Improving the Performance of Facial Recognition System Using Artificial Neual Network

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***Abstract:* This work presents "improving the performance of facial recognition system using artificial neural network". The aim is to develop a more reliable and précised face recognition system. This will be achieved using the AT&T database as the training dataset, image acquisition, image processing, and artificial neural network. The work will be implemented using image processing toolbox, image acquisition toolbox, statistics and machine learning toolbox and Mathlab. The accuracy was measured using the neural network performance evaluation toolbox and the result achieved is 97.6%.**

***Keywords*: facial recognition, artificial neural network, accuracy, AT & T dataset**

I. INTRODUCTION

According to [1], facial recognition is dated back in the early 70's. In simple words, it is a process of identifying and recognizing a face. But as easy as it sounds is not a simple task because there are lots of similarity in certain facial traits of different individuals, and this similarity in face has resulted to lots of problems like mistake identity, mistake arrest, fraud, impersonation and lots more. These challenges have become a major problem in the world generally.

Today face recognition has drawn the attention of researchers in fields from security, identification, engineering, banking sector, psychology, and image processing, computer vision and lots more. In fact a search of facial recognition on google.com produces over 350,000 000 results. However, one will wonder why despite the numerous works done and huge success achieved so far with this technology, yet research works are still being published on the topic daily. The answer to this is simply lack of consistency in the performance accuracy of the conventional systems.

Over time various techniques like [2], [3], and [4] have been adopted to improve the performance of face recognition systems, yet despite their success, precision is yet to be attained. This is because of the variable frequencies, noise and complexities associated with the human facial feature vectors. Hence there is need for a more précised system to be developed, considering all this complexities.

To solve this problem, artificial neural network have been called upon in [5], however, despite the success, it lacks complete image filtering techniques before feature extraction and training. The implication is that when an image is not process (filtered), the impurities from the image and also the background noise will be associated with the feature vectors and hence can dent the performance of the neural network. This is what is being currently experienced in the conventional neural network systems. This work therefore seeks to address this challenge, developing an improved facial recognition system with an image processing techniques which filters both the query image and the background, before feature extraction and training. This is believed to produce the desired performance needed.

II. LITERATURE REVIEW

In [2], the application of machine learning for digital recognition of identical twins to support global crime investigation was developed. The work was done using image processing techniques and K-nearest neighbor (K-NN) classifier. The accuracy recorded is 92%, however the performance was based on only 2D images.

In 2011, [3] presented a wok on facial recognition system using artificial neural network (ANN). The work was trained using back propagation algorithm (BPN) and the validation result obtained is 94.6%. Despite the success, the recognition result can be improved using image processing techniques on the query images before training.

[4] Presented a hybrid approach for facial recognition, combining the principal component analysis (PCA) and geometric appearance based recognition approach (GABRA). The result obtained for their work when tested with an AT & T dataset was 91%, however despite the success, the performance needs improvement.

[5] Research on the facial recognition using eye blink detection. The work was developed employing the viola jones algorithm and support vector machine (SVM) classifier for the process. The result achieved an accuracy of 87% when trained with AT & T dataset. Therefore there is need for improvement.

III. METHODS AND SYSTEM DESIGN

Data collection: to develop this work, the AT & T dataset was employed as a multiset for the training and the testing dataset. The AT & T datasets contains 400 images made up of 40 classes each containing 10 images of differential facial expressions. It is an open source facial recognition dataset developed for research works on face detection and recognition systems.

*Image acquisition***:** this process involves uploading the images from the dataset or capturing a query images for face detection which is a processes of identifying a face from an image. This was achieved using the viola and Jones algorithm in [9], [2], [8] and [6].

Image pre-processing: this is the first stage of image processing step. The implication of this process is to eliminate any form of impurities associated with the background of the acquired image. This is done using an implementation procedure called histogram equalization as discussed in [2].

Image processing: this process involves the filtration of the query image to remove noise associated with the image acquisition device. The techniques employed for the image filtering are the binarization [6], adaptive filtration using the Gaussian filter model in [7], edge detection using the canny edge operator in [8], normalization [2] and feature extraction process which will be discussed next.

Feature extraction: this is the extraction of the interesting part of the face in a compact feature vector [9]. These vectors are statistical values which will be feed to the neural network for training purposes. This is done using the histogram oriented gradient (HOG) under the statistical method of feature extraction.

Artificial neural network

Since the interesting parts of the images are extracted as a feature vectors represented using the feature extraction model in [9]. They are identified by the neural network as a pattern recognition problem using nonlinear pattern regressive (NXPR) model as shown in

$$b(k+d)=P^{-1}(b(k),b(k-1),\ldots,b(k-n+1), u(k), u(k-1),\ldots\ldots u(k-n+1)) \quad (1)$$

Where u(k) is the input matrix from the testing dataset, P^{-1} is the training images, and b(k) is the system output. These NXPR model is trained using the feed-forward back-propagation algorithm (see the flow chart in figure 2) as shown in the training mpde below;

$$\hat{b}(k+d)=f(b(k),b(k-1),\ldots,b(k-n+1),u(k-1),\ldots,u(k-m+1))+g(b(k),b(k-1),\ldots,b(k-n+1),u(k-1),\ldots,u(k-m+1))\,u(k) \quad (2)$$

The training model presented in the structure (see (2)), produce the desired out of the training result which is the reference face model for future classification of feature vectors from the testing dataset. The reference model is presented in the model of equation (3) as;

$$u(k+1) = \frac{br(k+d) - f[b(k),\ldots,b(k-n+1),u(k),\ldots,u(k-n+1)]}{g[b(k),\ldots,b(k-n+1),u(k),\ldots,u(k-n+1)]} \quad (3)$$

Table 3.1: Neural Network Parameters

Training epochs	22
Size of hidden layers	14
Controller training segments	30
No. delayed reference input	2
Maximum feature output	3.1
Maximum feature input	2
Number of non hidden layers	2
Maximum interval per sec	2
No. delayed output	1
No. delayed feature output	2
Minimum reference value	-0.7
Maximum reference value	0.7

Training algorithm

The training algorithm (shown in the flow chart of figure 1) employed for this work is the offline feed forward back propagation algorithm. This is an adaptive training algorithm employed for training feature vectors identified by neural network. The algorithm trainings by monitoring the performance of the training process at various epoch and if the training process under performs, the epoch value is increased by 0.7, while is the training process is about to overshoot, the epoch value is decreased by 0.5. This is done automatically, and when the best performance of the training process is achieved the training stops immediately.

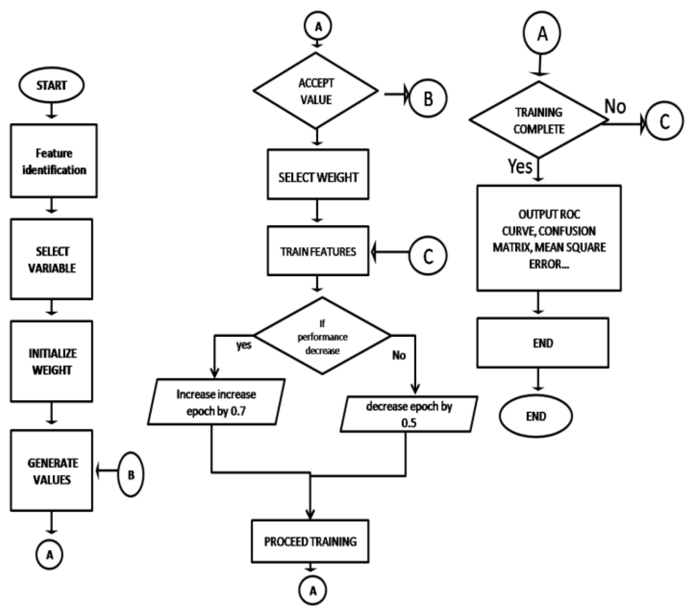

Figure 1: flow chart for feed-forward back-propagation algorithm

The system block diagram is presented in figure 2 with the testing as the input matrix which is pre-processed to filter background noise, then the image processing steps are applied using the techniques identified in [6][7][8] and [2]. The processes image from the testing dataset and the images in the training dataset are drilled using the HOG feature extraction technique to extract feature vectors which are trained and classified for prediction of result.

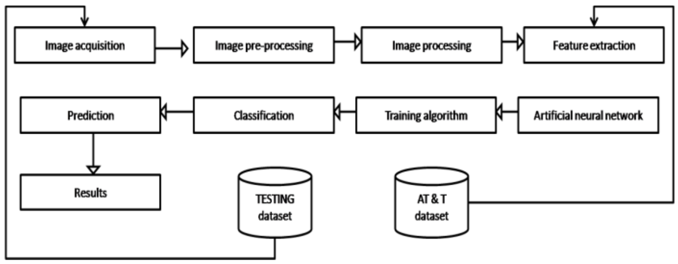

Figure 2: system block diagram

IV. RESULTS AND DISCUSSIONS

This section will discuss the performance of the neural network used, however before this begins the system was implemented using Mathlab. This was done using the image acquisition toolbox to acquire the images from the dataset, then the image processing toolbox was used to implement the various image processing techniques employed. The statistics and machine learning toolbox was used for the feature extraction implementation, then the neural network models designed in equation 1, 2 and 3 alongside the training parameters were implemented using the neural network training toolbox.

The implementation result were simulated using the training parameters in table 3.1 and the performance such as the validation result, mean square error among others are automatically plotted using the neural network performance tool.

The performance of the training process is analyzed using a receiver operator characteristics curve as shown in figure 3. The result is divided into four sections (a) training receiver operating characteristics (b) testing receiver operating characteristics (c) validation receiver operating characteristics and (d) overall receiver operating characteristics

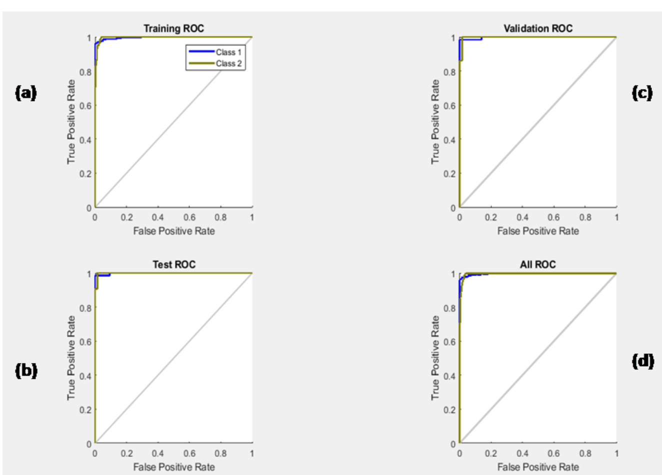

Figure 3: Receiver operating characteristics result

From the results of figure 3; the (a) presents the ROC performance analysis of the training dataset with sensitivity rate of 0.975 and selectivity of 0.25. These ROC result for the training dataset is also reported at a sensitivity of 0.971 and selectivity of 0.29 as shown in 3 (b). The ROC for the validation set is presented in 3 (c) with the sensitivity value of 0.981 and selectivity of 0.19. The overall ROC analysis is presented with 3 (d) with a sensitivity value of 0.976 and selectivity of 0.024.

The result presented in figure 4 shows the status of the training process. The X-axis shows the number of training epoch used for the process as of 22, while the Y-axis presents the cross entropy for mean square error at each check. The performance graph is computed for every iterations in the training process, and the graph in which all the three training results (test, validation and training) coincide at almost the same point is chosen to be the best performance and at that point the training was stopped.

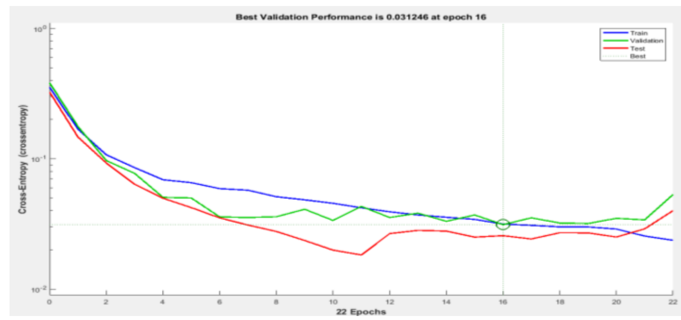

Figure 4: training performance check

From the figure 4, it was observed that the three results for training, test and validation coincided closest at epoch 16, with a performance validation of 0.031246. This implies that at this epoch value (16), the ANN produced the best performance which is summarized in the table 2.

Table 2: performance of the new system

Iteration	Sensitivity	Specificity	Training time (s)	Accuracy %
Training	0.975	0.025	3.1	97.5
Testing	0.971	0.029	3.3	97.1
Validation	0.981	0.019	3.3	98.1
Overall	0.976	0.024	3.1	97.6

From the table 2, the performance of the ANN was analyzed using the result of the receiver operator characteristic presenting the training behavior of the multi sets using sensitivity, selectivity and the step response time of the of the new system

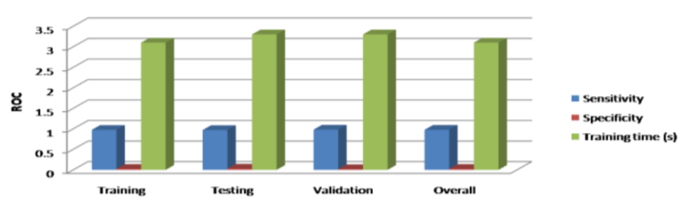

Figure 5: performance of ANN

A comparative analysis is also performed which considers the behavior of the existing system in terms of accuracy and the new system. The overall accuracy of the new system which is 97.6% is compared with the performance of the selected techniques in the literature review and presented in the table below as;

Table 3: comparative performance with the existing systems

Technique	Performance Result%
ANN	94.6
PCA + GABRA	91
SVM	87
K-NN	92
New System	97.6

This behavior is measured using an analyzer to physically compare and contrast the new system and the existing system techniques. The implication of this is to use this criterion to validate the new system. From the result of the analyzer as shown in figure 6, it was observed that the new system performs better than the traditional ANN techniques and other related machine learning techniques generally.

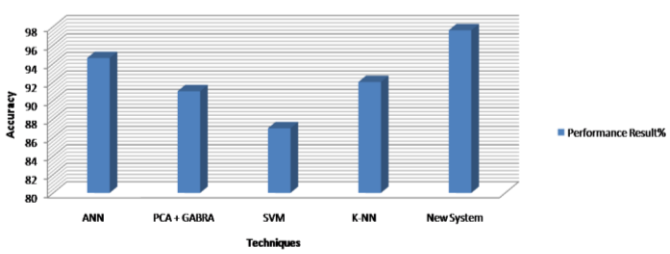

Figure 6: comparative result

V. CONCLUSION

This work has successfully developed a facial recognition system with 97.6% recognition accuracy. This was achieved due to the selected image pre-processing and processing techniques used to filter the image before feature extraction and training process. The implication is to remove unwanted noise and impurities associated with human face complexions and thus improve recognition accuracy to precision using artificial neural network. From the comparative result presented and discussed it was evident from the result of the new system, comparing the existing system that face recognition will produce a better and précised result when designed with image processing techniques.

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