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Offline Signature Verification using Artificial Neural Network

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***Abstract*—Conformation of offline signature is one of the most difficult area for personal authentication. Throughout literature, various techniques have been studied to find out whether a given signature is certifiable or false. Signature is a critical part of making a distinction between evidence and validation of an object in this present world of digitalization. Authentication an offline signature is a crucial and worrying signature verification process. As signature can be used by many organizations and associations as a means of authentication to secure their sensitive information and also to safeguard their security because of which less information measure is accessible, which is not sufficient to identify the pattern used as a part of signature. This paper portrays a novel approach to the authentication of signatures and identifiable proof in an offline environment. In the proposed work, sample signatures are being collected in the database by scanning the actual signatures and image processing methods that will be used for generalization and to extract the features of the scanned signature. With the use of artificial neural networks such as back propagation algorithms, machine learning algorithms are used to verify signatures.**

***Index Terms*— Signature verification, Authentication, Signature acquisition, Feature extraction.**

I. INTRODUCTION

Signature is main means of both authenticity and authorization in the legal process, the need for accurate automated signature verification has increased. Unlike a password, handwritten signature captured values are unique to an person and nearly impossible to replicate, PIN, PKI or key card identification data which can be missed, lost, stolen or exchanged. Verification of the signatures is both natural and intuitive. The system is easy to describe and to have faith in. The primary benefit that signature verification systems have over technologies of another sort is that signatures are already recognized as the standard identity verification process[1]. A method of signature authentication and the methods used to solve this problem can be divided into two Online and Offline groups. On-line approach uses a computer-connected electronic tablet and stylus to collect information about a signature and for verification purposes takes complex information such as strain, speed, writing speed, etc. Off-line signature authentication requires less electronic power, and uses scanner or camera recorded signature images. An off-line signature authentication device uses features that are derived from the signature image being scanned. The apps used for authentication the of offline signatures are much simpler. In this you only need to evaluate the pixel image. But it is a complex process to design an offline system due to unavailability of many desirable features such as stroke sequence, speed and other dynamic details in offline mode. The verification

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process must rely wholly on the features that can only be extracted from the static signature image trace. Biometric characteristics are used to identify a person. The most prominent biometric characteristics of a person are fingerprint, voice, face recognition [2]. Among the non-visual biometric characteristics are voice recognition and signature verification. Signature verification is widely used in financial, legal and commercial transactions. Image processing techniques can be used to enhance the signature of the person for verification process. This work deals with offline signature verification using Artificial Neural Networks and image processing techniques.

II. LITERATURE REVIEW

To enhance proficiency, Researchers are utilized distinctive strategies with the end goal of signature verification framework. This document specializes in offline signature verification, characterized by means of the usage of digital signature pictures, the motive of which is to decide whether the given signature was made by way of the plaintiff or produced by way of a fraudster. This section offers an idea of the ways through which this problem has been dealt with by many researchers over the last few decades and the latest developments in the this field.

R Shilwant. M. Samant, Mahendra, Bhojraj Sarasambi, Mahesh Shelke, "Signature Verification System"[1], . This paper outlines a new way to verify signature and tangible evidence in an offline environment. In the proposed work, the photograph of the signature would be captured by the camera or the signature would be photographed by certain sources such as a signature, which would then be used as signature collection, signature input, signature thinning, border identification. . The drawing comes true by executing it through various methods. Feature extraction, signature recognition. Sakshi Bhatia[2], presented "Systematic Review of Biometric Advancement and Challenges" in which Talking about security is the most important thing for an individual, biometrics is the best way to protect individual identity. This paper clearly describes the functioning of different biometric systems. It also examines the shortcomings of each biometric method and the significant benefits. The methods provided by her are very popular with many users because this method has been used since time immemorial, previously on paper and now on automated tablets.

Gulzar A. Khwaja and Mohammad S. Laghari [3] suggested offline handwriting signature identification using biometrics, which would identify a person based on physical or behavioral characteristics, including the authorized person and the fraudster. It has the ability to distinguish in a reliable way. This work provides neural network-based validation of an offline handwritten signature system trained with low-resolution scanned signature images. Shashi Kumar DR and KB Raja [4] proposed offline. Signature verification based on a combination of grid and global features using neural networks. This function involves performing offline signature verification based on a combination of grid and global features using neural networks (SVFGNN). Global features and grids are linked to create a set of signature verification features. V Bharadi [5] has developed an offline signature recognition system. This handwritten signature is one of the most widely used biometric features to authenticate a person and a document. The performance metrics of certain systems are compared with their output methods.

Mohamed A. Abdala [6] proposed that the system is based on two separate neural network divisions and two dynamic features (global and grid features). The system designed consists of three stages, namely pre-processing, feature extraction and neural network stage. .Nilesh Y Chowdhury, Dr. Umesh. Bhade [7] presented a signature recognition and authentication system using back propagation neural networks. It proposes offline signature recognition and verification using the Back Properation Neural Network based on image processing steps, Unchanging Central Moment and some Global Properties and Back Propagation Neural Networks.

In Ankit Arora, Akanksha S. Choubey [12]'s research, specific properties (set of squares, projection, ratio coefficient, center of gravity) are examined separately and the effect of each feature is observed.

In the paper Signature Verification Using Neural Network by Manoj Kumar[18]. They have developed an offline signature verification system developed using global features and signature textures. This program is based on a pre-signature processing system to get a binary image and calculate global features and texture points from it and save the feature vector. All calculations are done based on these factors points. The feature vector derived from the global features and textures is used to compare the vector feature of the incoming test signature. Based on the values obtained, the network will determine the suitability of the signature. Liang, Shan; Nie, Shuai; Liu, Wenju; Peng [21], Shouye has proposed a novel aspect of the opposition element (AFL) to integrate pre-printed data knowledge with the author's independent semantic features to improve HCR performance in limited training data.

Prashant CR [26] proposes DWT based offline signature verification using the Facility. It introduces DWT based offline signature verification using Angular Features (DOSVAF). The signature size has been changed and Discrete Violet Transform (DWT) is applied to the block to capture the features.

III. PROPOSED METHODOLOGY AND WORK

A. Image Acquisition

In image processing, image acquisition is the process of getting an image from an external source for further processing. It is always a basic step in the process as there is no process available before getting a picture. The process of photographing an uncultivated image in an object or square by means of a optical device to become a manageable form for processing and analysis [3]. Photos of the signatures are scanned using a digital scanner for the verification method of offline signatures. For offline processing, the scanned images are stored digitally[4].

B. Image Preprocessing

Pre-processing is needed in the application for image processing to eliminate inconsistencies, from the image data. Signatures are transformed into greyscale images, and grayscale images are converted into binary images for easier image data processing. The key factor in the pre-processing stage is creating standard signature that is prepared for feature extraction. The purpose of pre-processing is to improve image quality so that we can better analyze it. With advance analysis we can suppress unwanted distortions and improve certain features needed for the particular application we are working on [5]. Those features may vary for different applications.

A. Thinning
   This is carried out by giving the image a thickness of 1 pixel to be able to lessen the opposing length. The upgrade process is complete to reduce the measurement time. The use of the merging point is terminated by raising. .This estimate is best for mark images, as it saves the mind-boggling points of interest and various signature properties.
B. Normalization
   The person's signature always may not have the same sizes or the same resolution. All signatures should have a common dimension after the normalization process has been completed. Therefore, signature processing is performed in which all images are normalized to the size required for further processing.
C. Feature Extraction
   Feature extraction is a process of extracting features to get a numerical representation of the information of the image. The data collected by feature extraction by image processing techniques are used to train the algorithm. The features used are Aspect Ratio, Centroid, Eccentricity, Skewness, Kurtosis, Solidity[8].

Aspect Ratio
The ratio of width and height of an image is represented as the aspect ratio of the image.

Centroid
In the sense of image processing and computer vision, an image is made up of pixels, and Centroid is the average of all the pixels that make up the shape.

Eccentricity
Eccentricity tests the shortest length of paths to reach every other vertex w of a connected graph from a given vertex v. ... It is defined by its neighborhood graph and the given metric for a connected region of a digital image.

Solidity
The image object's width is defined as the area of the image object object separated by its binding rectangle.. An image object's solidity (convexity) is, area of the image object separated by area of its convex hull.

Skewness
Skewness is a measure of how much a distribution varies from a normal distribution. It is used to characterize the data in the distribution. If the deviation of distribution is below 0, then the process must be done carefully as the data is not normally distributed.

Kurtosis
Kurtosis is a statistical term used to characterize the distribution, as well as skewness. Widespread kurtosis shows tail data that exceeds normal distribution tails (e.g., five or more standard deviations from definition).

C. Data Acquisition/Signature Database

The signature database contains the signatures of 500 users. Each user data contains 24 real and 30 forged images. To solidify the system, signatures are collected at different times without seeing other signatures that the signatories previously signed.

IV. Neural Network Training

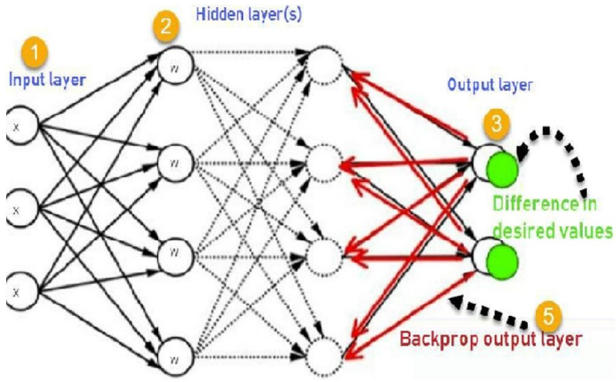
Neural network consists of linked neurons. Each link has a numerical heading. Neurons are key building blocks of a neural network[9].

A. Feed Forward Mechanism

The feed forward neural network by the name moves in one direction only that is in forward direction from input layer to the output layer. The network is without cycles or loops[11].

B. Back Propagation

Back-propagation is a technique used to reduce the loss at each neuron and correct the error at the output layer and adjust the values of weights in the hidden layer[12].
Back-propagation is the basis of neural net exercise. It is a method of correcting neural net's weights based on the degree of error detected during the past period (i.e., repetition). Proper weight tuning means you can reduce the levels of error and make the model stronger by increasing its overall performance.
Backpropagation is a short term for "backward error propagation," a popular approach for training artificial neural networks. This approach helps to measure a loss function's gradient with respect to all the network weights.



Propagation Working

1 Put through the inputs at input layer.
2. Input is real weights selected at random.
3. Calculate the output of each neuron.
4. Calculate the Output Error.
5. Update the hidden layer values and input weights of neurons according to the error generated.

Keep repeating the process until achieving the desired output[13].

Advantages of Back propagation

Backpropagation has the following popular advantages:

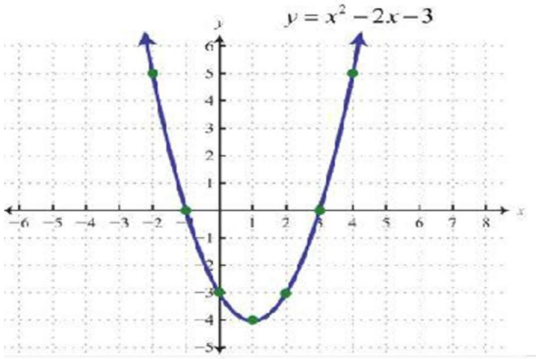
- Backpropagation is easy and quick to program.
- There are no parameters to change apart from the input numbers
- It is a versatile tool, since it does not require prior network awareness
- This is a typical approach that works fine in general
- No special notice is needed of the features of the role to be learned.

C. Stochastic Gradient Descent

Stochastic gradient descent algorithm is used in neural networks in most cases to make the computation of gradient descent more quicker.

Gradient Descent

Gradient, means slope in simple terms. So gradient descent literally, descends through the slope to the minimum point on the face of curve. Let us imagine a two-dimensional graph, as in the figure below, for example a parabola.



The goal of gradient is to start at the lowest point of x value and proceed through the algorithm to find x at which the value of y is lowest[14].

Gradient Descent Algorithm

Gradient descent is a repetitive algorithm that begins at a random point on a function and descends its slope until its target is reached.

It is the algorithm's crux. The algorithm start with selecting a random point (beginning with a random x in our parabola example) and update it through the iterations of process. The Algorithm is as follows:

1. Calculate the feature gradient.
2. For the parameters select a random initial value.
3. Initialize the function with random values to the parameter.
4. calculate the sizes as slope * learning rate
5. The new parameters are determined by eliminating size from the old parameters.
6. Repeat steps from 3 to 5 until the target is near 0 [18].

Downside of Gradient Descent

The gradient descent algorithm has some downsides. For each iteration of the algorithm, the number of computations is as follows.

Say, we've got 1000 data and 10 process. Therefore, each iteration there are 10000 computations. When we have 1000 iterations in the program. we need to do 10000 * 1000 = 10000000 computations. So, the gradient descent on large number of data has a slow computation time.

Stochastic Gradient Descent (SGD)

When selecting data points for calculating the derivatives at each stage, Stochastic Gradient Descent selects a starting data in entire data set for every cycle to dramatically reduce the computations.

Sampling a small number of data points instead of just one point at each stage is also normal, and this is called "mini-batch" gradient descent. Mini-batch is attempting to strike a balance between SGD 's goodness of gradient descent and speed.

V. Results and Discussion

5.1 Given the data of 54 images for every single person, consisting of 24 real images and 30 forged images. After pre-processing, feature extraction has been done on every single signature for every person, resulting a csv file featuring 54 objects of values of features of every single image in a row.

As shown in the figure above, is a graph comprising of features of a single person dataset, the relations among features are clearly represented as plotted values in feature extraction.

6.2 After feature extraction, the data is sent through dataset into the neural network via folds (parts of the data), in which folds are distributed over to training and testing set of data. Every fold is taken as testing data for better efficiency, the results are stored in an array and plotted as a graph as shown below. So, every single image is

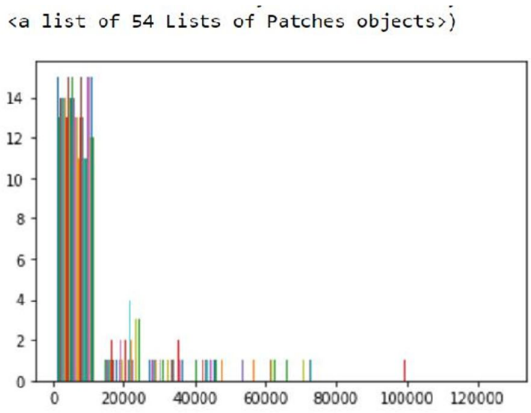


Fig. 6.1 Features of a single person dataset

taken into consideration as test data to check for better accuracy, and the best performance is plotted as red circle in the below graph, And a quarter of the data accuracy for the back propagation neural network algorithm we used was 70 percent.

And the algorithm operates with different numbers of folds, different learning rates, different age levels, and different numbers of hidden layers in the neural network. The accuracy varies for each specific combination of different parameters for the algorithm and is best provided.

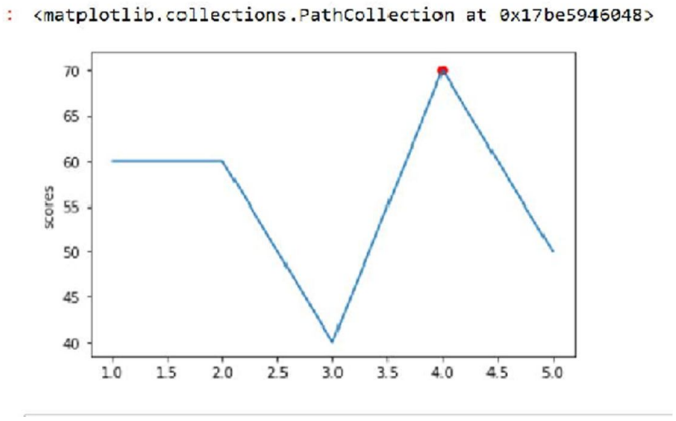


Fig. 6.2 scores of performances for every single part of fold

6.3 The bar graph representation of Scores resulted from the algorithm is shown below.

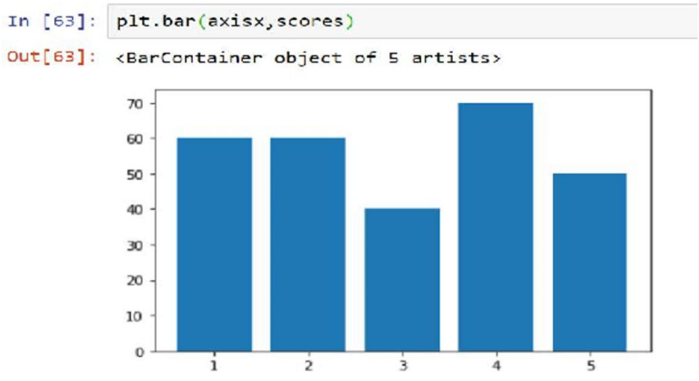


Fig. 6.3 Bar Graph Representation of Scores

VI. IMPLEMENTATION

A. Tensor Flow

TensorFlow is a learning tool for machine learning algorithms. TensorFlow is a rich framework for controlling all facets of a machine learning system; however, this class focuses on the creation and training of machine learning models using a specific TensorFlow API. For more information on the wider TensorFlow framework, please see the TensorFlow documentation.
TensorFlow APIs are hierarchically structured, with the high-level APIs based on low-level APIs. The low-level APIs are used by machine learning researchers to build and explore new machine learning algorithms.

B. Numpy

NumPy is used for arrays. It is a library used in python used for the implementation of operations on multi-dimensional arrays.

C. Matplotlib

Matplotlib is a library in python programming language. It is used to plot different graphs to estimate the range of computation. There is also a state machine-based procedural pylab interface (like OpenGL), built to closely mimic that of MATLAB, but SciPy uses Matplotlib to prevent its use.

D. SCIKIT Learn

Scikit-learn is definitely the most powerful machine learning library in Python. The sklearn library includes several effective machine learning and statistical modelling resources including classification, regression, clustering, and reduction in dimensionality.

VII. FUTURE SCOPE

As the database raises the processing time of the program of verification of the offline signature. And using this approach the complex information gets lost. Far more effective dynamic information is far more effective than static information. Then we can develop a system as a future work that is a combination of static and dynamic knowledge, i.e., the combination of both offline and online verification systems. Or we can build an online signature verification system based on more powerful dynamic features than this.

VIII. CONCLUSION

Using the findings, we can infer that the proposed method significantly improves system protection thereby improving the system and also enhancing system accuracy. There are several methodologies built for the verification of signatures. The method of authentication differs by modifying the functions derived from a signature. So, a signature analysis can be performed using the same neural network methods but use different signature characteristics. Therefore, verification of digital signatures is still a challenging field for research since forgeries are still being created.

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