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Offline Signature Recognition Using PCA-NN Method and GLDM Feature Extraction

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Abstract*— Offline Signature verification is still stand out amongst the most difficult issues in biometric systems. In this study, we implement Offline Signature Recognition using Principal component analysis (PCA) and Neural network (NN) approach. We extract signature features using gray-level difference method (GLDM). The proposed system works in three parts. First Pre-processing: where binarization, filling holes and fitting limit box is done to make signatures prepared for feature extraction then Feature extraction: where GLDM based projection elements are extracted which are utilized to recognize the distinctive signatures. In the feature extraction process, we evaluate probability density function for each image. Finally signature recognition and designing Back Propagation Neural Network (BPNN) as classifier to recognize signature. In the experimental results, we improved signature recognition accuracy in terms of recognition rate up to 90-99.99% with database of SVC20EU (110 signatures of 10 persons).

***Keywords*— Signature Recognition, PCA, GLDM, Signature Verification, Neural Network**

I. INTRODUCTION

A signature is a handwritten depiction of person's name, or other mark that it creates on records as a proof of its identity. The writer of a signature is also known as the guarantor or the signatory. Unlike PIN codes and passwords, signatures cannot be borrowed, stolen and even hard to be forgotten or replicated by others, for this reason, signature has been broadly used now a days as a secure means to authenticate legal documents , financial transactions and many more.A signature is generally a fusion of exceptional characters and/or the individual's name. It is frequently composed in an extraordinary manner, regularly coming to an incomprehensible state [1][2].Different automatic signature confirmation systems have been proposed all through the writing. But still signature recognition remains a challenging task. Automatic signature recognition frameworks can be utilized in various fields, including MasterCard approval, security frameworks, bank checks, contracts, and many other aspects in daily life. Frameworks in this field can be comprehensively ordered into either signature check frameworks or mark as distinguishing proof frameworks. While signature confirmation frameworks choose whether a given mark fits in with a guaranteed signatory or not, a mark distinguishing proof framework, then again, needs to choose to which one of a specific number of endorsers a given mark fits in with. Signature check frameworks can be further characterized into two categories: online (or dynamic) and offline (or static) frameworks. In Online mode ,users write their signature in digitizing tablet, which acquires the signature in real time and thus get the dynamic information like velocity, acceleration, pressure, position .While in offline mode , we get only the 2D (gray level or binary) image of signature ,which make design of its verification system more complex .Whether offline or online, the configuration of a verification framework requires five fundamental steps: information procurement or acquisition, preprocessing, feature extraction, correlation procedure, and decision. The outline of the static framework is more mind boggling than that of dynamic because of the unavailability of timing and element data.

In this paper, offline signature recognition framework is exhibited, where the signatures are caught and further investigated and distinguished. The creators accept that by permitting the signatory to take part amid the choice stage, a higher precision signature verification framework would be accomplished. Appreciating results have been achieved by artificial neural networks in the process of signature recognition. In this methodology, artificial neural network is trained to recognize similarities and patterns between different signature samples [3] [4].

II. LITERATURE SURVEY

Various methods have been presented for signature recognition in literature.

In [1], Mujahed Jarad et al. present Offline handwritten signature verification system using a supervised neural network approach. In this, an Artificial Neural Network is designed based on back- propagation algorithm for signature recognition and verification. This system was tested with 400 test signature samples, including forged and genuine signatures of twenty individuals. Recognition decision is based on local or global features extracted from signature under processing. For testing the performance of the system, the False Accept Rate, False Reject Rate, and the Equal Error Rate are calculated. This approach allows judging the signature accuracy, and achieving more effective results.

Handwritten signatures standout amongst the most utilized biometrics, especially in budgetary and lawful transactions. Wajid et al. in [6] evaluated the capabilities of different classifiers for static signature verification based on LBP (local

binary patterns) which is an efficient gray-level feature extraction technique. The feature vector is shaped by separating the signature pictures into twelve neighbourhood locals and framing a code lattice by their LBPs. The histogram of every code lattice is formed and linked. The dimensionality of vector is consequently decreased by keeping the 256 DCT coefficients of the connected vector. He researched the execution of seven classifiers on FUM-PHSDB dataset containing 20 classes of honest and fake signatures of depth 20 and 10 respectively. Tentative discoveries describe that LS-SVM performs best among the seven classifiers, accomplishing the Equal Error Rate (EER) of 13%.

Angadi et al. in [7] presented an offline signature recognition system based on local radon features. In this to distinguish different signatures total 16 radon transform based projection characteristics are extracted and then finally back propagation neural network is sketched and trained with 16 extracted characteristics. The trained Neural Network is then further employed for signature recognition and gives an average accuracy ranging from 97%-87%.

Ali Karouniin et al. [8] employed a system to verify offline signature using shape based geometric features which are Area, Kurtosis, Skewness, Eccentricity and Center of Gravity. Before feature extraction preprocessing is done to remove the unwanted noise present and then converted into binary image. Proposed system improves recognition by using a variety of global shape features. Graphical User Interface (GUI) was used for getting the level of accuracy.

Bhattacharya [9] in his paper proposed pixel matching technique for signature verification and recognition. The performance of the projected system has been judge against the existing Artificial Neural Network's (ANN) back-propagation method and Support Vector Machine (SVM) system and outcome shows comparable performance with the advantage of being simple and easy to implement

Nilesh [10] proposed an offline signature recognition & verification using back propagation neural network where Invariant Central Moment and Modified Zernike moment methods are used for invariant feature extraction. Preprocessing is done before applying these method for removing unwanted noise present in the signature. The system is firstly trained using record of 56 persons signatures then a mean signature is obtained for each by integrating the features obtained from a set of his/her genuine sample signatures .MATLAB is used for designing this system.

III. PROPOSED METHODOLOGY

The proposed methodology for accomplishing offline signature recognition consists of following main steps:

A. Data Acquisition

The database can be taken from individuals by making them to sign on a piece of paper and converting it into digital format by scanning or is available on internet for research purpose. In this paper, SVC20EU handwritten signature database consisting of 110 signatures of 10 persons is used.

B. Pre-processing

In this acquired signature is further pre-processed to make signature standard and ready for feature extraction. This is generally done to eliminate any noise if they get induced in data acquisition phase. In this stage image is first binarized to make feature extraction simpler. The binary image of the signature contains just 0's and 1's. Where 0's indicates signature boundary and 1's indicates blank white area as indicated in Fig 3. This is performed by setting a particular threshold value, above which every gray value is 1 and below which every value is 0. After this, we perform image filling operation for filling image holes so as to get the proper geometric shape of the signature as shown in Fig 4.

C. Feature Extraction

Achieving good performance in signature recognition system mainly depends on the selection of resourceful feature extraction methods. The proposed system used Gray level Difference Method (GLDM) for feature extraction [6] which estimates the Probability Density Functions for a given image. For a given, image intensity function I(x, y) and displacement $\delta = (\Delta x, \Delta y)$, the value of probability density function $f(i|\delta)$ is estimated from the number of times change in intensity $I_\delta(x,y)$, occurs for a given displacement d, i.e $f(i|\delta) = P(I_\delta(x, y) = i)$. In this four possible forms of inter sample spacing distance d were considered: (0, d), (d, 0), (-d, d), and (-d, -d).

Other then GLDM technique, central moment and Zernike moments [10] are also obtained for scale, translation and rotation normalization respectively.

D. Signature Recognition

Principal component Analysis (PCA) technique is utilized for signature recognition. It is a way of identifying patterns in data, and expressing it in a way to highlight their similarities and differences. The purpose behind PCA is to decrease the hugged dimensionality of the data space to the littler natural dimensionality of the element space (autonomous variables), which are expected to explain the information economically.

- Firstly acquire an initial set of N training signature images represented by $I_1, I_2, \ldots, I_N$ .Every signature I_i is represented to as a vector Fi.
- Estimate deviation for every signature image from the mean (average) signature vector given by φ. The equation will be as follows:

$$\emptyset i = Fi - \varphi$$

Where $\varphi = \frac{1}{N}\sum_{i=1}^{N} Fi$

- Determine A , a set of deviation vector of N images

  $A= [\varphi_1 , \varphi_2 , \varphi_3 ,..... \varphi_n]$

  where, φ_i is the deviation vector for ith image, which will then be used for forming covariance matrix given by D.

  $D = A A^T$

  Here D is an M_2xM_2 matrix and A is an M_2xN matrix. In place of matrix AA^T, we study the matrix A^TA. Remember A is a M_2xN matrix, thus A^TA is an NxN matrix.

- Compute the Eigenvectors of this matrix, it would return N Eigenvectors, each of dimensions Nx1, which provide us with information about the patterns in the data. Once eigenvectors are found order them by their eigenvalue, highest to lowest, giving the components in order of their significance.The eigenvector with the highest eigenvalue is the principle component of the data set.
- Form feature vector with the selected eigenvectors in the columns.

  Feature Vector = (eig_1, eig_2,eig_3.....eig_n)
- Finally recognize the signature by finding euclidean distances between the projected test image and the projection of all centered training images, with matched signature be the one with minimum euclidean distance.

E. Performance Evaluation

For performance evaluation Neural Network is designed and implemented using MATLAB 12a with Neural Network Toolbox. It is a mathematical model inspired by the observation of neural network processing in biological system. There are numerous algorithms that can be used to create neural network, but Back propagation is chosen as it is easiest to implement, while preserving efficiency of the network. Neural Network consists of simple computational elements called neurons, which are linked with weights. It generally consists of 3 layers: the input layer, hidden layer and the output layer. The first layer takes the inputs while last one producing the outputs. The middle (hidden) layer has no connection with the external world, and hence is called hidden layers. It serves as a propagation point for sending data from the previous layer to the next layer.

In the exploration of proposed system, the number of units in the hidden layer is 30 and the total number of units, must reach the following rule: $h \geq (p -1) / (n + 2)$, where p is the quantity of preparing cases, and n is the quantity of inputs in the system.

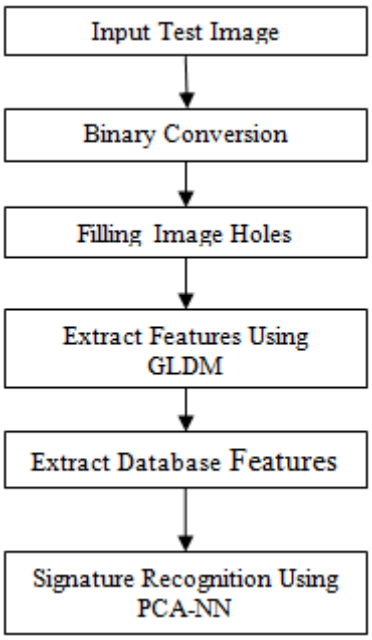


Fig1. Proposed System Block Diagram

1. Read Original Image

Fig 2. Show Test Image

2. Binary Image

Fig 3. Show Binary Image

3. Filled Image

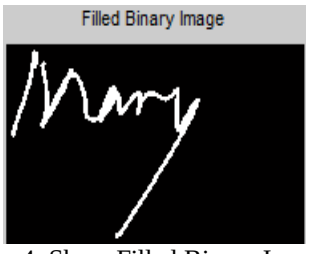


Fig 4. Show Filled Binary Image

4. Signature Matching

Fig 5. Signature Matched

IV. COMPARATIVE RESULTS

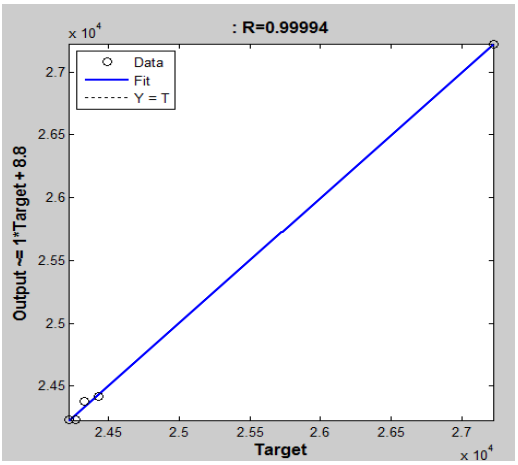
MATLAB:

Matlab is a data analysis and visualization tool which has been designed with powerful support for matrices and matrix operations. Along with this, Matlab has excellent graphics capabilities, and its own powerful programming language. One of the reasons that Matlab has become such an important tool is through the use of sets of Matlab programs designed to support a particular task. These sets of programs are called toolboxes, and the particular toolbox of interest to us is the image processing toolbox.

Table1. Recognition Rate Comparison between Base and Proposed Algorithm

Image	Mujahed Jarad's Recognition Rate (%)	Proposed Recognition Rate (%)
	57.4	98.87 Correct
	63.54	98.0 Correct
	99	99.96 Correct
	70.85	99.73 Correct
	33.33	99.95 Correct
	65.98	99.05 Correct
	74.84	95 Correct

	68.37	99.22 Correct
	99.77	98.316 Incorrect
	66.78	99.32 Correct



Graph1. Show Recognition Rate of Signature

In this graph, we showed the genuiness of the signature in the form of regression line and it reached up to 99.99%.

V. CONCLUSIONS

Offline signature recognition is an imperative biometric technique and has wide applications. In this paper, we implement Offline Signature Recognition using Principal component analysis (PCA) and Neural network (NN) approach. The proposed system has used GLDM technique for feature extraction and back- propagation neural network as classifier to recognize signature. It has been observed that features extracted using GLDM, along with central moment and Zernike moments are found to be efficient for signature recognition. We achieved the accuracy rate ranging from 90%-99.9% for enrolment of 10 persons. Future work of this work includes the analyses of the new features of signature image and combining those with the feature vectors used in this work to obtain better accuracy than the accuracy of the present works.

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