Review of Feature Extraction Techniques for Offline Signature Verification

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***Abstract*-- Signature is considered as one of the most important biometrics, since every person has, his/her own unique signature. Signature by authorized person is only considered as authentic. Signature verification is very important in financial, commercial and legal transactions. Signature verification is split into two according to the available data in the input, Off-line and On-line. Signature verification system consists of preprocessing, feature extraction, classification and verification phases. Since performance of every signature verification system depends on the quality and types of features extracted, feature extraction is very important phase. This paper presents survey on several feature extraction techniques used by researchers in their offline signature verification system.**

I. INTRODUCTION

A signature is a handwritten depiction of someone's name, nickname, or other mark that a person writes on documents as a proof of identity and intent. Handwritten signature may contain special characters or symbols and most of the time it can be unreadable. Each person has a unique handwritten signature. The way a person signs their name or writes a letter can be used to prove a person's identity. That is signature can be considered as one of the biometrics. Signature verification is the decision about whether signature is genuine or forge. Signature verification basically consists of Preprocessing, Feature extraction, and Classification and Verification stages explained as in next paragraphs.

A. Preprocessing

The purpose of pre-processing phase is to make signatures standard and ready for feature extraction. The pre-processing stage primarily involves noise reduction, resizing, Binarization, thinning, clutter removal and normalization. Some or all of these pre-processing steps are required for any offline signature verification system since offline signatures are obtained as a digital image through a scanning device which may include any noise or distortions.

B. Feature Extraction

Feature extraction is required when input data to an algorithm is too large and redundant. This redundant input is then transformed into concise and essential set of features. This method is called as feature extraction.
Features relative to offline signature may include
1. Global features: Global features are the features extracted from the whole signature image. Global features include signature area, signature height to width ratio, center of gravity, Maximum horizontal histogram and maximum vertical histogram, Image area, Edge point numbers of the signature, Signature height, Horizontal and vertical center of the signature Image area, Pure width, Pure height, Vertical projection peaks, Horizontal projection peaks Number of closed loops Local slant angle Number of edge points Number of cross points Global slant angle Baseline shift. etc.
2. Local features: Local features are the features extracted from the small portion of signature image. Local features include local pixel density, slant features, critical points etc.
3. Geometric Features: Geometric features are the features that describe the characteristic geometry of a signature that preserves both their global as well as local feature properties. Geometric features have the ability to tolerate with distortion, style variations, rotation variations and certain degree of translation.

C. Classification

Classification is the process in which input data is categorized. A new data when input into the system it can be easily identified as belong to particular category. The algorithm that implements this task is called classifier. This classifier maps the input data into category. Classifier for any signature verification system may include Hidden Markov Models, Support Vector Machine, Neural Network, Distance classifiers etc.

D. Verification

In this step trained classifier verifies test signature against set of sample signatures it was trained during classification phase. If match is found above certain threshold then signature is considered as original otherwise it is considered as forged.

II. LITERATURE SURVEY

In [1] Vu Nguyen, Michael Blumenstein and Graham Leedham used global features based on the boundary of a signature and its projections for enhancing the process of automated signature verification. The first global feature is derived from the total 'energy' a writer uses to create their signature. The second feature employs information from the vertical and horizontal projections of a signature, focusing on the proportion of the distance between key strokes in the image, and the height/width of the signature. The combination of these features with the Modified Direction Feature (MDF) and the ratio feature are used to show promising results for the off-line signature verification problem. When being trained

using 12 genuine specimens and 400 random forgeries taken from a publicly available database, the Support Vector Machine (SVM) classifier obtained an average error rate (AER) of 17.25%. The false acceptance rate (FAR) for random forgeries was also kept as low as 0.08%.

[2] Samit Biswas, Tai-hoon Kim and Debnath Bhattacharyya used clustering technique for feature extraction of signature image based on a k nearest neighbours approach enabling to handle clusters of different sizes and shapes. After pre-processing region of interest (ROI) is detected from sample and test signatures and scaling is performed on them. Features extracted include signature height width ratio, signature occupancy ratio, distance Ratio calculation at boundary, length and ratio of Adjacency Columns, number of spatial symbols within the signature Image which are then used for clustering of signature image for verification stage. These features are extracted for both sample and test signature image. Finally using K-nearest neighbours algorithm used for verifying a test signature belongs to which cluster. Experimental results of this method clearly showed the difference between actual and forged signatures.

Prasad A. G. and Amaresh. V. M.[3] performed geometric feature extraction on signature image. They extracted shape features of signature such as baseline slant angle, aspect ratio, normalized area of signature, centre of gravity, Slope of the line joining the centres of gravity of the two halves of signature image. Euclidean distance method is then used to perform verification of test signature against sample signature. 70 original signatures with 8.57% FRR and 45 forged signatures with 13.33% FAR are found with database under test in this method.

Prashanth C. R. and K. B. Raja [4] proposed offline signature verification based on angular features. The scanned signature image is skeletonised and exact signature area is obtained by pre-processing. In the first phase, the signature is divided into 128 blocks using the centre of signature by counting the number of black pixels and the angular feature in each block is determined to generate 128 angular features. In the second phase the signature is divided into 40 blocks from each of the four corners of the signature to generate 40 angular features. Totally 168 angular features are considered from phase one and two to verify the signature. The difference between the angular features of the genuine and test signatures is computed and compared with the threshold value to authenticate the signature.

Vibha Pandey and Sanjivani Shantaiya [5] used morphological or shape features to perform feature extraction from signature image. Total 9 features are extracted using this technique as Total Area, Convex Area, Equidiameter, Euler Number, Extent, Major Axis Length, Mean Orientation, Solidity, Number of objects etc. These features are extracted for sample and test signatures and passed to feed forward neural network classifier for signature verification. This signature verification performed on database containing 200 genuine and 200 forged signatures. This method gave accurate identification of genuine and forged signature i.e. 0.99 (approx 1) for genuine and 0.02 (approx 0) for forged signature.

Mahendra Singh Chauhan [6] used fixed point arithmetic method, 12 feature point methods for feature extraction of a signature image. The method they used is based on selecting 60 feature points from the geometric centre of the signature and compares them with the already trained feature points. The classification of the feature points utilizes statistical parameters like mean and variance. FRR found with this method is 20.83.

H. H. Wai and Soe Lin Aung [7] proposed a new feature extraction technique based on signature image splitting. Signature image having in lower right corner of the bank cheque is acquired. Signature image is converted to binary image using Otsu's method and then bounded in the (rectangle) bounding box. Before finding centre of gravity of the whole signature image, it is initially detected whether it has interesting pixel or not. After finding the centre of gravity, the image is firstly partitioned to achieve four blocks. When partitioning parts of each of four blocks, its block is detected whether it has interesting pixel or not. After detecting pixel, blocks are further partitioned until 64 sub-blocks are achieved. Finally, three robust features that include pixel density and angle are extracted from each sub blocks.

Marianela Parodi, Juan C. Gomez and Abdel Belaid [8] proposed a new technique for rotation invariant feature extraction based on a circular grid. Graphometric features for the circular grid are defined by adapting similar features available for rectangular grids, and the property of rotation invariance of the Discrete Fourier Transform (DFT) is used in order to achieve robustness against rotation. A Support Vector Machine (SVM) based classifier scheme is used for classification tasks. The classification results on a public database, quantised by the FRR and the FAR for simple and skilled forgeries, show that the proposed signature verification system has a performance comparable to similar ones of the state-of-the-art.

Minal Tomar and Pratibha Singh [9] proposed new feature extraction technique for offline signature verification system with directional feature and energy density of a signature. Directional feature and energy density both are used as inputs to the same neural network which then classifies the signature. The results when compared with both the very basic energy density method and a simple directional feature method of offline signature verification system this proposed new network was found very effective as compared to the above two methods, specially for less number of training samples, which can be implemented practically.

Mustafa Berkay Yilmaz, Berrin Yanikoglu, Caglar Tirkaz, Alisher Kholmatov and Tubitak Uekae [10] presented an offline signature verification system based on a signature's local histogram features. The signature is divided into zones using both the Cartesian and polar coordinate systems and two different histogram features are calculated for each zone namely histogram of oriented gradients (HOG) and histogram

of local binary patterns (LBP). The classification is performed using Support Vector Machines (SVMs), where two different approaches for training are investigated, namely global and user dependent SVMs. User-dependent SVMs, trained separately for each user, learn to differentiate a user's signature from others, whereas a single global SVM trained with difference vectors of query and reference signatures' features of all users, learns how to weight dissimilarities. The global SVM classifier is trained using genuine and forgery signatures of subjects that are excluded from the test set, while user dependent SVMs are separately trained for each subject using genuine and random forgeries. The fusion of all Classifiers (global and user-dependent Classifiers trained with each feature type), achieves a 15.41% equal error rate in skilled forgery test, in the GPDS 160 signature database without using any skilled forgeries in training.

Almudena Gilperez, Fernando Alonso-Fernandez, Susana Pecharroman, Julian Fierrez, Javier Ortega-Garcia [11] built machine expert for offline signature verification system based on contour features. It works at the local image level, and encodes directional properties of signature contours and the length of regions enclosed inside letters. Results obtained on a subcorpus of the MCYT signature database shows that directional-based features work much better than length-based features EERs of 6.44% and 1.18% for skilled and random forgeries, respectively.

K. N. pushpalatha, Aravind Kumar Gautham, D. R. Shashikumar, K. B. Shivakumar and Rupam Das [12] presented offline signature verification with random and skilled forgery detection using polar domain features and multi stage classification regression model. They used polar feature descriptor for signature that contains Radon Transform and Zernike Moments. Verification is performed using Multiclass Support Vector Machine. Once a signature is verified as being of a registered class, PLS Regression is applied on the sample against all samples in the database of the verified user to obtain regression score. Log Likelihood of the sample against all sample of the user is calculated using Hidden Markov Model. Authenticity of the
Classification is justified if the regression score and Log Likelihood distance deviation is less than 5%. Results showed that the system verifies signature with an accuracy of 98% with false acceptance rate of .8%. This system also detected skilled forgery with an accuracy of 71% and Random forgery with an accuracy of 76%.

Meenakshi K. Kalera, Sargur Srihari and Aihua Xu [13] used a Quasi-Multiresolution technique using GSC (Gradient, Structural and Concavity) features for feature extraction for offline signature verification system. These features when used at word level instead of character level, provides promising results with accuracies as high as 78% and 93% for verification and identification respectively.

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