ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

**IARJSET**

International Advanced Research Journal in Science, Engineering and Technology

NCRTET-17

National Conference on Recent Trends in Engineering & Technology

Government Polytechnic College Kasaragod, Kerala

Vol. 4, Special Issue 1

# Combined Global And Grid Features Based Handwritten Signature Recognition And Verification Using Support Vector Machine

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**Abstract-** The paper presents a Hand Written Signature Recognition and Verification System based on haar wavelet transform and Support Vector Machines (SVM). Signature recognition and verification systems are existing research area in which a number of research works are there and ongoing. This paper presents a system which recognizes and verifies signatures within less time, good accuracy in a less complicated way. For feature Extraction global features and grid features are considered mainly based on the Discrete Wavelet Transform (DWT) using the haar wavelets. Recognition of signatures done using Support Vector Machines (SVM) and Artificial Neural Network (ANN) and compared with the output accuracy. The inputs are images and outputs are the name of the signer if the test input is the genuine signature otherwise shows as forged signature. The features are extracted after pre-processing of the images and Principal Component Analysis is used for global wavelet feature reduction. Support Vector Machine training for combined grid and global features gives higher accuracy than other comparable methods here.

**Keywords**—Handwritten signature; Signature Recognition; Signature Verification; Support Vector Machine; Discrete Wavelet Transform;

## I. INTRODUCTION

The unique identification of persons is a very important security problem. Various Biometric Characteristics are considering for this purpose like a fingerprint, signature, iris, voice, etc. The signature of a person is unique and which can be used for identifying that person and also that can be used for ensuring security in many fields [1]. It consists of a person's name or which is a combination of special characters written in some special way. The Banking, Insurance, Educational areas are some examples fields in which the signatures can be used as the security technique. Now digital security is ongoing such as the smart cards, password security, pin code, etc. The addition of signatures will increase the uniqueness of such smart cards. The biometric technology is very useful for ensuring more security. The Physiological verification and behavioral verification are the two Biometric verification methods [2]. The speech, iris, fingerprint and retinal recognition are the examples of the physiological recognition and the signature verification is included in the behavioral recognition.The signature recognition and verification is the problem of identifying the person as well as finding whether the signature is genuine or forged. This is a research area in which numbers of methods are proposed in order to solve the problem using different technologies. The offline and online signature recognition and verification are two types of signature identification techniques. The online signature verification known as dynamic signature verification includes the dynamic features or the behavioral characteristics and static characteristics where as the offline signature verification includes only the static features. The pen pressure, time, acceleration, pressure applied to the pen, the angle of the pen, etc. are examples of the dynamic features and which is obtained at the time of signing [3]. The offline signature verification is complex because which only gets the static features and the input is here the scanned digital image of the signature.In this paper the global and grid features are extracted and they are given separately as well as combined in the training process. For the training purpose the Artificial Neural Network (ANN) and Support Vector Machines (SVM) are used separately and the performance of the system is evaluated. In the feature extraction process the Discrete Wavelet Transform (DWT) is used and for that haar wavelets are used. The system includes preprocessing of the signature image to make the input noiseless and clear. Here the database is prepared by collecting 8 genuine signatures each from 50 persons and 4 forged signatures of these 50 persons from different peoples.

### *A. Handwritten signatures*

The handwritten signatures are different for peoples and also for a person, it may vary depends on his/her mood, time, illness, urgency, etc. Hence the handwritten signature identification is difficult. The signature forgery is another security problem in the field of signature verification. A forger tries to imitate the handwritten signature of a person. Figure 1 shows the genuine signature and forged signature of same person.

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**Fig.1. (a) genuine signature (b) forged signature**

## II. RELATED WORK

Number of research works is on going in the field of handwritten signature verification and recognition. The paper [1] proposed the feed forward neural network based classifiers for designing the verification system. The projection moments and upper and lower envelope base characters are the features used for the classification. From the experimental results they concluded that combination of the classifiers will increases the reliability of the verification results. The error rate reduced to about 3% for the combining net and mentioned that combining net through learning is the desirable option. Paper [2] proposed wavelet-based offline signature verification. They used a closed contour tracing algorithm. From the experimental results they mentioned the average success rates for English signature and Chinese signatures are 91% and 93%.

In paper [3] proposed a signature verification system using Discrete Random Transfer and Hidden Markove Model (HMM). They only considered the global features. From the experiments they concluded that satisfactory results were obtained by considering the global features only. Here the Equal Error Rate (ERR) of 18% obtained when high quality forgeries are considered and 45% obtained when casual forgeries considered for skilled forgeries. Paper [4] presented an offline signature verification using support vector machines. They used the global features, directional features and grid features as feature vectors.

In paper [5] proposed a three stages method of signature recognition. Here Hough Transform Technique is used and also center of signature gravity is determined. For the identification mode the ERR is 2% and for the verification mode ERR is 4%. The paper [6] proposed a recognition system based on discrete cosine transform and 2 Dimension Discrete Hidden Markove Model (P2D-DHMM). The recognition rate of the proposed system is 92.3% and the non recognized rate is 7.67%.. They used the Baum Welch Algorithm for training the separate discrete HMM and forward algorithm is used for recognition. In paper[7] compared the signature recognition problem in the statistical feature method and artificial neural network approach .In the case of competitive networks the accuracy is ~97% but the precision is very low and also the complexity is high.

Paper [8] gives a study of the recent trends in biometric signature verification. They done the comparison on study of different signature verification schemes such as Bayesian learning, Hidden Markove Model (HMM), Dynamic Time Warping (DTW) and its variations, Neural networks, Support Vector Machines etc. Paper [9] gives a survey on the various signature verification and recognition schemes. The different forgeries such as random forgeries, casual forgeries, skilled forgeries, simulation forgeries, tracing forgeries, cut and paste forgeries, electronic forgery and freehand signature forgery are explained. They concluded by describing the two different problems associated with signature verification they are the non-repetitive nature of variations in the signature image due to age, geographic location and illness. The emotional state of the person may make variation in the signature. The second one is the security reasons. They concluded that the principal component analysis can be used to reduce the wavelet coefficients in order to make the time very less.

## III. PROPOSED SYSTEM

The proposed system used Discrete Wavelet Transform for extracting the global as well as the grid features and also other global features are considered. For training purpose the Support Vector Machine as well as Artificial Neural Networks are used separately and evaluated based on the accuracy and performance of the system. The System has five main stages they are Signature database acquisition, Pre-processing, Feature extraction, Training, Recognition and Verification.

### *A. Signature Database Acquisition*

The handwritten signature images are collected in a white paper and scanned them for creating the train data as well as the test data. For scanning the signatures normal scanners can be used and images can be saved in any of the format like png, jpg etc. For proposed system 400 genuine signatures are collected from 50 persons each with 8 samples. 200 forged signatures of these 50 persons are collected from different peoples each with 4 samples. Out of 8 samples of genuine signature from a person 7 are used for training and 1 used for testing and out of 4 samples of forged signatures 3 are used for training and 1 used for testing.

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*B. Preprocessing*

The signature image preprocessing are done for making the images clear and noise free. Gray scale image conversion, Thresholding, Filtering, Thinning, Boundary detection and cropping. Median filtering is used for noise removal and filtering. The Otus's global thresholding method is used for the binarization of the signature image. For thinning the morphological operation dilation is used. Boundary detection has been done for finding the region of interest of the signature images.

*C. Feature Extraction*

The Discrete Wavelet Transform is applied on the signature images for the extraction of the global as well as grid features. The global features extracted using haar wavelet single level decomposition is wavelet coefficients, horizontal projection positions and vertical projection positions. For ensuring accuracy of the system other global features are also considered based on the appearance of the signature such as height, signature width, vertical and horizontal centre of the signature image, Number of black pixels of the signature image. For grid feature extraction the images divided in to 9 segments and DWT is applied on each of the 9 segments. Vertical as well as horizontal projection positions of horizontal, vertical and diagonal components are extracted from the 9 segments. The down sampling filters and principal component analysis is used for the reduction of wavelet coefficients.

*D. Training*

The global and grid features extracted are given to the training stage as individually and combined. Here Artificial Neural Network (ANN) and Support Vector Machines(SVM) are considered separately for training and best method chosen by performance analysis. Back propagation algorithm is used for training neural network. Since Support Vector Machine (SVM) classify two classes here used multiclass SVM for the classification of different signatures. For training 350 genuine signature features and 150 forged signature features are used as for one person 7 signatures and 3 forged signatures.

*E. Recognition and Verification*

After the training process next stage is to recognize a test signature and also verify whether the signature is genuine or forged. The Recognition and verification gives the final output by extracting the features from test images. For each person 1 genuine signature and 1 forged signature of total 100 testing data set is used. The Recognition is done by mapping the test signature with the signature identification number given and the name of the signer.

## IV. SYSTEM DESCRIPTION

The technique is based on the Discrete Wavelet Transform (DWT) based global and grid features and other global features. The signature images are converted in to waveforms using the haar wavelets. The single level two dimensional decomposition filters are used for transforming the images in to wavelets and down samplers are used for extracting the wavelets. Number of hidden layers and neurons are present in the Artificial Neural Network (ANN) training phase. The number of hidden layers and neurons are adjusted based on the number of training samples and features extracted. When considering Support Vector Machine Training the classification module is applied to the learned module for the recognition and verification of new test samples.

The system takes test input samples in order to compare the extracted features with the trained model. Here for both the training method choosing the training samples features are stored in the form of numerical values in the matrices. Hence comparing the test input features with the trained features vectors in order to recognize the signatures and also to verify.

*A. Architecture*

The Architecture of the proposed system is shown in figure 2.

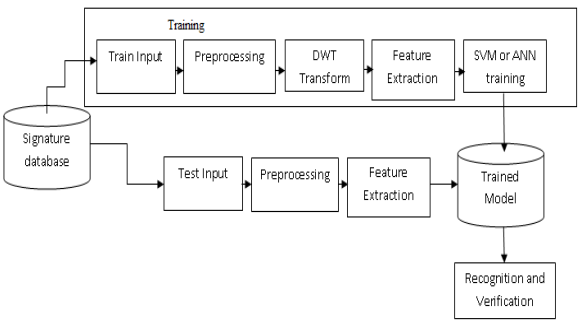


**Fig 2. Architecture of the proposed system**

The architecture contains the training part and the testing part. The training part also known as system developer's part and the testing part is the user part. The training part and testing part are two independent modules in which it done

IARJSET
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International Advanced Research Journal in Science, Engineering and Technology
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separately. The training part consist of preprocessing, Feature extraction, Training and classification. The user part gives input to the trained model for the recognition and verification of the signatures.

## V. OUTPUT AND PERFORMNACE ANALYSIS

Samples of 8 genuine signatures and 4 forged signatures of 50 persons are collected. Training is done by giving 7 genuine and 3 forged signature samples to the system. Feature vectors are created as matrices for the training samples. Test input with 1 genuine signature and 1 forged signature are given to the system and they are successfully determined the signed person and classified signature is genuine or not. If the signature is a forged one the system prints forged signature else prints the name and signature identification number.The system is trained using 500 training samples of 350 genuine signatures and 150 forged samples. Then the same person's genuine sample and forged sample are given for testing. Then the system recognizes and verifies the samples in few seconds by comparing the test input with the trained model. If more variations of training samples are given, it will be possible to recognize and verify the signatures. An example for testing a person's signature is given below.

### *A. Performance Analysis*

The performance of the system can be analyzed by the recognition and verification efficiency of the system. Here performance of the system comparing with the feature vectors and training method chosen. The feature vectors can be global features only, grid features only or combined global and grid features. The training methods can be Support Vector Machines (SVM) or Artificial Neural Network (ANN). Table 1 shows the performance of the system in terms of FRR, FRR and Accuracy.

TABLE 1: PERFORMANCE OF THE SYSTEM

| Number of Persons | Training Method | Features Chosen | FRR | FAR | Accuracy |
|---|---|---|---|---|---|
| 10 Persons | SVM | Global | 0 | 0.1 | 99% |
| | | Grid | 0 | 0.1 | 99% |
| | | Global & Grid | 0 | 0 | 100 % |
| | ANN | Global | 0.05 | 0.2 | 98% |
| | | Grid | 0.05 | 0.2 | 98% |
| | | Global & Grid | 0 | 0 | 100 % |
| 20 Persons | SVM | Global | 0.05 | 0.1 | 98% |
| | | Grid | 0.025 | 0.1 | 98% |
| | | Global & Grid | 0 | 0 | 100 % |
| | ANN | Global | 0.15 | 0.2 | 96% |
| | | Grid | 0.15 | 0.2 | 97% |
| | | Global & Grid | 0.05 | 0.1 | 99% |
| 30 Persons | SVM | Global | 0.066 | 0.1 | 97% |
| | | Grid | 0.05 | 0.033 | 97% |
| | | Global & Grid | 0.033 | 0 | 99% |
| | ANN | Global | 0.833 | 0.066 | 95% |
| | | Grid | 0.15 | 0.1 | 95% |
| | | Global & Grid | 0.05 | 0.033 | 96% |
| 40 Persons | SVM | Global | 0.0625 | 0.1 | 95% |
| | | Grid | 0.0625 | 0.075 | 96% |

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| | | | | | |
|---|---|---|---|---|---|
| | | Global & Grid | 0.0375 | 0.1 | 97% |
| | ANN | Global | 0.075 | 0.15 | 91% |
| | | Grid | 0.075 | 0.125 | 92% |
| | | Global & Grid | 0.05 | 0.1 | 92% |
| 50 Persons | SVM | Global | 0.08 | 0.1 | 89% |
| | | Grid | 0.06 | 0.09 | 90% |
| | | Global & Grid | 0.06 | 0.1 | 92% |
| | ANN | Global | 0.15 | 0.3 | 87% |
| | | Grid | 0.14 | 0.28 | 87% |
| | | Global & Grid | 0.12 | 0.3 | 88% |

Any signature verification system is basically analyzed using False Rejection Rate(FRR), which is the total number of rejected genuine signatures per the total number of test signatures and False Acceptance Rate(FAR), which is the total number of accepted forged signatures per total number of signatures submitted. The Accuracy of the system is in percentage which is the number of recognized signatures per total number of testing signatures. As the persons number increases the performance of the system decreases but by using SVM it increases. Obtaining 92% by combined global and grid features when 50 person's signatures are used for training and testing by SVM.

## VI. IMPLEMENTATION

The system is implemented in the Matlab 2014 version and the snapshot of the implemented system is shown in figure 3.

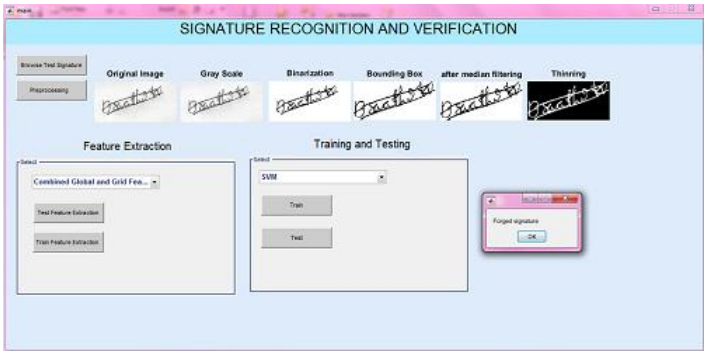


Fig. 3. Snapshot of the signature recognition and verification system

## VII. CONCLUSION

The system proposed in this paper can be used for signature recognition and verification. Lots of research work are there for this system but here combined some special grid and global features and trained using the Support Vector Machine (SVM) and Artificial Neural Network (ANN). By the performance analysis it is found that when using the combined global and grid features with SVM training the accuracy of the system increases. The system can be extended in order to use large databases with good accuracy. The system can also be enhanced to work with online signature recognition and verification.

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ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
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Vol. 4, Special Issue 1

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