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Biometric Trait: Offline Signature Identification and Verification based on MultimodalFusion Techniques

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Abstract:

Biometrics refers to the process of identification of humans by their characteristics or traits. Biometrics is used in computer science as a form of identification and access control which is one of the most secure methods to keep humans' privacy. Biometric can be classified into two categories: behavioral and physiological. Handwritten signature is amongst the first few biometrics to be used even before the advent of computers. Offline Signature verification is an authentication method that uses the dynamics of a person's handwritten signature measure and analyses the physical activity of signing. In this research we demonstrate to study about offline signature verification system. There are 2 main steps: Training and Testing. In training the database is read one at a time and it is preprocessed by denoising, skeleton identification by converting black/white image format and then identifying bounding box of actual signature image and cropping it. By applying Integer Wavelet Transform followed by Discrete Cosine Transform followed by Principal Component Analysis, then features such as geometric, statistical are extracted, concatenated, and saved with class tag and train with Neural Network and develop structure. In testing after reading case image, preprocessing, and extracting feature we test using Neural Network and display class of test case. The accuracy of each method is found better on local database and graph is plotted.

Keywords: *Biometrics, Signature, geometric, Neural Network, Wavelet Transform.*

1. Introduction

Biometric system is a technology that takes individual physiological, behavioral or both traits as input, analyses it and identifies individual. It relies on specific data about unique biological trait to work effectively. Unique identifiers include fingerprint, hand geometry, earlobe geometry, retina, iris patterns, voice waves, DNA, signature. Basically, Biometrics is divided into two parts i.e., Physiological and Behavioral. Physiological is includes face, fingerprint, hand, iris, DNA. Behavioral includes Keystroke, signature and voice as shown in the Fig 1

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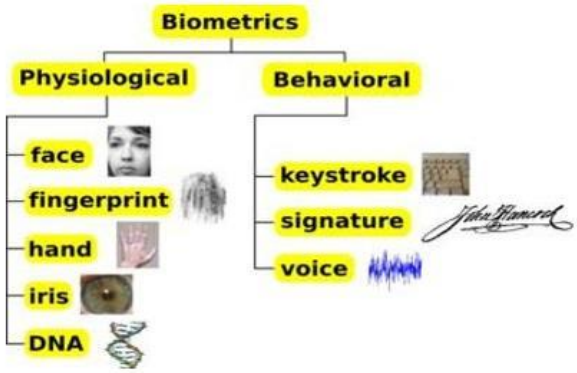

Figure 1: Biometric Traits

The human characteristics such as physiological or behavioral traits can be used for biometric in terms of related parameters described below.

- Universality: Each candidate should have characteristic.
- Uniqueness: Each has separate characteristics and don't match with other person.
- Permanence: Measures how better a biometric resist aging and over time.
- Collectability: Ease of acquisition for measurement.
- Performance: Accuracy and robustness of techniques used.
- Acceptability: Degree of approval of a technology.
- Circumvention: Ease of use of a substitute.

Handwritten signature verification consists of two parts online and offline. In offline signature verification method, it makes use of simple scanner or camera that can take an image having signature and process the image further with whatever feature it gets. This method can be seen useful in many applications such as banking cheques, medical certificates, and prescriptions etc. Offline signature verification is one the most challenging area of pattern recognition. The problem however is that the offline signature can be easily imitated or forged which could lead to false representation or fraud. Therefore, there is need for adequate protection of personal signatures.

The main objective is to recognize offline handwritten documents, which include characters, words, lines, paragraph etc. There is extensive work in the field of handwritten recognition, and several reviews existed. Our approach is to recognize handwritten by using templates. Along with this we maintain a unique user accounts, which enables a particular user to create his/her training sets.

2. Related Work

Tejas Jadhav et al,. [1] applied local binary pattern (LBP) to extract the feature of image. The features obtained from LBP are compared with test features using K-Near Neighbor classifier. The experiments are conducted and tested on CEDAR signature database to obtain recognition rate. Somaya et al., [2] characterized Otsu thresholding algorithm PDF to extract the feature of image. The features obtained from Otsu thresholding algorithm PDF are compared with test features using Codebook based and feature based approaches. The experiments are conducted and tested on IAM handwriting database and OUMI database signature database to obtain recognition rate. Anujsharma et al., [3] gave detailed information about combined static and dynamic feature extraction technique to extract the feature of image. The features obtained from combined static and dynamic feature extraction technique are compared with test features using Hybrid convolution neural network classifier. The experiments are conducted and tested on SVM recognition technique signature database to obtain recognition rate. Piotrporwik et al., [4] specified dynamic handwritten time frequency characteristics FIR system characterizing to extract the

feature of image. The features obtained from dynamic handwritten time frequency characteristics FIR system characterizing compared with test features using K- nearest neighbor and self-adaptive classifier. The experiments are conducted and tested on SVC Spanish MCYT database to obtain recognition rate. Aininajwa, et al., [5] explained free man chain code to extract the feature of image. The features obtained from Freeman chain code compared with test features using KNN classifier. The experiments are conducted and tested on MCYT bimodal data base to obtain recognition rate. Armando Beltran Castanon et al., [6] expressed Dynamic evolution to extract the feature of image. The features obtained from Dynamic evolution are compared with test features. The experiments are conducted and tested on Offline image signature database to obtain recognition rate. Shekhar et al., [7] described Morphological pattern spectrum to extract the feature of image. The features obtained from Morphological pattern are compared and with test features using EMD earth movers distance classifier. The experiments are conducted and tested on CEDAR, GPDS-160 and MUKOS database to obtain recognition rate. Sunil et al., [8] contributed the study of biometric systems and its applications in the current scenario. Geetha et al., [9] characterized Gradient detection to extract the feature of image. The features obtained from Gradient detection are compared and with test features. The experiments are conducted and tested on CEDAR, benchmark database to obtain. Sunil et al., [10] explained different feature extraction techniques available for face recognition. George S Eskanderet al., [11] narrated concept of dissimilarity representation to extract the feature of image. The features obtained from are compared and with concept of dissimilarity representation test features using FV decoding functionality classifier. The experiments are conducted and tested on Brazilian biometric confirms database to obtain recognition rate. Sunil et al., [12] give the brief introduction of iris biometric traits in his study. Giuseppe et al., [13] gave an account to vDIVt, N. Log Norm to extract the feature of image. The features obtained from vDIVt, N. Log Norm are compared and with concept of dissimilarity representation test features using CART algorithm, BAGGING CART algorithm, SVM algorithm classifier. The experiments are conducted and tested on private database to obtain recognition rate. Prasanth et al., [14] explained signature recognition based on Angular Features (OSVAF). Prasanth et al., [15] Standard Scores Correlation based Off-line Signature Verification is explained. Prasanth et al., [16] presented DWT based Off-line Signature Verification using angular features.

The difficulties in verification of different signatures of same person that leads to unauthenticated an individual. The main objective of the proposed model is to develop the algorithm which can reject imposters and accept the genuine persons by improving the algorithm in terms of error rates by using the better techniques. Experimentation and testing of the algorithms will be carried out on local database.

3. Proposed Model

There are two main steps training and testing. Fig 2 shows the proposed model for signature verification using IWT, DCT and PCA. Here, in training, the database is read one at a time and it is preprocessed by denoising, skeleton identification by converting black/white image format and then identifying bounding box of actual signature image and cropping it. By applying IWT followed by DCT followed by PCA, then features such as geometric, statistical are extracted, concatenated, and saved with class tag and train with Neural Network and develop structure. In testing after reading image, preprocessing, and extracting feature and test using Neural Network and display class of test case.

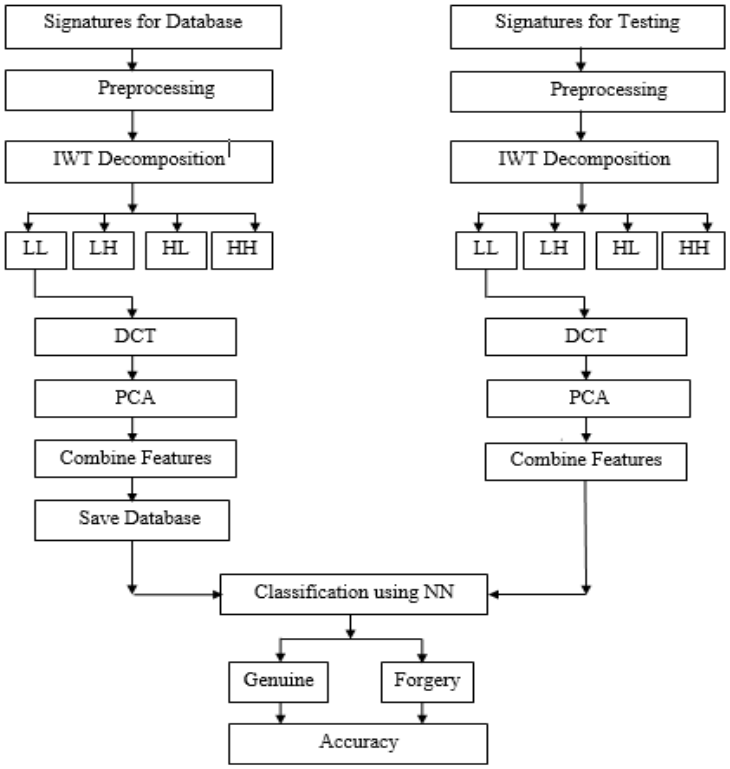

Figure 2: Proposed model

The proposed model consists of three major steps:

- Pre-processing: that includes, image resizing, boundary identification and cropping, image filtering to reduce the noise in image, skeletonizing of image hence perimeter calculation, and image inversion.

Figure 3: Original image and cropped image

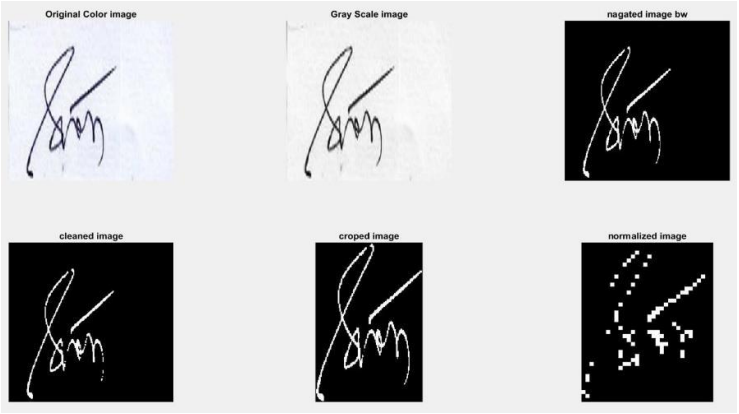

Figure 4: Preprocessed results

- Feature extraction: the pre-processed image is taken to the feature extraction step, in where the two types of features of the signatures are extracted, the geometric and the texture or the statistical features [17]. The geometric features are extracted from the skeleton of the image that is already obtained during pre-processing part. For texture features extraction the gray co-matrix of the image that is passed through a IWT filter and then DCT for better feature access is taken. Training and testing: as the inputs parameters for training or testing are same but for different purpose, the pre-processing and feature extraction is common to both.

Figure 5: Original Image

Fig 6., shows the image that is bounded by the top row, bottom row, left column and right column of cylinder, within which the actual region of interest exists.

Figure 6: Binary skeleton of input image

The geometric features of the image are extracted from the skeleton shown in Fig 6. The geometric features of image are as follows euln = -1, orient = 41.1999, centrd = 220 161, convexarea = 65179, eccentricity =0.8673, extent = 0.0096.

The second step of feature extraction involves matrix representation of data and changing data format from one to another form [18]. However, the interim steps used are IWT and DCT the matrix cannot be displayed though. The image form of the IWT matrix is shown in Fig 7 and that of DCT depicted by Fig 8.

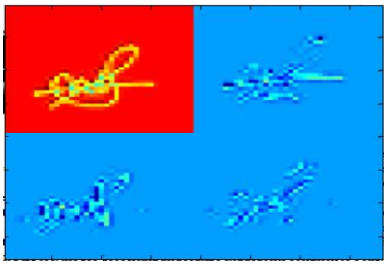

Figure 7: Scaled IWT image matrix

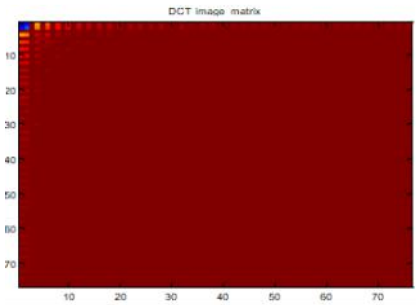

Figure 8: DCT Image Matrix

In Fig 7, the regions of interest Average, Horizontal, Vertical, and Diagonal filtered outputs are distinguishable [19]. In Fig 9, it can be observed that after the DC component, lower frequency component is prominent and most of the higher frequencies are absent, the reason being no color [20].

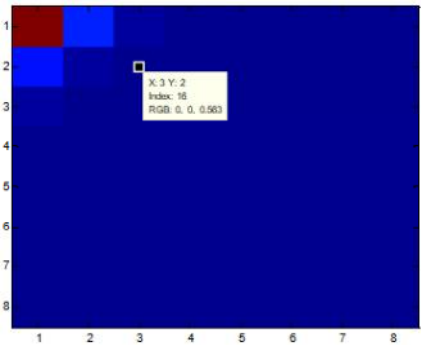

Figure 9: Sample gray Co Matrix

The numerical values of Fig 9 are

g =	4162	593	91	3	1	0	0	0
	566	72	16	1	1	0	0	0
	93	14	3	0	0	0	0	0
	4	0	0	0	0	0	0	0
	1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0

The set of properties and their values are: Feat= [Contrast, Correlation, Energy, Homogeneity, Mean, Standard_ Deviation, Entropy, Variance, Smoothness, Kurtosis, Skewness, IDM] [21] Feat values=[0.3720, 0.0065 0.5696, 0.8706, 0.0022, 0.1147, 3.8970, 0.0132, 0.9264, 3.4518, 0.2699, 1.3348]. These feature values combined with geometric features to obtain set to be trained or tested. The results in single test case are displayed by set of 0,1 or 1,0 for original and forged signature respectively.

- For training the type of network with its set parameters such as layers, training function, output function etc, chosen. The weights are obtained by training the NN with the set of training images. In case of testing the network that is built during the training is taken and input features from the test set/case image is fed and simulated to get the results.
- Neural Network: Neural network generally work like the neurons of the brain and the connected neurons will work in network process to collect and process the data for providing the necessary output. There will be an input layer to the system which consists of all the patterns in which the system should process and also the necessary inputs

and it communicates with the hidden layer as shown in the below figure and the hidden layers use the patterns and inputs by the input layer and are used to find out a relevant function for the task to be performed and then they communicate with the output layers to display the final output.

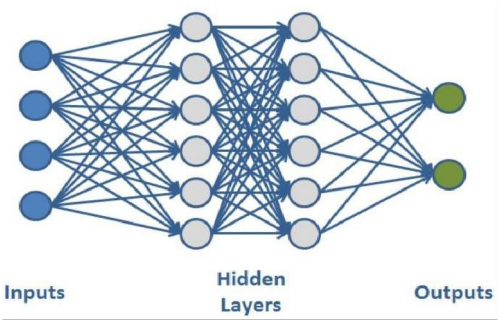

Figure 10: Neural Network

This mechanism goes in a single way from the input to hidden layers then the outputs and do not form any loops or circles in the process. The layers between the input and the output layer are the hidden layers.

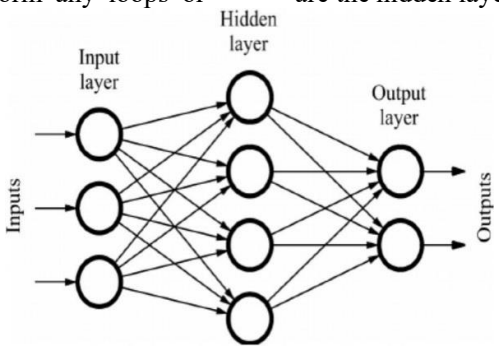

Figure 11: Feed Forward Neural Network

The addition of feedback from the last hidden layer to the first hidden layer represents a recurrent neural network. The architecture of feed forward mechanism is shown in below Fig 11. Pattern recognition networks are feed forward networks that can be trained to classify inputs according to target classes. The target data for pattern recognition networks should consists of vectors of all zero values except for 1 as in element I, where I is the class, they are to represent. And here we are giving 19 features as input and 2 outputs that the signature is original or forged and 15 hidden layers. The pattern net is shown in the below Fig 12.

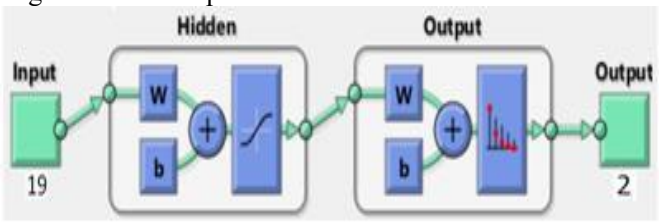

Figure 12: Neural Network Pattern Net

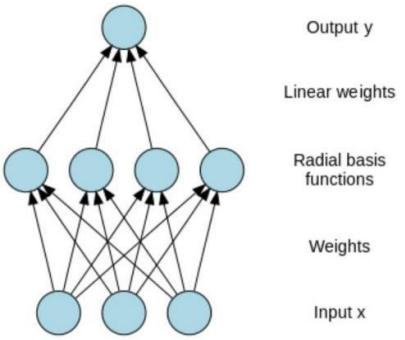

Figure 13: Radial Function Neural Network

Functions that depend only on the distance from a center vector are radially symmetric about that vector, hence the name radial basis function as shown in Fig. 13. However, the credibility of the system is dependent on the accuracy and performance parameters of the neural network in consideration. The three various NN performances in terms of accuracy are plotted in Fig 14.

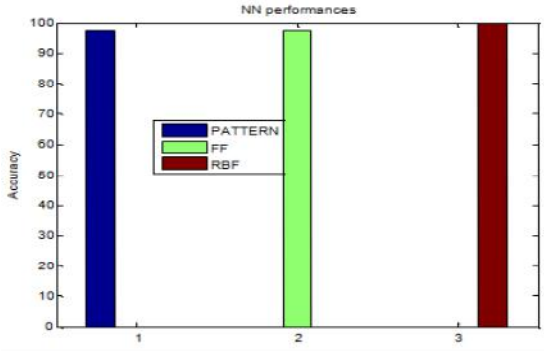

Figure 14: Sample gray Co Matrix

4. Results and Discussions

The model developed based on IWT, DCT, PCA using NN was evaluated on own collection of signatures and simulated using MATLAB software. The algorithm and flow of offline Signature verification process is already discussed, an outline is a prerequisite for the explanation of implementation. The images of signatures, original as well as forged are stored in specific folders. The images of a specific folder are accessed by pointing/referring to it, for training, each of the images are read one by one from the folder, preprocessed for image enhancement, each image features, geometric as well as statistical/texture, are extracted and concatenated to form the final feature set. The texture features are extracted from the DCT of image is transformed into frequency-space. For testing a specific case the image is input and the process of image preprocessing, feature extraction is followed and feature set is obtained. This feature set is input to the trained and obtained forms of caricatures obtained during training process to get an output of the belongingness as to whether it is forged or original one.

To measure and evaluate the performance of the proposed offline signature algorithm, False Rejection Rate (FRR) and False Acceptance Rate (FAR) [6] are used.

- False Acceptance Ratio (FAR): The false acceptance ratio is defined as the number of fake signatures accepted by the system with respect to the total number of comparisons made.
- False Rejection Ratio (FRR): The false rejection ratio is defined as the total number of genuine signatures rejected by the system with respect to the total number of comparisons made. It is as represent below:
- Accuracy: Accuracy of any system is defined as the total number of signatures correctly recognized by the system with respect to the total number of tested signatures.

Looking into Fig 15, the RBF neural network with spread=1, gives the best result. The spread =1 is the maximum that one can achieve. However, in case of pattern net and the feed forward network the hidden layers can be chosen manually, the performance parameters measured and analyzed.

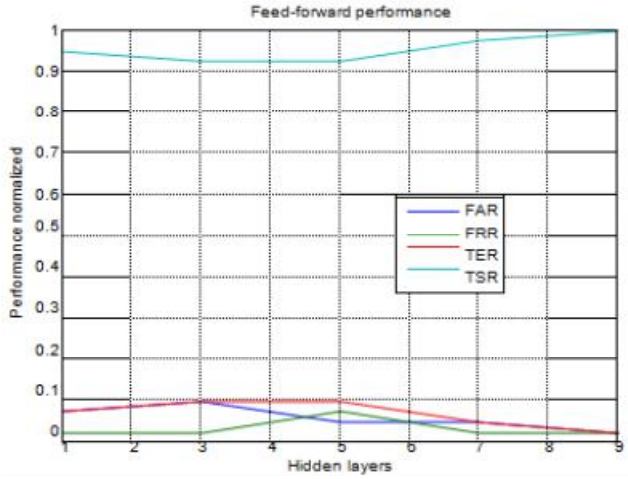

Figure 15: Performance of Feed Forward Neural Network

Fig 15 depicts the performance of feed forward neural network for varying hidden layers it is seen that as the number of hidden layers increased, the performance gets better.FAR is high and FRR is low for lower number of hidden layers giving under-fitting, but as the hidden layers are increased the weight matrix gets better up to hidden layers 4-5 the network is over fitting, resulting into higher FRR compared to lowering FAR, for an ideal network both should decrease which can be observed from hidden layers 7 onwards. Total error rate is averagely around 0.05 due to varying FAR and FRR, once both start dropping the TER drops down resulting into better TSR.

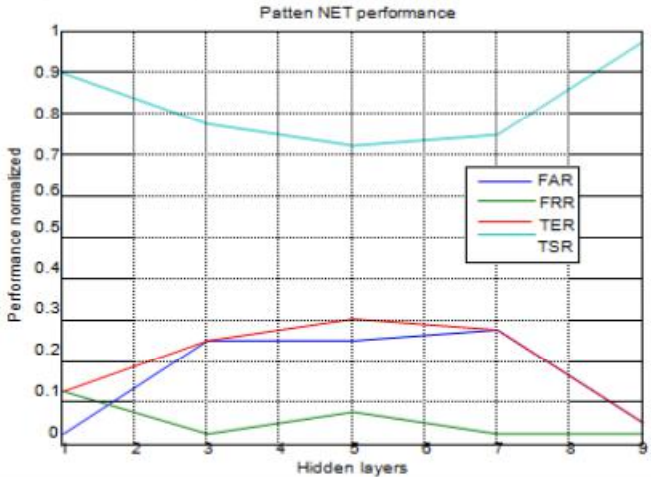

Figure 16: Performance of Pattern Net Neural Network

Fig 16 shows a typical FAR increase with hidden layers so much that the overall performance TSR drops rapidly, also the FRR consistency is lost with varying layers, however, owing to the weights and neurons burden the network TER starts dropping, proving that the pattern net is not suited for the purpose.

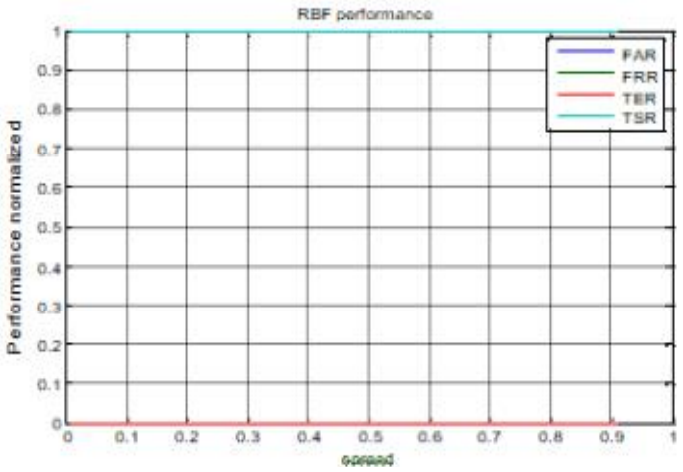

Figure 17: Performance of Radial Basis Function Neural Network

In RBF, the True Successive Rate results 100 percentage with zero error rates which is shown in Fig 17.The model is tested on different techniques for offline signature verification and results 96% of TSR and is given in Table 1.

Table 1: Comparison of proposed methodology with existing techniques

Technique used	**%TSR**
PCA and Minutia Matching	85
Navies and SVM	89
DWT and PCA	92
Proposed Model	96

5. Conclusion and Future Scope

The offline signature model basedIWT, DCT, PCA using NN is presented. The images of signatures, original as well as forged are stored in specific folders. The images of a specific folder are accessed by pointing/referring to it, for training, each of the images are read one by one from the folder, preprocessed for image enhancement, each image features, geometric as well as statistical/texture, are extracted and concatenated to form the final feature set. The texture features are extracted from the DCT of image is transformed into frequency-spacefollowed by PCA. In testing after reading case image, preprocessing, and extracting feature we test using Neural Network and display class of test case. The accuracy of proposed model on RBF-NN produced better results compared with existing. Further, the model can be trained with large set of databases in public domain using various fused feature extraction techniques to recognize the signatures.

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