and 5 were skilled. So the database had 400 original signatures and 100 skilled forgeries and 100 unskilled forgeries.

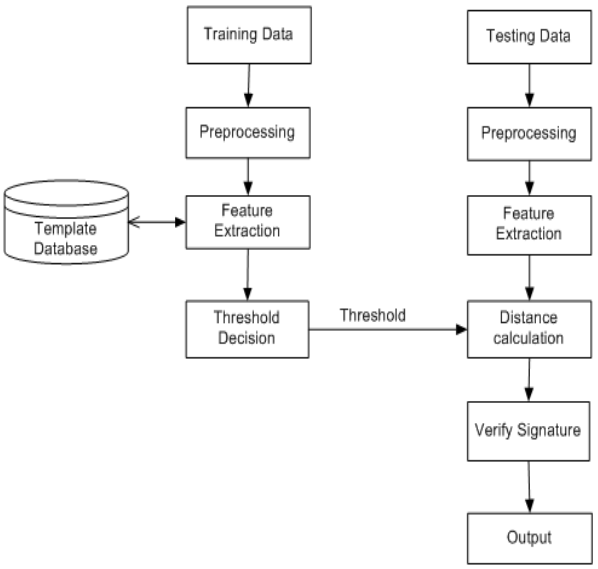

Figure 1: Detailed modules of signature verification system

B. Pre-processing

The samples of original signature are as shown in figure2. These samples contain some salt and pepper noise due to impurities of the paper or the dust particles on the scanner. The images were binarized to obtain two intensity values to simplify the feature extraction process. After binarization, a bounding box for each signature image was created so that irrelevant space surrounding the signature can be removed. It is a region obtained by joining the extreme points [6] from top, bottom, left and right . Figure3 shows the pre-processing steps followed in this verification system.

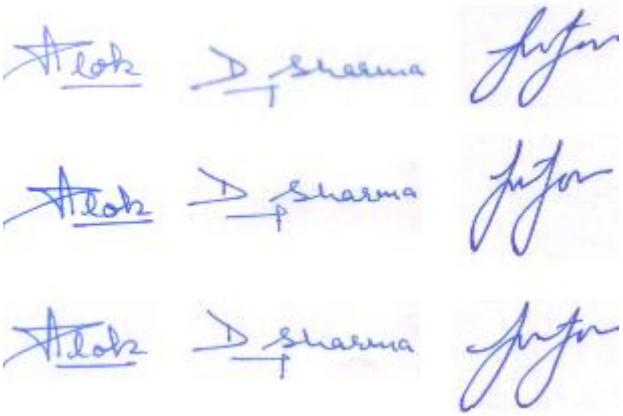

Figure 2: Samples of original signature of three signers

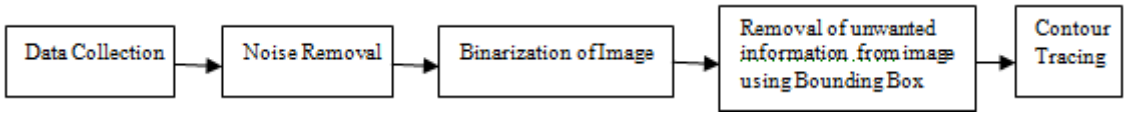

Figure 3: Pre-processing Steps

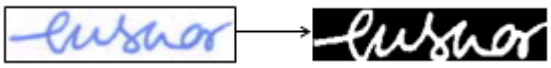

Figure 4: Bounded image of signature

The signature images are contour traced by imploying moore-neighbour tracing algorithm to extract information about their general shape. Once the contours are extracted, its different characteristics will be examined and used as features for signature verification. Here, the contoured signature patterns are considered rather than whole signatures because the contour pixels are generally a small subset of the total number of pixels representing a pattern. Since the contour shares a lot of features with the original pattern, the feature extraction process can be effectively performed on the contour rather on the original pattern.

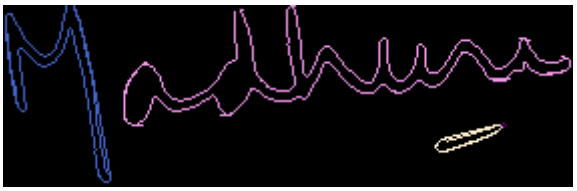

Figure 5: Components of signature

The subset of the pixels which are connected together form a single component in the signature image. Figure 5 contains three components. The components which had number of pixels less than 3% of the total number of pixels in signature image were discarded. This helped in removal of salt and pepper noise and dots of signatures.

C. Feature Extraction

Feature means similar characteristics and „extraction" means accurately retrieve those features. Feature helps in explaining the structure of the signature image. Various types of features can be extracted from the images in general but for signature images only few feature extraction techniques can work because signature verification requires analysis of very minute details. A proper feature extraction technique plays an important role in development of the robust system as all other phases are based on these features. Prior to application of any technique it should be kept in mind that we have to select features that provide variance which is large enough to identify the forgery and small enough to accept different signatures of same person.

By feature extraction of signatures we mean extraction of the properties of the shape of the signatures we are not

concerned with the texture, color or contents of the signature. A signature cannot be considered as character recognition because individual characters cannot be recognized in offline signature images.

For the good accuracy of the project it is required that the shape descriptor should effectively accept the authenticated signature images and reject the forged signatures. Shape representation and description techniques can be classified into two classes of methods: Contour-based methods and Region-based methods. The classification is based on whether shape features are extracted from contours only or are extracted from whole shape region. Under each class, the different methods are further divided into global and structural methods. This sub-class classification is based on whether the shape is represented as whole or represented by segments/sections. These features can be further sub-divided into space domain and temporal domain.

The whole hierarchy of classification is shown in figure:

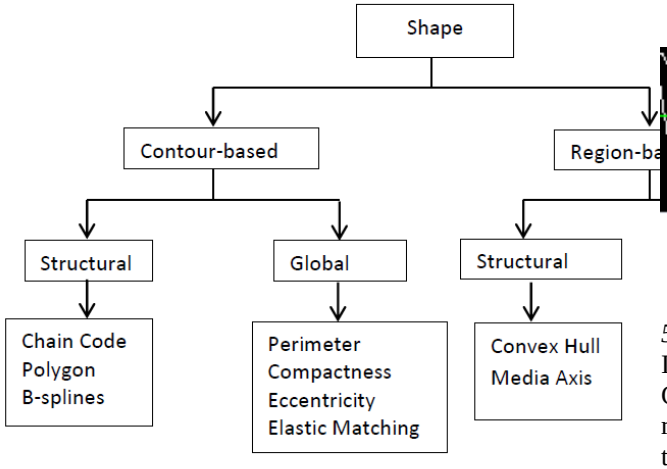

Figure 6: Classification of shape descriptors

This approach has used Contour-based global features. The details of few relevant features are given below.

1) *Extreme points of the entire image* :

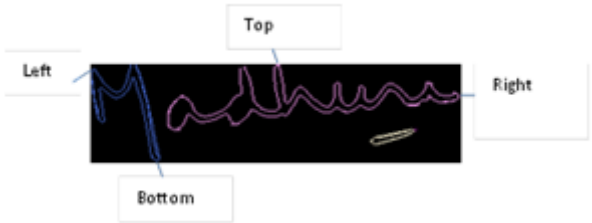

Figure 8: Extreme points

Here, four extreme points namely: top, bottom, left and right are considered which are as shown in fig 7. The X and Y coordinates for each extreme point are stored as feature.

2) Normalised height and width of each component: Width is calculated as ratio of width of each component to the area of each component. Area is computed as product of width and height of a component.

3) Aspect ratio of each component: It is computed as ratio of width to height. It is calculated for each component in signature image.

4) Centroid : The centroid is calculated for each component and the X coordinates are calculated by formula (1) and Y coordinates are calculated by formula (2).

$$X_{coordinate} = \frac{\sum_{x=1}^{width} x \sum_{y=1}^{height} a[x][y]}{\sum_{x=1}^{width} \sum_{y=1}^{height} a[x][y]} \quad (1)$$

$$Y_{coordinate} = \frac{\sum_{x=1}^{width} y \sum_{y=1}^{height} a[x][y]}{\sum_{x=1}^{width} \sum_{y=1}^{height} a[x][y]} \quad (2)$$

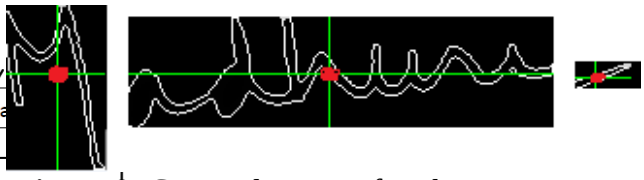

Figure 8: Centroid points of each component in signature image

5) Inter-Centroid Distance

It is the Euclidean distance the centroid of each component. Computation of inter-centroid distance will provide the relativeness between each component and helps to keep track of the distance between each component.

D. Training

From each person 20 signatures were taken, so we have 20 values for each feature for a individual thus there is a need to decide one value for each feature which can be used to verify the signature. We have used Standard deviation to depict one value for each feature. It is the measure of amount of variance or dispersion from the average. A low standard deviation indicates that data points tend to be very close to mean; a higher value indicates that data points are spread out at larger range of values. First 15 signatures are taken for training so average is calculated for each feature point by the below given formulas.

$$X_{centroid\_coordinate\_avg} = \frac{1}{15}\sum_{i=1}^{15} x_i$$

$$Std\_deviation = \sqrt{\frac{1}{15}\sum_{i=1}^{15}(x_i - X_{centroid\_coordinate\_avg})^2}$$

$$Y_{centroid\_coordinate\_avg} = \frac{1}{15}\sum_{i=1}^{15} y_i$$

$$Std\_deviation_{y_i} = \sqrt{\frac{1}{15}\sum_{i=1}^{15}(y_i - Y_{centroid\_coordinate\_avg})^2}$$

Similarly, the average and standard deviation can be calculated for other features.

E. Test

To test a signature, the same feature extraction process is followed and the feature points are determined. The difference between each feature value and its corresponding standard deviation is calculated. If the difference is greater than the training distance the signature is rejected otherwise accepted.

4. Result

The performance of proposed system is given in terms of Type I error (False rejection of genuine signatures) and Type II error (False acceptance of forge signature).

Type I error: False rejection of genuine signature (FRR) is the ratio of number of genuine signature rejected and total number of genuine signature. For computation of FRR, different numbers of signatures were used for training and except those, 5 signatures were used for evaluation. The graph shows the effect of number of signatures on FRR.

Type II error: False acceptance of forge signature (FAR) is the ratio of number of forged signature accepted to the total number of forged signature.

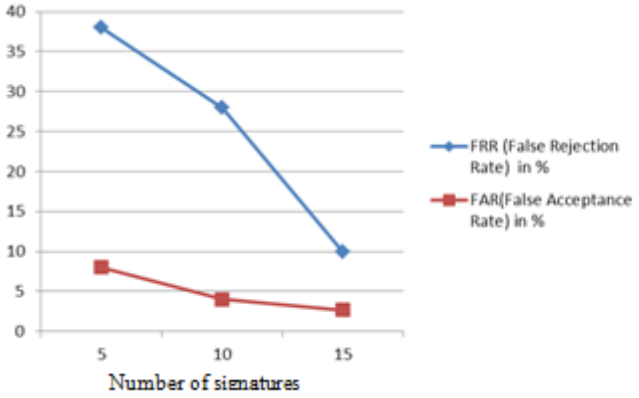

Figure 1: Graph showing relation between signature and rates Fig. 2 Graph showing FRR and FAR

The graph in Fig. 1 represents the false rejection rate and false acceptance rates according to the variation of number of signature samples. There is a inverse relation between FRR and FAR. If the thershold values are relaxed and we try to decrease the false rejection rate than false acceptance rate tends to increase. Thus there is a need to attain an optimal value for FAR and FRR.

5. Conclusions

Signature verification is a current research topic and various approaches have been proposed based on structural and geometrical features. All of these approaches have certain advantages and disadvantages. The proposed approach tries to trace the handwriting style of the signer and effective results are produced.

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