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A Survey on Signature Verification Approaches

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***Abstract*—Signature is one of the most popular biometrics used for authentication. There are different techniques through which one can classify the signature as true or forged .This paper reviews the different approaches towards sign verification methods. And this is what the reason that explains applications of signature verification in areas like mortgage, cheque processing, in financial transaction etc. Different techniques give different figures for measurement of FAR (False Acceptance Rate), FRR (False Rejection Rate),EER(Equal Error Rate)which are elaborated in this paper.**

***Keywords*— signature verification, forgery, FAR, FRR, EER**

INTRODUCTION

The signature is one of the unique identities but still signature of the same person may vary with time, age, emotional state of a person. Signatures are a subconscious expression. Both the signer and the authorizer are impacted by mood environment, writing instrument, writing Surface, fatigue. Due to this signatures are highly vulnerable. So it becomes necessary to be secured from attacks like forgeries or frauds. So the main approach of this paper is to review the different methods to avoid and control the forgeries which can be either random forgery, unskilled forgery or skilled forgery where we can say that skilled forgery is somehow difficult to detect among other type of forgeries. Signature verification can be applied to many fields such as automated fraud management, matching for document search and retrieval, Transaction authorization, passports, voting, etc.

The applications using signature verification reduces cost and risk and also unlike human being doesn't get tired or have a bad day, Can process much higher volumes, consistently demonstrates higher accuracy.

I. TYPES OF SIGNATURE VERIFICATION

There are generally two ways by which verification of signature is possible in order to classify the test signature for its originality or forgery. Those are: Offline Signature Verification System and Online Verification System.

A. *Offline Signature Verification System:*

In offline method of verification static characteristics are to be taken into account so that it satisfies the name "offline". The static characteristics includes component oriented and pixel oriented features of signature image. As static features are to be extracted it doesn't require special devices like stylus or digitizer tablet to recognize the signature as shown in fig.1. Its only requirement is image or snap of the signature which can be acquired through the good quality cameras or if possible scanners.

Fig.1 The way of signing in offline method

B. *Online Signature Verification System:*

Online method of signature verification considers the dynamic characteristics for computation purpose. The dynamic characteristics or features include writing speed of signature, pressure points, strokes, acceleration etc. To grab signature dynamic information the extra devices such as electronic tablets become the necessity for the applications using online approach for signature verification.

Fig.2 The way of signing in online method

II. PHASES OF SIGNATURE VERIFICATION SYSTEM

There are different phases through which test signature has to pass. For such type of verification first it has to decide approach i.e. online or offline. Depending on the approach the features are extracted and only those features are verified against the features of sample signature which are used for training.

A. *Signature acquisition*

Test signature is acquired according to the method used for verification. If offline method is adopted the signature is made conventionally on paper having direct contact between pen and paper. And Off-line signature analysis can be carried out with a scanned image of the signature using a standard camera or scanner as per the quality is required. On the other hand if online method is used for verification then On-line or dynamic signatures are written with an electronically instrumented device and the dynamic information (pen tip location through time) is usually available at high resolution, even when the pen is not in contact with the paper. Once the signature is acquired it is just available in the actual form. But the signature in this form cannot be considered for further verification as it is. It needs some pre-processing.

B. *Signature Pre-processing*

The signatures are required to be pre-processed mainly for removal of noise. The signature may contain extra dots or extra lines which are not the real part of signature. In online signature verification hooks are needed to be removed and also to be smoothened. As a signature is to be pre-processed resizing, binarization, rotation, thinning, cropping, grey scale conversion and such more operations are supposed to be performed.

Due to such pre-processing the signature does not require the unnecessary comparisons which may make the algorithm complex. And at this stage actually the signatures are ready for feature extraction. And so the signature is preceded towards feature extraction.

C. *Feature Extraction*

Signature verification is a system which extracts the features of the signature depending on the method used. In online method it extracts the features like momentum, pressure, velocity, break points, writing angle which can be analysed dynamically when signer is actually writing a signature on the specialised hardware like digitizer. While in offline method local and global features such as aspect ratio that is ratio of height to width, grid, contour features are studied to get the signature in terms of its features.

D. *Verification*

Last important phase of this system is verification which is performed to get the result that whether the sign is originated from original signer or it is forgery. In this phase the extracted features of test signature are verified against the features of sample signature which are already stored in database of the system. If the features are matched for their particular parameters according to the assigned threshold value. Threshold value is specified as per the level of security is needed. And finally the determined result of verification step classifies the signature as original or forgery.

III. APPROACHES USED FOR SYSTEM

[1]This paper presents a method for offline signature verification and recognition by using MLP neural network It includes Image Pre-Processing, Feature Extraction-For this signature recognition and verification research, four main features will be extracted. These features are: eccentricity, skewness, kurtosis, orientation.

Pattern Recognition through Neural Network and it used Multi-Layer Perceptrons MLPs neural network. The structure of this neural network depends on the multi-layer feed forward, where all the nodes in any layer have connections to all the nodes in the next layer and so on, but these nodes do not have any connections with the previous layers. Then, it was modified to function as a back-propagation neural network, using the BP algorithm. The implementation of BP learning, updates the network weights and biases in the direction in which the performance function decreases most rapidly.

[2] This paper has presented an analysis of fluctuation of Hu's moment invariants on image scaling and rotation. This is divided into loosely coupled phases like pre-processing, feature extraction, feature matching, feature comparison and classification. Several local features are introduced and compared using different classification approaches. The features extracted from signatures are based on HSV system. This paper uses HSV by using NN architecture. Various static signature features like Maximum Height, Horizontal Length of signature, Aspect Ratio, Number of "pen-ups" ,number of breaks in signature, etc. .are extracted and used to train the NN. Most important feature under consideration for the process of signature verification is Hu's Moment Invariant. Hu's introduced seven moment invariants in 1962. The non-orthogonal centralized moments are translation invariant and can be normalized with respect to changes in scale. However, to enable invariance to rotation they require reformulation. Hu described two different methods for producing rotation invariant moments. These moments having the desirable properties of being invariant under image scaling, translation, shear in and rotation .this paper has also given Table showing the values of fluctuation for seven moment invariants on different resolution from 60x60 to 330x330.

[3] This paper presented a new technique based on variable length segmentation of signatures in a HMM model for on-line signature verification. the algorithm in, "Segmenting handwritten Signatures at their perceptually important points, "by J. J. Brail and R. Plamondon is modified to segment each signature based on its perceptually important points or segmentation and then computes for each segment a number of features that are scale and displacement invariant. The resulted sequence is then used for training an HMM to achieve signature verification.

Besides the choice of the HMM-topology, the probability density function modelling of the HMM is the most important part in order to design the most appropriate models for the verification task. They have chosen continuous HMM based on a Gaussian mixture model. This method separates curve lines of an image in areas of nonzero values spaced by areas of zero values. A nonzero domain characterizes an important area of signature and is represented by the point of maximum significance.

[4] This paper presents an off-line signature verification system that aims specially at verifying Arabic and Persian signatures. The proposed system is based on Discrete Wavelet Transform (DWT) to extract common features to aid the verification step. This system consists of four steps: pre-processing, signature registration, feature extraction, and signature verification.

Each sample is decomposed using DWT into four images , the first image represents the low pass values, while the other three images represent the high pass in vertical, diagonal and horizontal directions, respectively. DWT is mainly used to extract the features from the image. The proposed technique uses the high pass images to extract the necessary information for the signature verification. Verification is performed this using an XOR operation and logical equations. The difference between the two images decides the verification percentage.

[5] We propose a graph-matching based automatic signature verification technique which is based on geometrical shape of the critical regions of the signature. The proposed approach consists of extracting critical points on the input signature, locating the corresponding critical points among the sample signatures, extracting the critical regions centred around the critical points on the respective signatures, matching the corresponding critical regions using graph matching algorithm, training the sample signatures and finally, verifying the authenticity of the test signature

All grey scale images are binarized with the help of modified Niblack algorithm. Noise is removed by using a simple morphological filter. The filtering is done by using 2-D convolution with a 5X5 Unity matrix. The grey scale image thus obtained is further binarized using a strict estimated threshold. We use the bottom pixels of a signature image as a template to fit an orientation line through them using the polyfit function. The technique of thinning is applied by LOCAL coupling Points.

A contour based approach is followed to extract the critical points. In this approach the contour is traversed and any sharp change in the curve is marked as a critical point. Critical points can be best described as the set of points which model the basic structure of the signature. They are a minimum set of points to represent the shape of a signature. Once we get the optimal distance vector we compare it against a threshold

This identified isolated, smaller critical portions of the signature images. These critical regions contribute significantly to the shape of the original image .These critical regions are utilized as a basis for graph matching, thus reducing the computational overhead by a large amount. Critical regions of size 31 ×31 are constructed and compared using Hungarian method.

[6] This paper proposes a new off-line signature verification and recognition technique. The proposed system is based on global, grid and texture features. In the first stage, the classifier combines the decision results of the neural networks and the Euclidean distance obtained using the three feature sets. The results of the first-stage classifier feed a second-stage radial base function (RBF) neural network structure, which makes the final decision.

The entire system is based on 160 features grouped to three sub sets and on a two-stage neural network classifier that is arrange in an-one- class -one-network scheme. During the training process of the first stage, only small, fixed -size neural networks have to be trained, while, for the second stage the training process is straight forward. No feature reduction process was used and the basic rule of thumb in deciding which features to include and which not was use all features and leave the neural networks decide which of them are important and which are not".

Global features like Image area , Pure width, Pure height, Baseline shift , Vertical canter of the signature, Horizontal canter of the signature, Maximum vertical projection, maximum horizontal projection, global slant angle, local slant angle, no. of edge points , no. of cross points etc. are extracted and also grid features and text features are extracted for verification purpose. Reduction of the feature space and Reduction of the necessary training samples are main features of this system.

[7] In this paper Off-line Signature Verification Based on Fusion of Grid and Global Features Using Neural Networks (SVFGNN) is presented. The global and grid features are fused to generate set of features for the verification of signature. The test signature is compared with data base signatures based on the set of features and match/non match of signatures is decided with the help of Neural Network.

The features of signature are extracted using pre-processing stages such as (i) Noise Reduction (ii) Size Normalization, and (iii) Skeletonization. The Gaussian filter is used for the noise removal. Since Gaussian function is symmetric, smoothing is performed equally in all directions, and the edges in an image will not be biased in particular direction. In grid features extraction skeletonized image is divided into 120 rectangular segments (15x8), and for each segment, the area (the sum of foreground pixels) is calculated. The results are normalized so that the lowest value i.e., the rectangle with the smallest number of black pixels would be zero and the highest value i.e., the rectangle with the highest number of black pixels would be one. The resulting 96 values form the grid feature vector. It is very encouraging to recognize diagonally so that more points may be diagnosed for generating the vector matrix to get results more accurate than the simple grid. And in global features like Aspect Ratio, Signature height, image area, pure width, and pure height are extracted from image of signature.

The standard back propagation neural network classifier for verification is used. Standard back propagation is a gradient descent algorithm, as is the Widrow-Hoff learning rule, in which the network weights are moved along the negative of the gradient of the performance function. Multilayer feed forward artificial neural network for verification of off-line digitized signatures is used.

[8] This paper presents a technique of Handwritten Signature Verification based on correlation between Handwritten Signature images using feature extracted from it. Five major phases for verifying a signature .These are Data gathering, Pre-processing, Training, and Testing. Feature extraction is a phase in which we extract various features from signature like its projection ,local point density ,spatial frequency distribution etc.

Instance-based learning or memory-based learning is a family of learning algorithms that, instead of performing explicit generalization, compare new problem instances with instances seen in training, which have been stored in memory. In feature Extraction various features from signature such as Feature Vector, Projection, Localization of Point Density, and Spatial Frequency Distribution are extracted.

[9]This proposed a local-shape-based model for handwritten on-line curves; this model is generated by first parameterizing each on-line curve over its normalized arc-length and then representing along the length of the curve,

in a moving coordinate frame, measures of the curve within a sliding window that are analogous to the position of the centre of mass, the torque exerted by a force, and the moments of inertia of a mass distribution about its canter of mass. Further, It suggest the weighted and biased harmonic mean as a graceful mechanism of combining errors from multiple models of which at least one model is applicable but not necessarily more than one model is applicable, recommending that each signature be represented by multiple models, these models, perhaps, local and global, shape based and dynamics based.

This approach parameterizes the signature over its length (l), Compute a moving coordinate frame, the coordinates of the centre of mass, the torque exerted about the origin, the curvature-ellipse measures. Measure of the discrepancy between the signature being verified and its model and whose comparison against a threshold determines whether we accept or reject the signature being verified

IV. SYSTEM EVALUATION PARAMETERS

A. *FAR*

The no of forgeries accepted by the system are given as the FAR that is False Acceptance Ratio which is measured as the ratio of no. of forgeries accepted to no. of forgeries considered for evaluation. So, FAR is calculated by the formula given in equation 1.1.

$$FAR= (N_{fa} / N_{ft})*100\ldots\ldots\ldots..1.1$$

Where N_{fa} is number of forgeries accepted and N_{ft} is number of forgeries tested.

B. *FRR*

The no of originals rejected by the system are given as the FRR that is False Rejection Ratio which is measured as the ratio of no. of originals rejected to no. of original signatures considered for evaluation. So, FRR is calculated by the formula given in equation 1.2.

$$FAR=(N_{or}/N_{ot})*100\ldots\ldots\ldots\ldots1.2$$

Where N_{or} is number of originals rejected and N_{ot} is number of originals tested.

C. *ERR*

In the graph plotted as FAR vs. FRR the crossing point is called as EER point which defines Equal Error Rate of the signature verification system.

V. COMPARISON TABLES SHOWING EXPERIMENTAL RESULTS

In this section the table I and table II are giving the experimental results of different methods which are measured for their FAR, FRR, EER values.

TABLE I
COMPARISON of FAR and FRR

Sr.no	Method		FAR (%)	FRR (%)
1	SVM[4]	Linear	21.06	18.53
		Poly	15.41	15.64
		RBF	15.41	13.12
2	Fuzzy Net[4]		13.26	11.89
3	Offline Signature Verification and Identification using Distance Statistics[10]		34.91(Set1)	28.33(Set)
			33.80(Set2)	30.93(Set)
4	Novel Features for Offline Signature Verification using feature point extraction[10]		16.36	14.58
5	Offline Signature verification using Local Radon Transform & SVM[0]		22	19
6	Grid Based Feature Extraction(Database A)[10]		9.7	17.9
7	Grid Based Feature Extraction (Database B)[10]		12.6(Set1)	10.2(Set1)
			13.5(Set2)	10.8(Set2)

TABLE II
COMPARISON of EER

Sr No.	Method	EER (%)
1	Neural Network Approach[1]	21.20%
2	Hu's invariant moment analysis [2]	25.50%
3	Variable Length Segmentation and Hidden Markov Models[3]	25.50%
4	Grid based feature Extraction [10]	8.80%

VI. CONCLUSION

In biometrics the signature is becoming most important for authentication and so it becomes necessary to enhance its application with automated systems to avoid forgeries and ultimately the fraud. In this paper the approaches of signature verification system are studied according to their different steps and also it gives the performance evaluation on the basis of FAR, FRR and ERR so they can be analysed for their efficiency to get better result.

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