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Offline Signature Recognition and Verification System Using Artificial Neural Network

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Abstract: There are several alternative life science techniques that are used to identify human, these techniques are namely eye recognition, face recognition, finger print recognition and currently a well-known signatures recognition and verification. The utilization of signatures is in all legal and financial documents. Verification of signatures now becomes necessary to distinguish between original and forged signature. A computer based technique is necessitated in this regard. Verification of signatures can be performed either offline or online. Under offline systems, signatures are taken as an image and recognition is performed using some artificial intelligence techniques including neural networks. We have worked on off-line Signature Recognition and Verification System (SRVS) by taking artificial neural network technique into account. Signatures are taken as image and after some necessary pre-processing (i.e. to isolate the signature area) training of system is done with some initial stored samples to which authentication is needed. MATLAB has been used to design the system. The system is tested for several scanned signatures and the results are found satisfactory (about approximately 95% success rate). Image quality plays an important role as poor quality of signature image may lead to the failure to recognize/verify a signature. Increase in the attributes/ features of signature will increase the verification ability of the system but it may lead to higher computational complexity

Keywords: Security, Authentication, Off-line, Signature Verification, Image Preprocessing, and Neural Network

I. INTRODUCTION

Handwritten signature of the person is recorded in different patterns for authentication and authorization purpose which can be used for bill of exchange, any document or any security countersign. There are several alternative life science techniques that are used to identify human, these techniques are namely eye recognition, face recognition, figure print recognition and currently a well-known signatures recognition and verification. This technique is extremely inspired authentication technique for researchers to push secure and ideal technique within the world. Signatures recognition and verification systems are divided into two categories which are namely offline signature recognition and verification system and online signature recognition and verification system.

In offline signature system, format of stored signature is in image format. Prior to the feature extraction, preprocessing is mandatory to be performed on a scanned image to separate signature segment and to eliminate noise part if any.

In on-line signature system, person's signature is extracted from capacitive tablet or PDA that provides x-y coordinates, pressure reading etc. These raw data values are then used to calculate various features. Signature authentication can be obtained by two ways that are Static and Dynamic. Static features are independent of time while the dynamic features are time dependent. Dynamic features are extracted using electronic tablet or PDA.

Remaining part of this paper is divided into five parts. Literature review has been done in section two. Section three contains the proposed system that is going to be used for offline signature recognition and verification. System implementation is in section four and finally conclusion and future directions can be found in section five.

II. LITRATURE REVIEW

With the use of modern technologies, there are several ways for human identification. Hand written signature is one of them. It is important to perform verification process on hand written signature in order to distinguish between original signature and the forged one. Reference [1] can be seen to find details regarding two types of precision errors occur in signature verification which are namely "False Rejection Rate" and "False Acceptance Rate". Reference [2] provides the comprehensive details for the types of forgery present in handwritten signature. In order to maximize the efficiency of signature verification system, there are number of methods for such verification. Some of the recent work under the heading of offline signature verification can be found as in [3] where the authors have suggested a grid-based template matching scheme. Based on pixels intensity, an offline verification model has been proposed in [4] to find the genuine signature. Lots of work have been done on SVM

for offline signature verification, a detailed review can be found as in reference [25], Further-more, as in references [5-7] different researchers have applied different concepts to achieve the efficient method for offline signature verification. Some of the most commonly used techniques for hand written signature verification are as follows:

A. Signature Verification Techniques

1) Hidden Markov Model: For the purpose of analyzing sequence in signature verification, it is recommended to use Hidden Markov Model (HMM). Signature by hand is considered as a string of vectors of values which is associated with all individual points of signature on its path. Thus, it is important to build an effective signature verification system by selecting appropriate set of feature vectors for Hidden Markov Models. Models type is stochastic and these type models have the ability to soak up the similarities of pattern variability. In Hidden Markov Models, matching of signatures and models take place. This matching can be achieved by either probability distribution of signature's feature or by finding the probability of the way calculation take place for the original signature. Signatures are considered as by original person when the resulting probability is greater than the test signatures probability, otherwise the signatures get rejected. HMM system utilizes only global features and "Sinograph" which is a discrete random transform. This discrete random transform is to be computed for all individual binary signature image that lie under the range of 0 – 360.

2) Neural Network: In pattern recognition, neural networks (NNs) are widely used as they are powerful and easy to use. The easiest way to start is to select feature set like height, length etc. of the signature by taking multiple specimens from various signer. Learning correlation among signature and its class ("genuine" or "forgery") will be the second step for the NN, once the relationship is developed. Network contains the sample signature owned by a specific signer. Thus, to build the global aspects for the signatures that have been done by hand, NNs are best suited. The system that has been proposed in this paper will utilize signature contour structure features, altered directional feature and some other features for example length skew, area of surface, centroid etc.

3) Template Matching: In template matching, for the detection of skilled forgeries there are two proposed techniques as in. [8]. Optimal matching of projection profiles of signature patterns that are one dimensional is one method while other method is of two-dimensional signature patterns which are dependent on the elastic matching of the strokes. To authenticate given sample signature, there will be an analyzation on variations of position by using statistics of the training set, moreover depending on distance measure decision has to be made.

4) Statistical Approach: Relationship, deviation etc. in between data can be determined by using statistical knowledge. If the correlation between set of data items is to be revealed, the concept of Correlation Coefficients is usually used. To verify the recently introduced signature, statistical approach pursues the concepts of correlation to determine the amount of dissimilarities among the newly introduced signature and already stored signature. Kolmogrov Smirnov Statistic is a unique method for signature verification in which various features are extracted. This feature includes gradient of image, statistical features (distribution of signature's pixels, geometry and topographical descriptors). The classification consists of collecting difference in the signatures of the writer and acquiring distribution in distance space. If signature is to be verified, then procedure secures the distribution that is compared with the recognized one. Kolmogorov-Smirnov test is used to find the probability of resemblance.

5) Support Vector Machine (SVMs): SVMs are basically an algorithm, these machine learning algorithms requires high dimensional feature space and calculate inequality among the classes of given data to generalize unseen data. Signature' features (global, directional & grid) are used by the system and for the verification and classification system uses SVM as in [9].

6) Self-Organizing Map (SOM) and Multilayer Perceptron (MLP): It has been suggested by Paigwar Shikha et al. [22]. Self-Organizing Map (kind of Artificial Neural Network)) is basically used to solve bundle of tasks. That is the reason SOM is used in problems of pattern recognition. The architecture SOM is comprised on single layer. In contrast with SOM, MLP is multilayered (Input layer, output layer and hidden layer). MLP is used to recognize information even from noisy data.

7) Back Propagation Neural Network: Signature verification and recognition can also be done by using Back Propagation of Neural network as proposed by Nilesh Y. Choudhary and can be seen in [23]. In this, for extraction of features, methods like invariant central moment and Zernike moment are used. Easy implementation is the key advantage of Back Propagation method which is based on three-layer architecture.

8) Signature Envelope and Adaptive Density Partitioning Approach: This approach has been proposed by Vahid Malekian et al. [24]. Partitioning takes place in this method on a pre-processing image into four segments by making center of gravity as its center point. Each segment is

then further equally divided into four parts. So, in this way there are sixteen segments of signature in total.

B. *Image Preprocessing Techniques*

In this technique i.e., image pre-processing; verity of range is present for the techniques that are used for manipulation and modification of images. Initial step is image preprocessing for the process of signature verification and recognition which produces better results with huge accuracy rates. Table I is presenting the various important image preprocessing techniques used.

TABLE I. IMAGE PREPROCESSING TECHNIQUES

Literature Review	List of Papers													
List of preprocessing techniques	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]
Background Elimination	T	F	T	T	T	T	T	T	T	T	T	F	T	F
Signature Normalization	F	F	T	F	F	T	T	T	F	T	T	F	T	F
Thinning	T	F	T	T	F	T	T	F	T	F	T	T	T	T
Convert Image to Binary	T	F	F	T	T	T	T	F	F	T	F	F	T	T
Bounding Box of the signature	F	F	F	T	F	T	F	F	F	F	F	T	T	T
Image Resize	T	T	F	F	F	T	F	F	F	F	F	T	T	T
Convert Image to Gray Scale	F	F	F	F	F	F	T	T	F	T	F	T	T	F
Noise Reduction	T	T	F	F	F	T	F	T	F	F	T	T	T	F

C. *Feature Extraction*

After Image preprocessing, Feature Extraction is the essential step for signature recognition and verification. The objective of feature extraction is to create features that can be operated as comparison measurements.

As it is noticed that the problems related to the signature verification is an extremely sensitive process, it is suggested to generate more than one feature measurement so that accuracy of the result can be enhanced. Table II is highlighting various important features that are utilized towards signature verification process.

TABLE II. IMAGE FEATURE EXTRACTION

Literature Review	List of Papers													
List of Features	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]
Signature Shape like area	T	T	T	T	T	T	F	T	T	T	F	T	F	T
Signature Height-to-Width ratio	T	F	T	T	T	T	T	T	T	T	T	F	T	F
Center Gravity	F	F	F	T	F	T	F	F	T	F	F	F	T	T
Edge Point of Signature	F	T	T	F	F	F	T	F	T	F	F	F	F	F
Direction of Line	T	F	T	F	F	F	T	T	F	T	F	F	F	F
Density of Thinned line	F	F	F	F	F	F	T	T	F	T	T	F	T	F
Aspect Ratio	T	T	F	T	T	F	F	F	F	F	F	T	F	T
Texture Feature	F	T	F	F	T	F	F	F	F	F	F	T	T	F

III. PROPOSED SYSTEM

Signatures are treated as a most promising authentication method in all legal and financial documents. So it is important to create such a technique which is efficient to verify (correct or forged) the handwritten signature. In the banking industry, signatures for long have been used for automatic clearing of cheques. Signatures from human are generally considered as image which is identified by using computer along with the techniques of neural network. In order to solve this problem, offline-signature recognition and verification system by using artificial neural network is a much better solution in our literature review analysis and in present research trend. The objective of this system is to verify signature by using average signature that has been obtained from the set of already stored signature thus reduce the time required for Signature verification.

There are so many algorithms for which neural network can be implemented but having some advantages of back propagation algorithm. It is proven to be the first choice for neutral network implementation. It is easy to implement while keeping efficient neural network. If we discuss about backward propagation NN [10] of the structure, it consists of three layers (refer to Fig. 1) in which first is Input Layer second is Hidden layer and final Output layer. In middle layer named as Hidden layer work to propagate (On this layer nodes/samples are classified based on proposed techniques) information from one layer to other. Output layer basically holds the propagated data and make comparison of that data which can be shown and results are shown using mentioned condition.

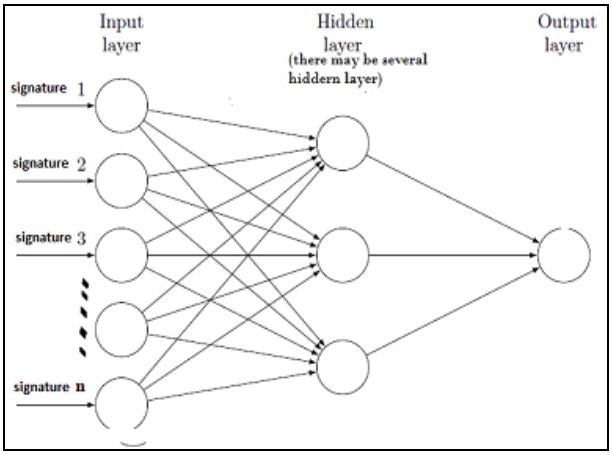


Figure 1. Back Propagation Neural Network

A. *Preprocessing and Features Selection for Proposed System SRVS*

After having detailed literature review as mentioned in Table I and II, the following pre-processing steps and features are finalized for signature verification

1) Pre-processing Steps:

- Image Resizing
- Converting to Gray Scale Image
- Background Elimination
- Image Thinning
- Bounding Box the Image

2) Image Features for Verification:

- Signature area
- Signature Ratio
- Geometric Centre
- Edge Points
- Aspect Ratio

B. System Design

System design is split into two main stages:

*1) Training stage of Signature:*This stage consists of following four major steps (implicitly 4 steps but explicitly 2 steps):

- Retrieval of 10 signature images from a storage file
- Image pre-processing
- Feature extraction
- Neural network training

2) Testing stage of Signature: The testing stage is based on the following five important steps (implicitly 4 steps but explicitly 3 steps):

- Retrieval of a 10 signature images from a storage file
- Image pre-processing
- Feature extraction
- Checking output generated from a neural network
- Application of extracted features to a trained neural network

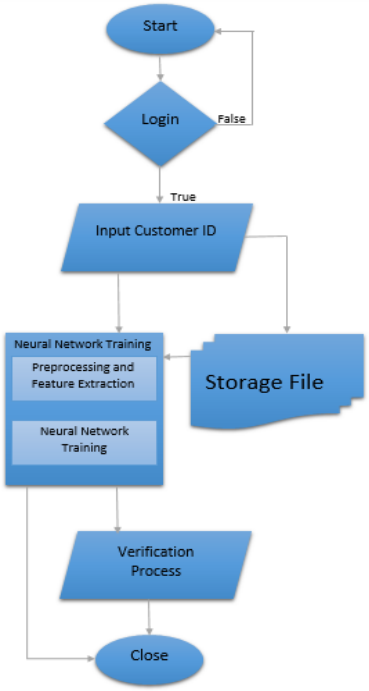


Figure 2. System Training Steps

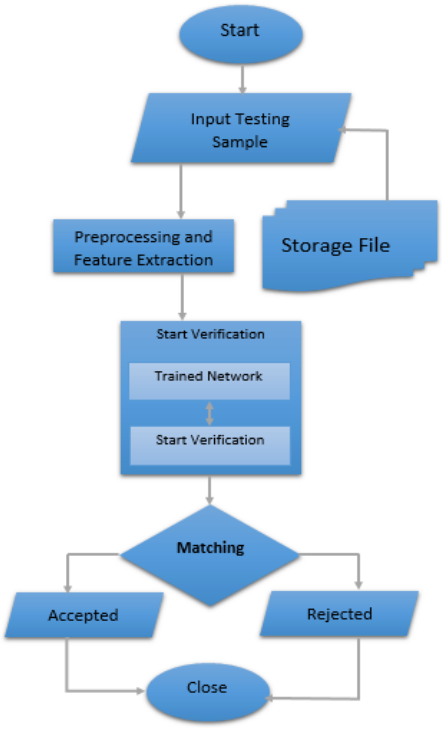


Figure 3. System Testing Steps

C. Preprocessing on Signature Image

Signature Image pre-processing is to manipulate and modify an image. It is counted as a first step in the process of

signature verification and recognition and produce improved results and higher accuracy rates, See table III

1) Image Resizing: Image resizing is the first process of preprocessing of signature image and it makes the image fit to box where that will be unique for all sizes.
Let consider Height as H of inputted image and width as W of the input image. We need to make homogenous image at 100*100 pixels by using equation as:

$$X_{new} = (X_{old} * 100)/H;$$

Where X_{new} is calculated using X_{old} (original X coordinate).

$$Ynew = (Yold * 100)/W;$$

Where Y_{new} is calculated using Y_{old} (original Y coordinate). By using these equations, transformation of uniformed 100*100 pixels of input image can be achievable.

2) Converting to Gray Scale Image: Now a day, all the latest devices which are capable of image capturing and scanning, use color. Due to this reason, we have used the color scanning device for the purpose of scanning signature images. Normally a color image is consisting of three color matrices (labeled as RGB) and a coordinate matrix (x,y coordinate values of the image). Techniques given in this study are based on grey scale images, and for this reason, scanned or captured color images at first are converted to grey scale using equation as in [17] [20].

Gray color = 0.299*Red + 0.5876*Green +0.114*Blue

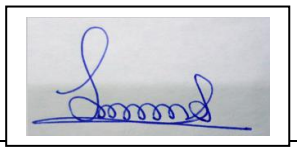
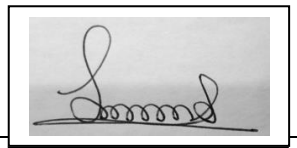
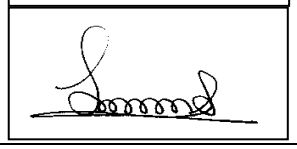
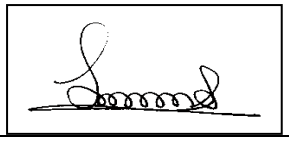
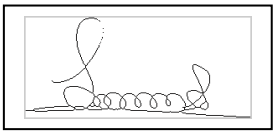
3) Background Elimination: In this step we focused on true object which is signature in this case, but when signature is captured it has background which may be because of a page or another shadow. For removing this background from signature images, we used thresholding, used extensively for the image segmentation. In thresholding, a value commonly known as threshold value and is represented by "T" has to be chosen. Moreover, a value 0 is to be assign to those pixels having values smaller than or equal to threshold value "T". Similarly, value 1 will be assigned to those who have values greater that "T" [20]. By using threshold method, extraction of signature pixels from its background pixels is possible. In this application, we are more interested in dark object with light background, for this reason, careful selection of threshold value is required and applied to image pixel [17] as;

If $f(x,y) \geq T$ then

$$f(x,y) = Background \text{ else } f(x,y) = Object$$

4) Image Thinning: It is used with the purpose of getting rid from the thickness variation of pen by adjusting image one pixel thick. Thinning was introduced to represent the global properties of objects and to cut down the original image into a more compact representation [20]. An algorithm known as Stentiford algorithm is used for thinning process.

TABLE III. PREPROCESSING ON SIGNATURE IMAGE

Signature	Image
Original	
Resized	
Gray Scaled	
Background Eliminated	
Thinned	
Boundary Bounded	

5) Boundary Bounded Image: When images are captured we cannot have supposed to have exactly the same dimensions which we have testing box. There is a huge chance to have irregularities during image capturing and scanning process which results in the fluctuation of signature's dimensions. Width to height of signatures proportion to signature even the one person can have same signature with different dimensions. Therefore, it is important to remove the dimension fluctuation and attain a benchmark for all input signature size. When process of normalization is going on, there will be no change in the characteristic ratio of signature's height and width. There will be an identical dimension for all the signatures. Following is the equation used for normalization process:

$$X_{new} = [(X_{old}-X_{min})/ (X_{max}-X_{min})]*M$$

$$Y_{new} = [(Y_{old}-Y_{min})/ (Y_{max}-Y_{min})]*M$$

Where X_{new}, Y_{new} = Normalized signature pixel coordinates, X_{old}, Y_{old} = Original signature pixel coordinates, M = Normalized signature Width/height meant.

D. *Features Extraction*

Feature extraction is a name of a process in which information is extracted from a raw data and that will work in allocation stage. Data can be reduced within-class pattern variation and increases the inter-class variations. Thus, in order to achieve high performance in signature recognition system, selection of efficient feature extraction method is of great importance. There are two characteristics of an efficient feature extraction algorithm namely: Invariance and reconstruct-ability. Features will have the capability to identify numerous varieties of signatures if they are invariant to definite signature transformations. Feature extraction is a second most important step for signature recognition and verification. The purpose of this step is to create features that can be used as comparison measurements. As it is noticed that the problems related to the signature verification is an extremely sensitive process, it is suggested to generate more than one feature/measurement so that accuracy of the result can be enhanced.

1) Signature Area: It is signature's normalized area. Ratio of area that signature has occupies by pixels of signature in the bounding box is known as normalized area

$$NA = \frac{\Delta}{D_x D_y}$$

2) Signature Ratio: Ratio of the range of x coordinates to the range of y coordinates is known as width to height ratio. To calculate the width to height ratio, use the following formula:

Width to Height Ratio = (Xmax - Xmin) / (Ymax - Ymin)

Where,

Xmax and Xmin = Maximum & Minimum values of x coordinates of non-zero pixels

While,

Ymax and Ymin = Maximum & Minimum values of y coordinates of non-zero pixels

3) Geometric center: The center of gravity is the 2-tuple (X, Y) and is given by:

$$X = \frac{1}{N}\left(\sum_{i=1}^{n} x_i\right)$$

$$Y = \frac{1}{N}\left(\sum_{i=1}^{n} y_i\right)$$

Where, X and Y denote the column number and row number of ON pixels (value 1) respectively.

4) Edge Points: A point that has only one 8- neighbor is known as edge point. With the purpose to extract edge point in a particular signature, an element structure of 3×3 should have only one pixel equal to 1 and others equal to 0.

5) Aspect Ratio: The ratio of width to height of the signature is said to be the aspect ratio which is represented by A. Coordinates of bonding box signature are determined and height Dy and the width Dx are measured using these coordinates.

$$A = \frac{D_x}{D_y}$$

IV. SRVS SYSTEM IMPLEMENTATION

To accomplish the results, we have implement offline signature recognition and verification system using neural network toolbox on MATLAB and train no of samples signatures of different users which are stored in file-storage system or hard drive with specific user ID, where neural network access the samples of user by its ID which is the folder name in Hard drive which is considered as database in this system.

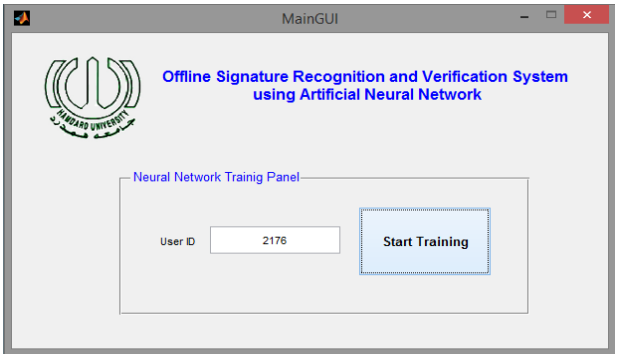


Figure 4. Training Window

In Fig. 4, the given window shows the process of input the user database ID (the folder name in Hard Drive) for access the no of samples that are pre-stored in database (Hard Drive) for neural network training, in the database each folder there are at least 10 samples (signature images of user) per user are pre-stored for training purpose in PNG (image file type) format. When a specific ID is inserted then system will train given dataset in neural network training panel.

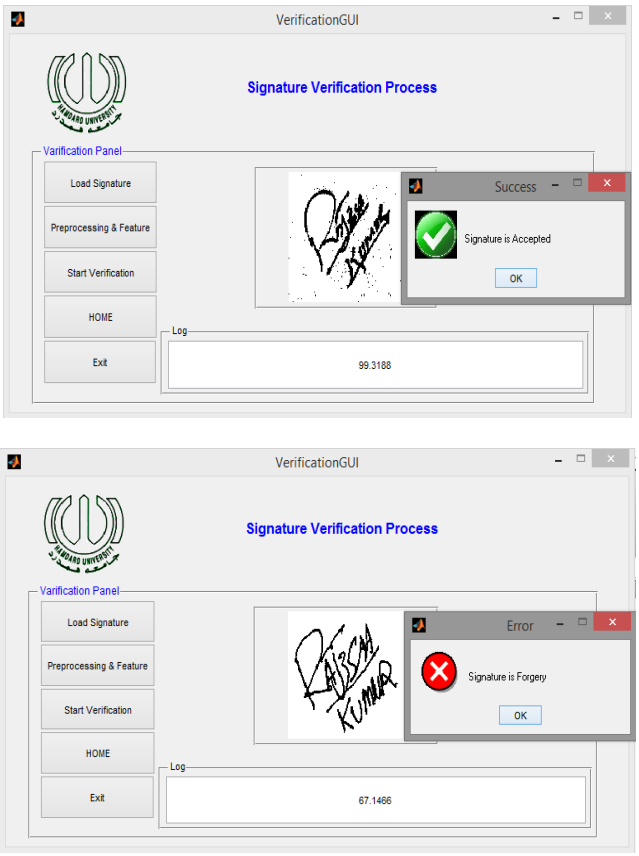


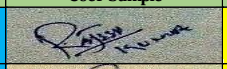
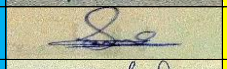
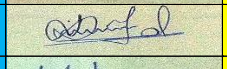
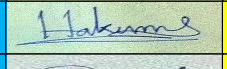
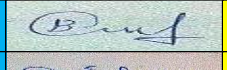
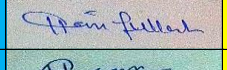
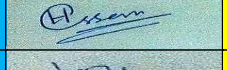
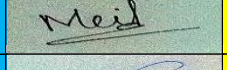
Figure 5. Result Window

In Neural network training panel, we have set the input nodes as 256 because neural network take input in the form of nodes, at Hidden layer nodes are process (applied preprocessing steps and features extraction techniques here) and classified in 20 nodes, which are resultant nodes from these nodes our required output (average results are stored in temporary classes for comparison at run time) is generate. After completion of neural network training it directly goes to verification window. In this window user input a single signature for verification purpose which may belong to original person or not after input, the given signature image will go to the process of preprocessing steps and features extraction techniques after that it will we compared with training dataset which are already trained and stored in temporary classes. After comparison, results are shown (refer to Fig. 5).

If result of ID is below 85% then it will be considered as False and it does not belong to original person.

Following table IV is presenting the results as Correct Acceptance Rate (CAR) that is the acceptance measurement factor from sample storage file. Samples are of different types and each of them shows percentage of matching/acceptance rate.

TABLE IV. CAR OF SAMPLE SIGNATURES

User ID	User Sample	Acceptance Rate	Remarks
1		99.93	Good
2		94.15	Better
3		99.55	Good
4		97.96	Good
5		97.24	Good
6		98.86	Good
7		92.94	Better
8		96.37	Good
9		95.09	Better
10		99.62	Good

V. CONCLUSION

In this study, Artificial Neural Network based off-Line Signature Recognition and Verification System is presented. Training of the system is a necessary part as the success rate depends on the appropriate training sample. The success rate of SRVS system is found approximately 95% (on average). Image quality plays an important role as poor quality of signature image may lead to the failure to recognize/verify a signature. Increase in the attributes/ features of signature will increase the verification ability of the system but it may lead to higher computational complexity.

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