High Performance Offline Signature Verification and Recognition Method using Neural Network

Saeid Fazli , Shima Pouyan , HamedFathi

***Abstract*—Signature is a useful biological technique to recognize persons because of its ease of use and fast processing. For using signature to verify persons we need a high performance verification and recognition system. These systems can be either offline or online identification system. IN [1] our system had three classifiers for recognizing 360 signatures of 20 signers and the recognition ratio was 95.625%. But when the number of signatures gets more or the database includes similar signatures the system couldn't work well. IN [2] the proposed system recognized700 signatures of 50 signers and the recognition ratio was 84%.but that system suffers from low ratio of recognition. Thispaper discusses,offline signature recognition and verification system using neuralnetwork. This system enables the user to verify whether a signature is original or a fake.Our proposed system includesthree main steps: preprocessing of image, feature extraction and classification. This system can recognize 700 signatures with recognition ratio of 93.5% and verification original signatures from fake ones with ratio of 97%.**

Keywords— recognition; verification; neural network;preprocessing; feature extraction.

I. INTRODUCTION

The recognition and verification of signature is one of the most important and reliable way to identify the individuals. So a system with ability of recognizing the owner of signatures and deciding the signature is whether original or fake, is essential.

Handwritten signature recognition can be whether on-line or off-line. In on-line recognition the signatures are collected by special devices such as tablet and in the off-line recognition systemsimages of signaturesare scanned or a camera is used. [3]

In this paper we use an offline signature recognition and verification system and the methodof classifying is neural network.

Our method includes three parts: 1- data collection and preprocessing, 2- extraction thefeatures and 3- data classification. Inour proposed method aftersignatures preprocessing, we derive some useful features that make signatures separable and show the differences of original and fake signature.

To achieve the best separation system, these features should determine differences between different signatures. After making a matrix of proper features, we use a classifier to devote signatures to the correct signers or decide about being original or fake. Figure 1 shows the block diagram of this system.

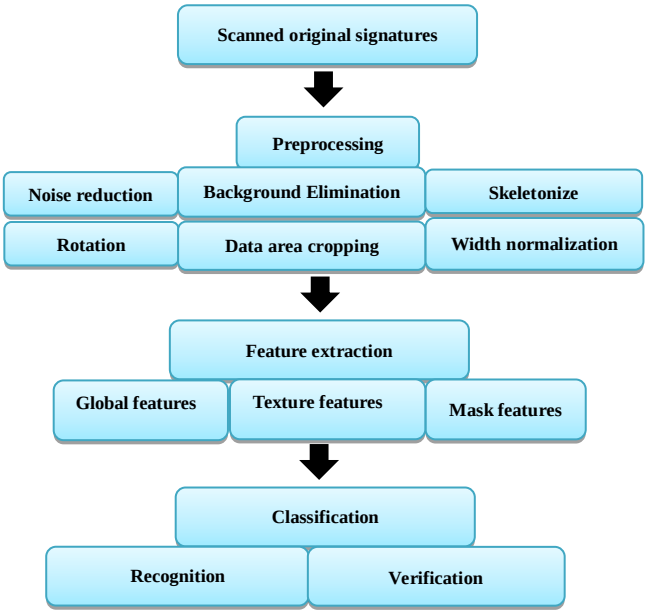

Figure 1. block diagram of proposed system.

To classify the signatures we use neural network. To achieve high-performance classifying system we test several NN topologies and finally a multilayer perceptron network is chosen.

The paper is organized as follows:

Before presenting description of data preprocessing in section 3, section 2 provides dataset we use in our experiments. Section 4 explains features which are extracted in this paper. The classifier explanation is

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defined in section 5. Section 6 presents experimental results and section 7 draws and discusses conclusions.

II. DATABASE

The signature database consists of 700 signature images. They are scanned at resolution of 300 dpi. They are organized into 50 sets, and each set corresponds to one signature enrollment. There are 14 genuine and 6 forgery signatures in a set. Each volunteer was asked to sign his or her own signature14 times on a white paper with base-lines.we asked some people to forge the signatures. Before main collection, they could practice 1 time and imitate the signature one time. It means each 6 set was forged by 6 persons.Fig. 1 shows somesamples of the database. 10 signatures of each person are given to train the Neural Network and 4 of them are for testing the classifier.Figure 1 shows examples of original database and figure 2 shows examples of fake data.

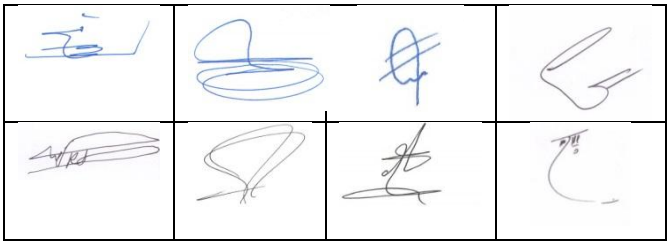

Figure 2. examples of dataset

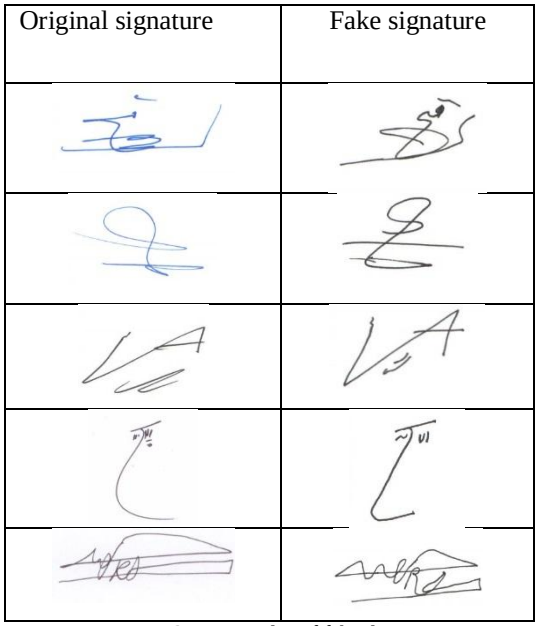

Figure 3. Examples of fake dataset

III. PREPROCESSING

After scanning the signature images they need to be preprocessed to make the dataset standard and in the same condition for extracting the features. Our preprocessing system includes:

a. Noisereduction:to increment clarity of images and remove noises of that we use Gaussian-filter.

b. Background Elimination: this step is for capturing the signature from its background and so that the extracted features are belongs to the signature.

c. Skeletonize: to eliminate the differences between pen pressureswe can make the thickness of images one pixel by removing pixels on the boundaries of signatures and it does not allow signatures to break apart. Pixels remaining make up the image skeleton.

d. Rotation: to make all signatures in the same directionswe rotate them. The rotation angle is finding by calculation the moment of order 2. Signatures are rotated in the clockwise around the centerofthescrew.

e. Data area cropping: we remove the margin of image to eliminate the white space of the image around the signature. this margin is before thefirstand after thelastpixel of the signature.[5]

f. Width normalization: to make the dimensions of the images the same we change the width and height of them and make them uniform. [3,5]

Figure2shows the results ofthisprocess on these images.

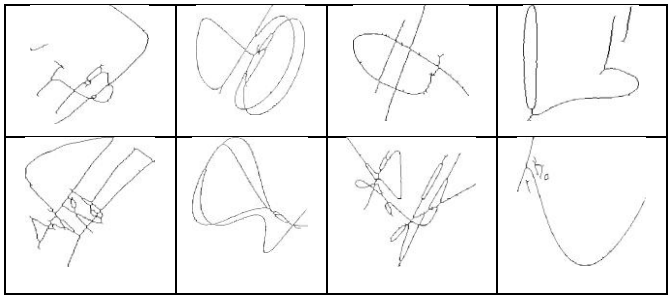

Figure 4. after preprocessing

IV. FEATURE EXTRACTION

The feature set plays an important role for verifying the signatures because learning of our classifier depends on that as an input vector for Neural Network. The features must be proper enough for the classifier. In this paper some features are used for the first time. These features are subset of global features and from 1 to 6.

The features we use in this paper are as followed:

a. Global features

1. Thickness: this feature is especially used to verify the fake signatures because to fake a signature the forger usually write with less speed and more pressure on pen so that the thickness of fake signature would be different from the original. This feature is calculated before thinning the images preprocessing. This feature causes 4% improvement in verifying fake and original signatures.

2. Roughness: to calculate the roughness of the signature we use this feature. This feature is also a good parameter to detect fake signatures because of the low speed of pen in forging the smoothness of the line will be change and so this feature will show difference between original and fake image so this feature is also used before preprocessing. This feature causes more than 6% increase in verification ratio.
3. Rotation angle: the angle of rotation in preprocessing is different in original and fake signatures because of the different angle of signing especially in fake and original ones.
4. Hough peaks: this feature identifies the coordinate of peaks of Hough transform. This one may be different in different signatures and can be useful.
5. Hough lines: this feature extracts line segments based on Hough transform and this one is variable for different signatures.
6. Loop counter:we name a branch line that turns from a direct path and rejoins it at the first location a loop. Number of loops in each signature is different so this feature is useful either in recognition or verification system. We use this feature in our system and achieve nearly 5% improvement in recognition ratio and more than 4% in verifying fake signatures.
7. Centroid: this feature specifies the center of mass of the signature.
8. Signature height-to-width ratio:the ratio of height to width of signatureis equal for each person.[3]
9. Signature Area: this feature shows area of each image which belongs to the signature.[3]
10. The Trisurface feature: we divide signatures into three parts so that we can calculate the area of each part and it is useful when the whole area of different signatures is the same. We name this feature,,Trisurface" .[10]
11. Number of edge points in the signature: this feature calculates edge pointsof the signature. Edge point is the pixel of the signature which hasonly one neighbor, in 8-neighbors.
12. Maximum horizontal and maximum vertical histogram: calculation of row's and column's horizontal and vertical histograms can be a good feature for different signatures. Finally we take the highest values as maximum horizontal and maximum vertical histogram.

b. Texture features

1. Texture homogeneity H:

$$H = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\{P(i,j)\}^2 \qquad (1)$$

This feature shows similarity of occurrence matrix with diagonal matrix called homogeneity.

2. Texture contrast C:

$$C = \sum_{i=0}^{G-1}\left\{n^2.\sum_{i=0}^{G-1}\sum_{j=0}^{G-1}P(i,j)\right\}, |i-j| = n \quad (2)$$

It shows local intensity changes in each pixel and its neighbours.

3. Texture entropy E:

$$E = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}P(i,j).\log\{P(i,j)\} \qquad (3)$$

This feature shows entropy of each image.

4. Texture correlation O:

$$O = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\frac{i.j.P(i,j)-(m_i.m_j)}{\sigma_i.\sigma_j} \qquad (4)$$

Correlation of each pixelwith theneighboringpixelsin theimage is calculated with this feature.

c. Mask features

We use 4 different 3x3 masks to provide information about directions of the lines of the signatures. These masks show the angles of the signatures. In Each mask is taken all around the signatures and the numbers of 3x3 parts of the signature, which are same with the mask, are calculatedand theresult is 4 features which define angles of 45, 90, 180 and 315.

V. CLASSIFICATION

In signature classification we are going to recognize the signer of each signature and verify if a signature is original or fake. So the input of classification system is a matrix of signature's features and the output of recognition system isa number which means the signer of that signature and the output of verification system is a number. 0 for fake images and 1 for original one and this number is calculated for all 50 sets.

The main reason for the wide usages of neural networks for pattern recognition is the high ability of that which can model the complicated functions and it is easy to use.We use multilayer perceptron with one input layer, one hidden layer and one output layer.

For recognition system the input layer includes24 neurons which is the number of features for recognition system. The output layer has 50 neurons because of 50 kinds of signatures which mean50 persons.

Inamulti-layerperceptronwithahiddenlayer, when deciding is on thetrainingfeatures, the problem is converting to decideonthe number of units inthe middle layer. Ascan be seen,the bestnetwork performanceis shownin Figure4. To find out the mostappropriatenumber of neurons we check

the system for different number of neurons. Figure 5 shows the overallscheme of proposed multilayer neural network, thenumber of neuronsis400with a value of0.01366.

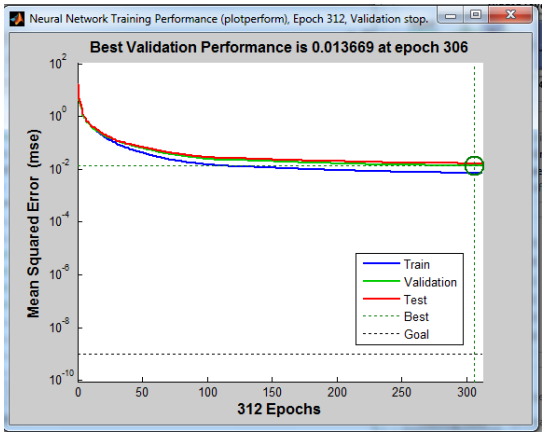

Figure 5:.Performanceof neural network for recognition system with 1 hidden layer.

For verification system the input layerincludes 22 neurons which is the number of features and these features are all mentioned above except maximum horizontal and maximum vertical histogram. Ascan be seen,the bestnetwork performanceis shownin Figure5. To find out the mostappropriatenumber of neurons we check the system for different number of neurons and thenumber of neuronsis200with a value of0.0196. Excitationfunctionsofthe middle layerandoutput layerofhyperbolictangentlineis selected as recognition system.

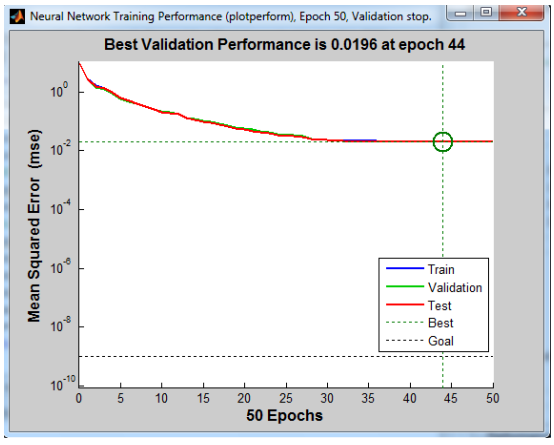

Figure 6.Performance of neural network for verification system with 1 hidden layer.

VI. EXPERIMENTAL RESULTS

We use 14 signatures of each 50 persons and totally 700signatures. We give 10 signature of each set for training our network and we have 4 signature of each one to test. The total number of signature to test our system is 200 andwe can recognize the signer of each signature with ratio of 93.5%.

And we have 6 fake signature of 50 signers and totally 300 fake signatures. We verify these signatures with ratio of 97%.

Table.1 shows the performance of our classifier for recognition and verification system.

TABLE I. PERFORMANCE OF CLASSIFIER FOR RECOGNITION AND VERIFICATION OF SIGNATURES

	Number of signatures	ratio (%)
Recognition	**200**	**93.5**
Verification	**300**	**97**

(Pansare et al., 2012) presented an approach which was tested on 30 individuals with recognition ratio of 85.7% and verification ratio of 88%.(Paigwar et al., 2013) have reported 81.5% correct recognition ratio using Neural Network and the signers number was 10.The verification ratio in this paper was 89%. (Hairong et al., 2005)proposed a method with 94.8% correct recognition ratio using SVM and the authors use 25 original signatures for each user.

This paper has reported 95.4% for verification ratio.The number of signers is similar to our signers number but the result of our work is better.(Martinez et al.,2006)described an approach that obtains 66.5% correct classification ratio using SVM and 45.2% correct classification ratio using Neural Network. The number of users of these authors is 38.(S.Fazli et al., 2014)presented a recognition system with ratio of 92% with SVM and the number of signature sets is 20. (I.A. Ismail et al., 2008)proposed verification system for 18 persons and reported 85% recognition ratio and 83% verification ratio.(Özgündüz et al., 2008) have reported 75% correct recognition ratio using neural network and 95% correct recognition ratio using SVM.

This paper also has reported 89% verification ratio using SVM and 84% verification ratio by neural network.The user numbers of these authors is 70.

In addition to the high efficiency of our proposed method, the recognition and verification systems we use are need just 10 signature to train them and number of features is proper enoughto be used in applications and the whole systems are simple.

So our approach is much simpler, realistic and high efficiency.Table.2 shows thesepapers results .

TABLE II.:OTHER PAPERS RESULTS

Method	Classifier	Recognition ratio (%)	Verification ratio (%)
Hairong et al.[7]	SVM	94.8	89
Martinez et al.[9]	Neural Network	45.2	-
Martinez et al.[8]	SVM	66.5	-
Özgündüz et al.[3]	Neural Network	75	84
Özgündüz et al.[3]	SVM	95	89
Piagwat et al.[9]	Neural Network	81.5	89
Ismail et al. [6]	Neural Network	84	83
Pansare et al. [10]	Neural Network	85.7	88
Fazli et al.[1]	K-Nearest Neighbor	79.5	-
Fazli et al.[1]	Neural Network	91.25	-
Fazli et al.[1]	SVM	95.6	-
Fazli et al.[2]	Neural Network	85	-

VII. CONCLUSION

This paper presentsnewsignature recognition and verification system which is based on three main steps: preprocessing to make signatures uniform,feature extraction with three groups of features: global features, texture features and mask features which are covers all aspects of signatures and a proper classifier. According to the low amount of features and the low number of signatures for training the system the result of both recognition and verification is very acceptable.It means we have a suitable preprocessing,the extracted features arecomprehensiveanduseful,and our classifier has the optimal parameters.The recognition and verification results of this paper provethat thefeatures we use combined with Neural Network classifier can result well.
In future research, we try to achieve higher recognition and verification ratio for more datasets by using more features according to the shapes of signatures and their different points.

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