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Novel Approach to Offline Signature Classification and Verification System

Ashish Kadlag[1], A. B. Ingole[2], K. P. Patil[3]

[1]Student of Sinhgad Academy of Engineering, Kondhwa (bk), Pune University, Maharashtra, India

[2]Assistant Professor, Sinhgad Academy of Engineering, Kondhwa (bk) Pune University, Maharashtra, India

[3]Professor, Sinhgad Academy of Engineering, Kondhwa (bk) Pune University, Maharashtra, India

Abstract: ***Now a days, signatures plays an important role in person identification and verification purpose. There is need of different methods for automatic signature classification as well as for verification system because financial and business related transactions became dependent and authorized via signatures hence in this work, based on a combination of features extracted such as normalized area of signature, aspect ratio, centroid features, trisurface feature, six fold feature and transition feature from the input signatures that is of train as well as from test signature are used for the signature classification and verification purpose. The system is trained using various samples signature of indiduals and from those various set of signature samples, we extract feature vectors for every indiduals signatures all signature which are used as template sign for the test signature during verification phase. Euclidean distance is used as classifier between the database signature and the test signature.***

Keywords: Offline Signature Verification, Forgery,FeatureExtraction, Center of gravity, Transition Feature, Euclidean distance, FAR, FRR.

1. Introduction

We can call today's world as growing information technologies world. In this world it is important to keep persons private data safe which is crucial task so we really need of security system for it. There are certain drawback of existing security systems which mainly consist of that they can easily forgotten lost even stolen and may be used by some other person also it is easy to crack password because most our password are not strong enough just because we keep it them as number, name or the words that can easily recall which is simple one to guess but if we will keep strong password which is meaningless then it is difficult for us to recall them easily. In this growing IT world various industries, schools, colleges, in banking sectors various biometric systems are used for identification purpose.

Biometric term is derived from Greek word bio means life and metric means to measure. Biometric is used by different peoples for identification purpose in various applications. For our purpose, we define it as the system that provides the biological information of persons on the basis of their characteristics. Certain characteristics are the ultimate property of indiduals so it is mostly used to verify the person's identity. The important parameters of biometrics are Physical and Behavioral. Fingerprint system, iris recognition, face recognition, hand geometry are the examples of Physical biometric whereas voice recognition, signature, keystrokes are of Behavioral biometrics.

Handwriting process is characteristics of the person and it requires large amount of energy and time in order to change it[10]. The rate of making crime is also proportional to advancement in the IT sectors.In case of signature based authentication system, rate of making crime means making forgery. handwriting characteristics over which forger works mainly consist of writing Line quality Word and letter spacing, Letter comparison, Beginning and ending strokes, Shading, pen pressure, Slant angle, Baseline style. Forgery signature of anyone persons which affects its legal right. Biometric authentication is gaining popularity as well as become alternative to password based security systems, since it is almost impossible to steal, copy, or guess.

Forgery, according to North Carolina Wesleyan College law professor Mark Stevens, is the "false making or material alteration of writing" that appears to defraud or deceive and fits the legal definition of being effective in doing so. Some key characteristics that will highlight that person makes forgery consist of slow, carefully writing,showing pen lifts at the unusual places,retouching to drawn signature for proper adjustment, hesitation in writing, presence of carbon outlines nearer to signature. Various types of forgery are namely Random forgery, Traced forgery, copied forgery, practiced forgery, computerized forgery. Out of which traced forgery can be done with the help of carbon paper, tracing paper, using transmitted light which is difficult to verify.

Some of them summarized as below

- Random forgery: This kind of forgery sign is done by the signer who does not any idea about the shape and structure of genuine signature. It is very easy to classify even with the eyes.
- Traced Forgery: This kind of forgery sign is done by the signer by tracing genuine signature model. Sometimes it will become difficult to classify such signatures. General observation about these signatures is they have some amount carbon outlines and ink strokes.
- copied forgery: This kind of forgery sign is done by the signer by copying the genuine signatures by process of drawing just keeping the original signature in front of

them and making a copy by drawing but these type of forged signatures are poor in their line quality.

- Practiced forgery: This kind of forgery sign is done by the signer by making practice of Genuine Signature, Such signatures lack natural variations in comparison with genuine Signatures. These are done by mostly the professional persons or say forger.
- Computerized forgery: This kind of forgery sign is done on Computers with the help of Scanner and Color Printer and can be identified by a careful examination using good Quality Lens with Light Source. Mostly computerized forgery used in making fake documents.

The types of forgery signatures are shown in figure 1.

Figure 1: Types of Forgeries

As Signature authentication system is cheaper and less constrain over other biometric authentication system hence it is extensively accepted. Signature verification systems are different both in their feature selection and their decision making methodologies[8].The advantage of signature verification and classification system for identify authentication is that most of modern portable computers and Personal Digital Assistants[PDA] makes use of handwritten inputs.

2. Types of Signature Verification

Depending upon the input data acquisition method the major types of signature verification systems are Online Signature Verification, Offline Signature Verification.

2.1. Online Signature Verification

Digital tablets, Digital pens or smart pens, Special hand gloves,CAD(Computer Aided Design),Pressure sensitive tablets, E-signature pad are mostly used for acquiring the input signature in online signature verification method. While dealing with these devices important parameters that are needed are their size of the pad, resolution, levels of pressure sensitivity, sampling rate, sequence of strokes, pen start and end point. The major importance is to be given to capabilities of the Input device because it will provides us the better quality of input signature features that is to be drawn during the signing. During On-line signature verifications data acquisition and preprocessing phase suffers with different problems such as the input devices cost and impracticality also they are not used in real time systems. The major feature extract during signing in online signature verification system are pressure at pen tip, acceleration, and pen tilt, signing speed, signature bounding box. This features help in determining the better accuracy because the dynamic characteristics are very difficult to imitate. Different approaches are used for the verification purpose includes Genetic Algorithms, Euclidian distance, dynamic time warping algorithm, Hidden Markov Models.

2.2 Offline Signature Verification

The offline signature verification uses the images collected from device like scanner, cameras, and from white paper to get information such as global, structural, geometric, or statistical features of the input scanned signature. In comparison with on-line signature verification systems, off-line verification system is complex to design because various characteristics related to signature such as the order of strokes, the velocity say dynamic information is not possible to obtain in the off-line signature verification system as it is deals with only scanned images. Offline signature verification system is prefer over online in major application such as;

1. Bankcheque processing,
2. Documents and forms processing,
3. In Exam assessment for Candidates authentication

Where signature plays an important role also for financial transactions or finance related work it is essential to verify a signature for authentification of indiduals. Out of these two methods, online has certain disadvantage such as it require the person whose signature is to be verify and thus it cannot be applied in many practical cases. Dynamic information is not available for the off-line signature verification system. Difficulties to be face in offline signature verification systems are introduction of noise by the scanning device like scanner, difference in pen tip width.

In our work, Some Important Phases that are required mainly consist of: Signature Acquisition Phase, Signature Pre-processing Phase, Feature Extraction Phase, Signature Classification Phase, Signature Verification Phase. Once the signature is acquired it is needed to be Pre-process. Various operations are performed on the input scanned signature image during pre-processing phase. In Feature Extraction Phase we extract various features from the obtained input signatures and collectively stored those in our database. While during Classification and verification phase we compare the test signature and easily classify it as the original or the forge on the basis of FAR and FRR.

3. Proposed Work

Algorithm for proposed work:
Step 1: Take input set of signatures of different persons.
STEP 2: Converting each colored signature image into binary image.
STEP 3: Perform pre-processing operation on each sample signature.
STEP 4: Find the bounding boxes of the input images.
STEP 5: Extract the different features from each signature and store in a database feature vector.

STEP 6: Database is created by calculating feature vectors of input signature sets.
STEP 7: If test signatures localized threshold or localized threshold matches with the database signature then it passes to that particular signature set for verification purpose then Calculate the Euclidian distance of test signature features from the train signatures features of the dataset.
STEP 8: If the Euclidian distance is below a certain threshold (local and global) then the test signature is verified to be of that of the claimed person otherwise it is detected as a forged one.

3.1 Block Diagram

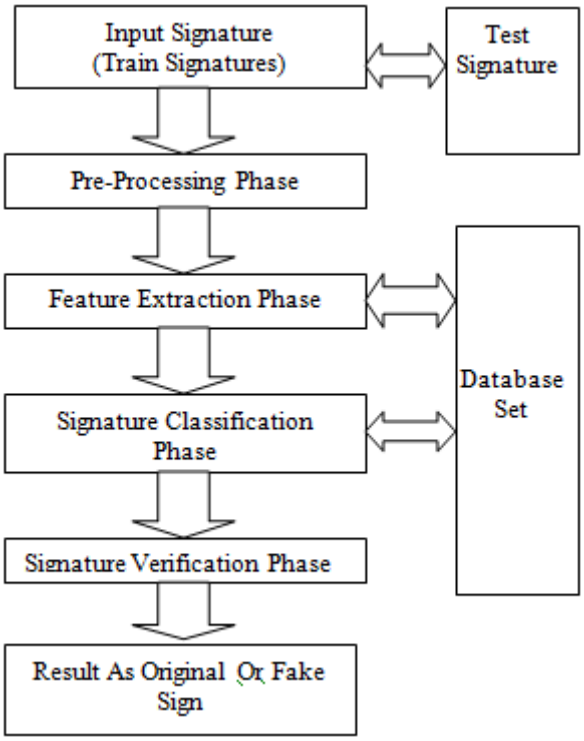


Figure 2: Proposed Block Diagram

3.2 Block Diagram Explanation

Offline Signature classification and verification system generally consist of the following 4 main phases:
1. Signature acquisition phase
2. Pre-processing phase
3. Feature extraction phase
4. Classification phase and Verification phase

3.2.1 Signature Acquisition Phase

In Offline signature classification and verification system the input signatures are drawn on paper and input image is taken it with the help of camera,scanners of good resolution,are the signatures made on papers. The first step is to extract these signatures from papers using scanners. For proposed method we make use of scanner of resolution of 300×300.

3.2.2 Signature Pre-Processing Phase

Once the image is acquired then various pre-processing operations to be performed on it which involves removal of noise to improve the quality of the image information and finally Image Binarization. In Image Binarization the input gray scale image is converted into a two tone image format, i.e., black and white pixels(commonly represented by 1 and 0 respectively).

3.2.3 Feature Extraction Phase

Extraction of feature from the input signature is a crucial task Features related to input signature mainly consist of parameter and functional feature. Function feature provides the information related to pressure, velocity say dynamic characteristics of signature whereas parameter feature is broadly classified into global parameter and local parameter,global parameter consist of FFT or DWT and local parameter are component oriented and pixel oriented.component oriented are further classified on the counter,slant and geometrical based whereas pixel oriented classified based on intensity and grids. For our work we need various features such as Normalized Area of the Signature, Aspect ratio,Centroid feature, Feature points based on vertical splitting, Feature points based on horizontal splitting, Transition Feature,and various common features based on dwt such as Vertical, Horizontal,Diagonal common feature. These feature of the test image that will be compared to the features of training images for verification purpose. For our work, features are based on geometric properties so we use Euclidean distance model.

3.2.3.1 Normalized Area Of The Signature

It is the ratio of the input signature occupied area to the actual area provided for sign. Mathematically it is expressed as

$$NormalizedArea = \frac{Signature\ occupied\ Area}{Area\ of\ Signature\ Bounding\ Box}$$

3.2.3.2 Aspect Ratio

The **aspect ratio** of an image gives the proportional relationship between its width and height. It is defined as the ratio of the signature width of signature to the height of signature. Bounding box provides us actual width and height required by the signature. It is commonly expressed as two numbers separated by a colon e.g.(x:y).It is expressed as

$$AspectRatio = \frac{Width\ of\ signature}{Height\ of\ signature\ ofBounding\ Box}$$

Signature may vary from size to size but the ratio between height and length stay always constant[9].

3.2.3.3 Centroid Feature

It is often called as Center of Gravity. As we are dealing with the binarized image of the input signature which contain certain Number of white pixels they are treated as ON pixel. Center of Gravity is the average coordinate point of all white pixels of the binary signature image(part of input signature). This feature is related to the angle of the signatures pixel distribution, the 'centroid' [4].In this stage of feature extraction, firstly image signature gets divide in two equal parts,then we have to calculate COG(center of gravity)of those half parts(say Image centroid 1 and Image centroid 2). From those two COGS another vertex is created for triangle of which angle between the horizontal axis and the line formed by joining the two centers of gravity (Image

centroid 1 and Image centroid 2) which will gives rise to feature that is used to calculate 'centroid'. To obtain the 'Centroid' feature, first we have to calculate α for the triangle, Equations (1) and (2) are followed to get this value.

$$Centroid = \alpha + \frac{1}{2}$$

Where

$$\alpha = \frac{\sin^{-1}(height/hypotenuse)}{\pi}$$

3.2.3.4 Feature Points Extraction Based On Vertical Splitting

We are getting total Six feature points from vertical splitting of the input signature. feature points are the geometric centers of that particular bounding boxes. The procedure for finding these feature points is as follows :

Algorithm

Procedure for calculating feature points extraction based on vertical splitting

1) By dividing the input image into equal parts by drawing the vertical line at the center of image we will get left and right parts of image.
2) Find geometric centers for the respective left and right parts.
3) Again Splitting left part of the main input image into two parts by drawing horizontal line over that geometrical center, then calculate geometric centers 1 and 2 for top and bottom part respectively.
4) Again Splitting right part of the main input image into two parts by drawing horizontal line over that geometrical center, then calculate geometric centers 3 and 4 for top and bottom part respectively.

3.2.3.5 Feature Points Extraction Based On Horizontal Splitting

We are getting total Six feature points from horizontal splitting of the input signature. feature points are the geometric centers of that particular bounding boxes.
The procedure for finding these feature points is as follows :

Algorithm

Procedure for calculating feature points extraction based on horizontal splitting

1) By dividing the input image into equal parts by drawing the horizontal line at the center of image we will get left and right parts of image.
2) Find geometric centers for the respective top and bottom parts.
3) Again Splitting top part of the main input image into two parts by drawing vertical line over that geometrical center,then calculate geometric centers *1* and *2* for left and right part respectively.
4) Again Splitting bottom part of the main input image into two parts by drawing vertical line over that geometrical center, then calculate geometric centers *3* and *4* for left and right part respectively.

3.2.3.6 Transition Feature

This provides features that is needed while creating the signature template. Transition features (TF) gives locations of transitions between foreground pixels(1's) and background pixels(0's) in a binary image during application of following approaches such as from top to bottom, bottom to top, left to right and finally right to left. If a transition occurs during these approaches then it provides total 8 features the location of the transition during those approaches and length/width of signature image provides feature. The ratios of the x and y positions of the transition for each of the four directions are recorded [7].

3.2.4 Signature Classification Phase And Signature Verification Phase

In this phase, based on the above calculated features of the input signature threshold(local and global) value of user is calculate first. Five signatures out of the original signatures collected from each one helps in determining the threshold value. In this manner for the respective training signature samples we get each feature vectors. The Euclidean distance acts as classifier in this phase. The last stage is the verification stage; this stage compares the incoming test signature with the user's signature templates in the database. The Euclidean distance and threshold(local) are compared based on each feature for each user then we calculate FAR and FRR.

$$FAR = \frac{No.\ of\ forgeries\ accepted}{No.\ of\ forgeries\ tested} X100$$

and

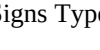
$$FRR = \frac{No.\ of\ genuine\ rejected}{No.\ of\ genuine\ tested} X100$$

These parameters are used for measuring the performance of any signature verification method [8].

4. Implementation and Simulation Results

For our work, we took 31 original signature of 6 persons and 147 forgery signatures of them. Out of which 5 original signature of indiduals are used for training, 31 original signature and 147 forgery signatures are used as test input signatures. Template file is used as reference(database). When test signatures(31 original and 147 forgery signatures) are entered into the system, it is compared with reference (Template file) on the basis of Euclidean distance and if it is below certain local threshold value or global threshold then it result as genuine signature otherwise it is fake.

Table 1: Result Table for FAR and FRR

Signs Type						
No. of genuine tested	6	6	9	5	5	-
No. of genuine rejected	2	2	4	3	1	-
No. of forgeries tested	40	26	8	22	14	37
No. of forgeries accepted	7	2	0	6	5	10
Global Threshold value	20	20	20	20	20	20
FAR	17.68%					
FRR	35.48%					

5. Conclusion

We propose an Off-line verification and classification system which is used to detect all kinds of forgeries for ***Tracing Forgery, Random Forgery, skilled forgery***. This work helps to improve current verification system methods. The various features extracted in this work such as Normalized Area of the Signature, Aspect ratio, the centroid feature, tri-surface feature & the six fold-surface feature will give better result for the system (better FAR) to avoid various forgeries. A better pre-processing stage and larger database can reduce FAR as well as FRR.

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Author Profile

Ashish Kadlag received the B.E. degrees in Electronics Engineering from Pravara Rural Engineering College in 2012. He is now doing his master of engineering in E&TC (VLSI and Embedded System) from Sinhgad Academy of Engineering, kondhwa (bk),.Pune, India