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EFFECTIVE USE OF ARTIFICIAL INTELLIGENCE FOR THE ENHANCEMENT OF FACIAL RECOGNITION SYSTEM

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Abstract
This research paper deals with the development of deep neural vision processing technique for the enhancement of facial recognition and verification. This was motivated by the need to recognize individuals in security-controlled environments. This problem was addressed in this research using methods such as data collection, image acquisition, computer vision, face detection, data pre-processing, data processing, training and face recognition. Mathematical models and universal modeling diagrams were used to design the new system which used discrete wavelet transform model, rendering model, convolutional neural network model to develop an enhanced facial recognition system and implement with Matlab. The system was tested and validated using tenfold cross validation technique and the accuracy achieved was 99.22%. Finally, comparative analysis was performed which compared the performance of the new deep learning algorithm developed and the existing state of the art algorithms; and the result showed a percentage improvement of 0.52% which was very good among other achievements, such as system reliability which was lacking in the conventional system.

Keywords*:* Vision processing, Focal recognition, Graphical processing, Deep neural vision

I. INTRODUCTION

Face plays a major role in our social intercourse by conveying identity and emotion. The human ability to recognize face is remarkable. We can recognize thousands of faces learned throughout our lifetime and identify familiar faces at a glance even after years of separation. The skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, ageing, and distractions such as glasses or changes in hairstyle (Henry and Johnson, 2011). Face recognition is one of the most active research areas in machine vision. After over 40 years of active study into the problem, great progress has been made but a universally accurate computer based system is still elusive. Unless affected by prosopagnosia (also known as face blindness), humans are able to recognize familiar faces effortlessly with great accuracy from a very early age.

The vast majority of researchers have used 2D data to solve the problem of face recognition system, because until recently the use of 3D data for this task was prohibitively expensive due to poor quality. However, now it is affordable and available due to the process of image normalization and segmentation process which potentially overcomes problems of illumination and pose variation associated with 2D images.

The advancement in the field of artificial intelligence (A.I) has also provided reliable avenues to solve the problem of face recognition using the various techniques as discussed in (Sharma, 2018). This A.I techniques have the capacity to learn and make the problem of face recognition a solve task. When this is achieved it will go a long way to solve issues of insecurity among other numerous applications.

AI. LITERATURE REVIEW

Zahraa (2014) researched on Real Time Face Recognition System (RTFRS). They study concentrated on the recognition speed and time of already existing system of facial recognition, with the view that accuracy alone is not the yardstick to justify the authenticity of facial recognition system. The research proposed the use of multi-core Central Processing Unit (CPU) and Graphical Processing Unit (GPU) which enables parallel computing to speed up computation time. The system was deployed, and was able to detect face in real time, but the recognition accuracy recognized has to be improved using deep learning.

Vimal and Virender (2015) studied the implementation and performance analysis of face recognition using Matlab. Their work presented a face recognition system that was developed using Matlab which the input face from a set of training faces. Furthermore, they analyzed face recognition using edge detection method which extracts the edges of an image. According to them, Edge detector gives a binary image in which the white pixels closely approximate the true edges of the original image. They affirmed that design implementing Edge Detection technique gave more accurate results because of its positive points, also it is less sensitive to noise and more adaptive in nature. However, the work lacked complete image processing technique to get more accurate, fast and efficient results.

Teoh et al. (2021) presented research on face recognition and identification system using deep learning approach. In the study, OpenCV was used to implement deep learning algorithm on python. The deep learning technique used is the convolutional neural network. The performance presented a face recognition accuracy of 86.7% for real time.

Tejal et al. (2020) presented a research on face mask recognition using machine learning. In the study, dataset of images with face mask was used to train deep learning algorithm and deploy for application using tensor flow. The detection accuracy was good, but can be improved to increase the quality of data in the training dataset.

Jun et al. (2015) presented a research on unconstrained face verification system using deep convolutional neural network features. In the study, the CNN was used to train labeled face wild and Youtube face dataset respectively. The performance showed that deep learning provided accurate result for face recognition; however the reliability of the performance can be improved using data processing technique.

Hannan et al. (2019) presented a research on automated face detection, recognition and gender estimation application to personal identification. In the research, a comparative method which comprises of deep learning and binary pattern histogram was used for the recognition of person. The system when tested showed that the deep learning performed better than the binary pattern histogram technique; however the overall performance can be improved using image processing.

Madan et al. (2018) surveyed the various facial recognition techniques. The study revealed that face detection was one of the most challenges pattern recognition problems to solve due to the complexity of the faces attributes. In the study the use of support vector machine (SVM), principal component analysis (PCA), artificial neural network (ANN), independent component analysis (ICA), Gabor wavelet, hidden markov model and graph based approach was considered as some of the most used technique to solve this problem. These techniques were tested on the FERET, LFW, YTF, Yale, AT&T and Yale dataset, respectively. The study concluded that despite the success achieved so far, there was still a lacuna to be filled to enhance reliability and efficiency of digital face recognition system.

Praneeth et al. (2020) presented a research on face recognition system based on deep learning technique. In the study, the features of face were extracted using the binary pattern histogram algorithm and then trained with convolutional neural network. The performance can be improved using image processing technique.

Michael and Aman (2020) presented a research on face recognition using deep learning technique. In the study, a systematic review was performed, and then convolutional neural network was adopted for the training faces with an accuracy of 97% when deployed and tested on tensor-flow software. The performance was however limited to the training dataset used.

Nishtha (2019) studied face recognition using deep convolutional neural network. In the research the architecture was developed and used to train ORL dataset which has 40 classes of different peoples. The result when tested showed that the accuracy is 95%; however, the performance when deployed in real time application may not be accurate as the data used to achieve this 95% accuracy is already processed. Hence there is need to incorporate filter to the system to sustain the same level of accuracy when deployed in real life application.
Cmak et al. (2020) researched on face mask detector with Pytorch and Deep learning techniques. The study used OpenCV, artificial neural network (ResNet) and computer vision to develop a system which could detect if a person is wearing face mask. The aim was to prevent the spread of coronavirus. The percentage accuracy when tested was 97%; however, the test was not done with a standard dataset, and hence could not be justified.
Prajyot (2020) researched on Deep learning approach for facial expression recognition. In the study, deep learning algorithm was developed and deployed for the recognition of face expression using convolutional neural network technique. The performance was evaluated using confusion matrix on Jaffe dataset and the performance was efficient. However, despite the success, the performance could be improved using image processing.

Mira (2021) presented a dissertation on face recognition and face mask detection using machine learning technique. In the study, systematic review of various approaches for the recognition of objects was discussed, and then machine learning was singled out and used for the design of the proposed system. The performance was tested using face mask person, and also for face recognition and the result was good. However, there is need for improvement using better dataset and also image processing to achieve system reliability.

Liu et al. (2020) presented a research on multi view face recognition system using convolutional feature extraction technique. In the study the YTF, IJB-A and celebrity dataset was used to train the CNN system and then tested for validation. The result showed high validation accuracy, but could be improved using image processing.
Sen et al. (2020) presented a research on face recognition with on snapshot learning. This was achieved using Siamese transfer learning and applied on the happy house dataset. When tested, a recognition accuracy of 56% was achieved, but could be improved using image processing.
Heidari and Ghaleh (2020) presented a research on face recognition system using transfer leaning-based MSiamese network and LWF dataset. The system when tested showed high recognition accuracy, but could be improved using image processing.

Zhao et al. (2020) used convolutional neural network feature extraction technique to develop a multi view face recognition system. The study was trained with CAS-PEAL dataset and achieved an accuracy of 98.52%; however despite the successes, the system could be made to be reliable using image processing technique.

III. MATERIALS AND METHOD

The methods used for the development of the proposed system are data collection, image acquisition, computer vision, face detection, data pre-processing, data processing, training and face recognition.

3.1 Data Description

The dataset provided by the NPF has a sample size of 1850 different suspected identities apprehended for various reasons and awaiting trials. The data were already sized and formatted according to their specification of the NPF as presented in table 1 and stored for official use.

Table 1: Data properties

Image parameters	**Values**
Dimension	190 x 260
Height	260
Weight	190
Horizontal Resolution	96dpi
Vertical resolution	118dpi
Bit depth	24
Size	5.6kb

The table 1 presents the properties of which all the images were formatted and stored in the station for investigation and other official purposes. The data samples of the data collected are presented in figure 1.

Figure 1: Sampled data from the NPF

3.2 Computer vision

A camera can be likened to the eye of a young child who can see without a common sense of the objected in focus. This camera, irrespective of its specifications and qualities, lacks common sense of the data it acquires in time series and as a result, captures unnecessary data which induced more noise and irrelevant features to the main image needed. This problem was addressed using computer vision method. This is a process where the camera is incorporated with intelligence which enables it to derive useful information from a digital image before capturing them. There are various computer vision algorithms in (Girshick et al., 2014) which can achieve this objective today. However the adoption of any algorithm is dependent on the type of data under investigation, which in this case is a human face.

This study adopted the Viola Jones algorithm which enables camera to not just detect face but also tracks it in real time and collects quality data. According to Vilmal (2015), the algorithm has many advantages, enables via its sophisticated and invariant detector which locates the scales of human facial features. This algorithm was reconfigured to be compatible with the specifications presented in table 1. The aim is to ensure that any image captured in time series are of the same size and properties. The data flow model of the reconfigured Viola Jones algorithm is presented in figure 2 as flowchart.

The flowchart in figure 2 presented as algorithm shows how it was configured to align with the properties of the recommended camera. The algorithm came into play when the camera reads image data using Haar features and Adaboast algorithms and then recognizes facial fudicial points (features) to detect a face.

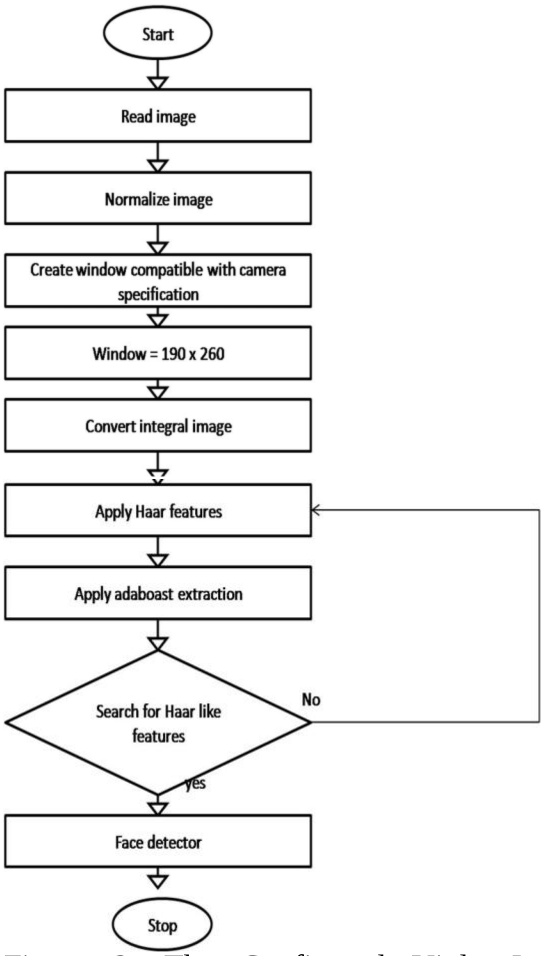

Figure 2: The Configured Viola Jones algorithm

3.3 Process Diagram

The process diagram was used to present the logical interaction of the various methods discussed to achieve the proposed system as shown in figure 3.

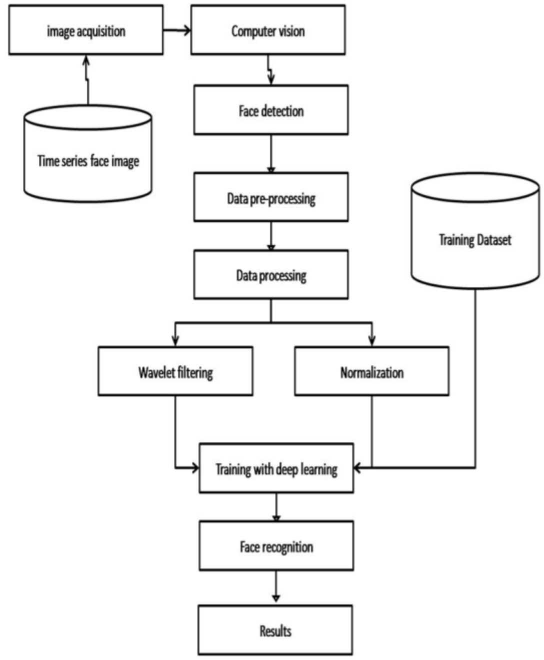

Figure 3: Process Diagram

The process diagram presented the face detection and recognition system workflow. The diagram shows how the training dataset containing images of suspected persons was trained to generate a reference model, and then use it to recognize time series face images. This was done using image acquisition process which intelligently collects the image of the suspect with the help of computer vision technology. The computer vision was used to make the camera only search for face-like images, based on Haar features and Adaboast algorithm to detect face and capture it. The data captures which is always characterized with noises; such as background noise, strip noise and impulse noise were processed using histogram equalization technique to remove the background noise; wavelet filter to remove the impulse noise and then normalization process to mitigate the strip noise. The processed data was then feed to the deep learning algorithm for training using convolutional neural network which train the input data and compare with the reference model to recognize face.

3.4 System Design

The system design was presented in three main sections which are: the face detection, data processing and face recognition. The design was done using Unified Modeling Language and mathematical models where necessary to present clear explanation and relations between all necessary actors and parameters which contributed to the realization of the new system.

3.4.1 The Face Detection Modeling Diagram

The face detection model shows how the camera was able to read, track and detect only face in a wide variety of other images within the camera scene. This was achieved using the logical data flow diagram which shows the marriage between the camera device and the configured Viola Jones algorithm in figure 3.2 to make it intelligent. The configuration was done also considering the standard and requirement of the NPF image set which was specified in table 1.
The face detection model shows how the camera reads image data from the scene and use computer vision to search for Haar features which represents face using facial features like eye, nose and mouth. These features are labeled as fudicial points (m) and the process continues until the points satisfy the requirement of face detection is greater or equal to 8 points. The reason for this value of fudicial point was based on the study of RaceFaces (2020) which revealed that 8 facial points satisfy the requirement for face detection.

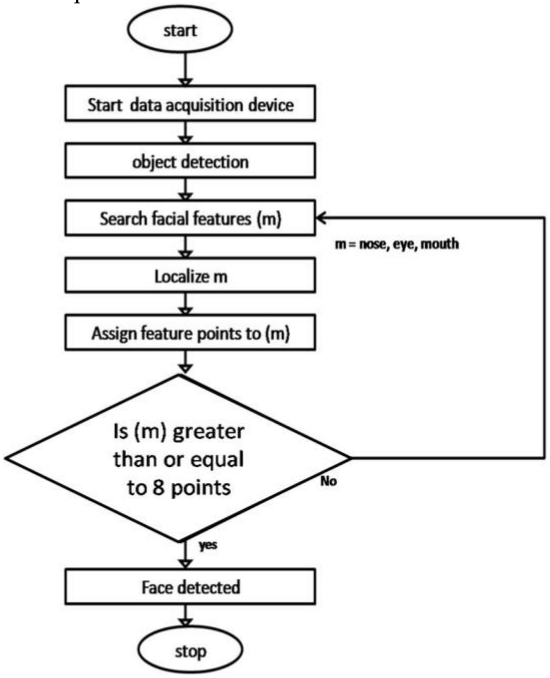

Figure 4: The Face Detection Data Flow Modeling Diagram

The Data Flow Modeling diagram in figure 4 presents the data flow of the facial detection system. The diagram shows the interaction between the camera and the computer vision algorithm to identify and capture a suspected person face for investigation via facial recognition.

3.4.2 Data Processing Model

The data processing model was developed using the Discrete Wave Transform (DWT) which uses three filters simultaneously to process image data and remove noise. The filters are the Haar wavelet, orthogonal filter and bi-orthogonal filters based on Wavelet Decomposition Theorem, which segments the images into various sub band of Low Low (LL), Low High (LH), High Low (HL) and High High (HH). These regions represent the various part of the image, with the major part within the low low pass bands, while the remaining parts like the edges are shared among the other bands.
The DWT which presents a two-dimensional representation of the face data detected and captured is modeled using equation 1.

F(u, v) = √ Σ Σ ... (,) + √ Σ Σ ΣΣ ... (,)(1)

Where the wavelet coefficients are presented as:

… (2) = √ Σ Σ (,) (,)

= … (3)

x = (H, V, D)

Where M is the power of 2, is the dilation and normalization factor, u and v are the translation parameters in terms of discrete values, and are approximation coefficients, F(u, v) is first scale input, y is scale parameters, s is shift function, T is time reverse scale, t is time domain, f is frequency domain, W or ( )

In two dimensional 2D and 3D the scaling function q(u,v) and three 2D wavelets of (,), (,) (') are used to deduct the wavelet representation of the image as the models below:

q(u,v) ….. (4)

(,) …… (5)

(,) …..(6)

(,) …… (7)

The models in equation 4 is the scale factor used to decompose the wavelet coefficients of the images into various scales as shown in DWT decomposition modeling diagram in figure 5.

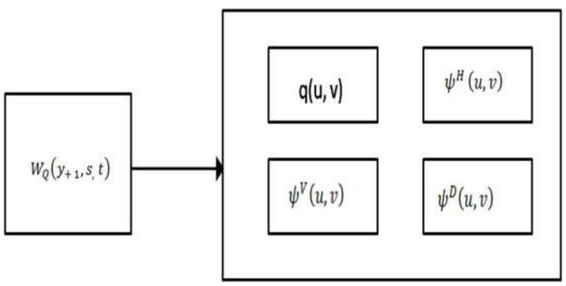

Figure 5: The Wavelet Decomposition Diagram

The figure shows how the DWT was able to scale the face input whose wavelet coefficients are represented with equation (2) and (3) to form the decompositions block modeled with equation (4) which represents the LL sub section of the band containing the main part of the face data and the other equations (5) to (7) which presented the edges and other features of the image as shown in figure 6.

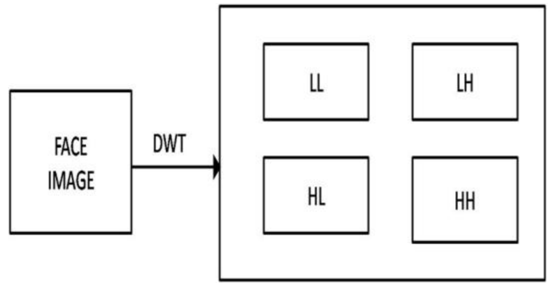

Figure 6: The Scaling of the Face Image with DWT.

3.4.3 The Proposed Deep Learning Model The deep learning model was developed using Convolutional Neural Network (CNN). This is deep learning algorithm which has proven in other areas of application to be the best in solving image based pattern recognition problem. This was modeled in this Thesis to train the wavelet image processed and to recognize face accurately. The CNN is made up of input layer responsible for the dimensioning of the image into a compatible size and then fed to the convolutional layer for scanning and extraction of the best feature parts, however these high quality of image pixels scanned, pooled and arranged in the last convolutional layer contains noise reflection originating from the high feature pixels which requires normalization before feeding to the fully connected layer. This was done using rendering technique to normalize the pixels behaviors and then fed to the fully connected layer for training using artificial neural network and then predict the output with softmax function. The block diagram of the CNN is presented in figure 7.

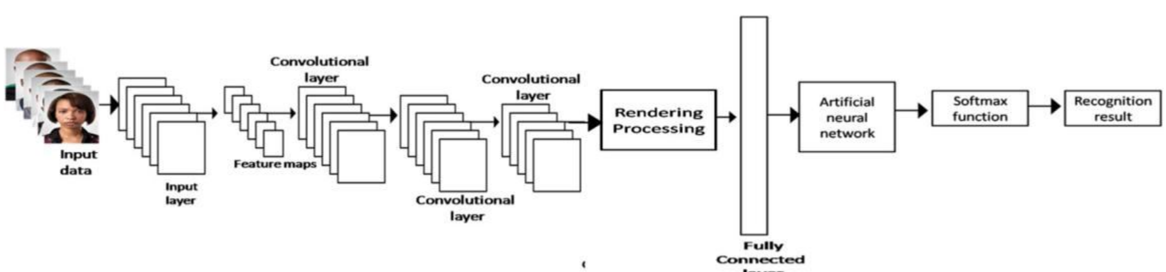

Figure 7: The CNN Block Diagram

3.5 The System Implementation

The face recognition system developed was implemented using the mathematical and modeling diagrams developed, neural network toolbox, deep learning toolbox, image processing . toolbox, wavelet toolbox, signal processing toolbox, image acquisition toolbox and then deployed with Matlab User Interface software as a criminal face detection and verification system as shown in figure 8.

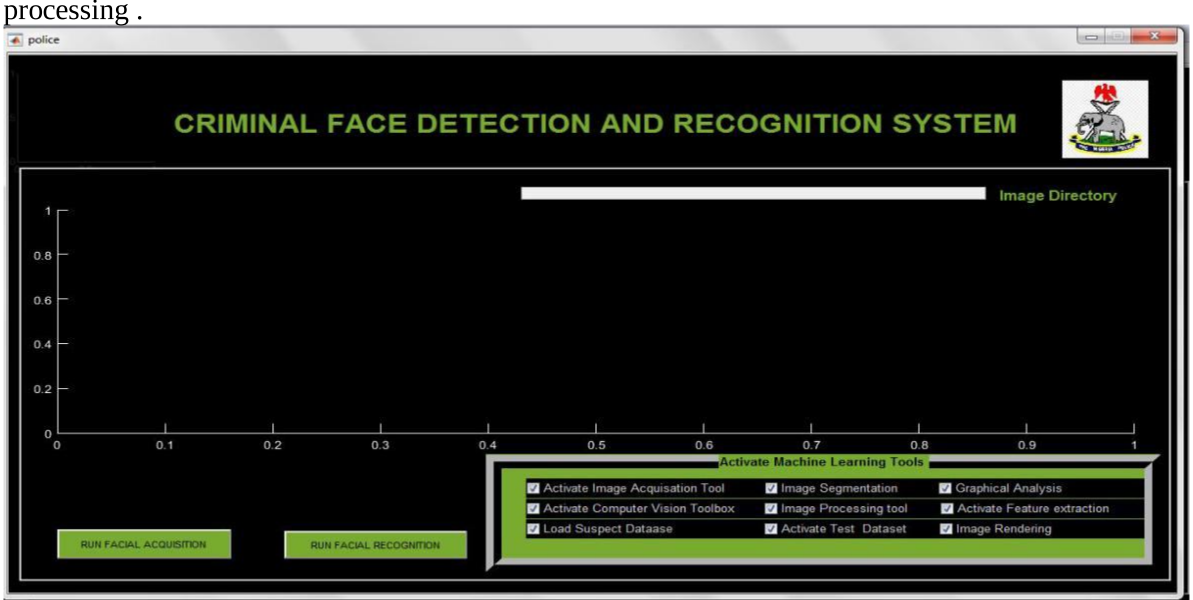

Figure 8 The Facial Recognition System

IV. RESULTS AND DISCUSSIONS

4.1 Result of the CNN Algorithm

The performance of the CNN algorithm was measured using the loss function model. This model was used to evaluate the accuracy of the training process via iterative evaluation of epoch at each training steps. To perform this training process, the dataset collected in figure 1 was loaded into the CNN algorithm and then trained using deep learning toolbox configured with the table 2 settings.

Before the training begins, the feature vectors were automatically divided into three sets which are: training, testing and validation sets in the ratio of 70:15:15. The aim is to evaluate the CNN algorithm by simultaneously training, testing and cross validating the performance as shown in the figure 9.

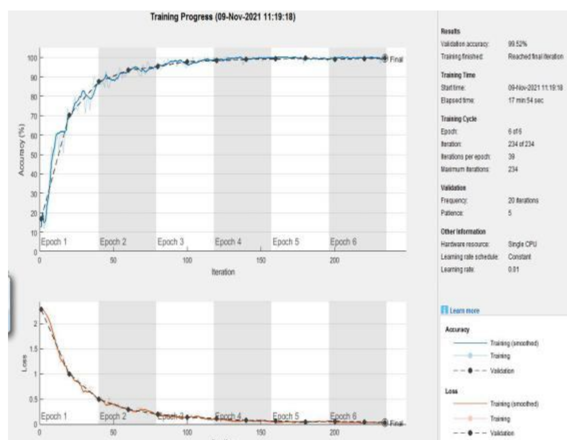

Figure 9: Deep Learning Algorithm Result

The figure 9 presented the performance of the CNN Algorithm and measured with the Loss function. The result showed the relationship between the multi sets and their performance at six different epoch cycles. From the result, the overall training performance was measured which computes the mean accuracies between the loss function for the training, testing and validation sets and the result is 99.52%. The loss function is 0.48% which is very good as it indicated a very acceptable Mean Square Error (MSE) result.

The implication of the result showed that the CNN algorithm was very efficient in learning the data of the criminals and ready for time series facial recognition with guaranteed high accuracy.

This result was validated using tenfold cross validation technique presented in equation (8).

$$CVA = \text{—} \sum A_i \ldots\ldots \qquad (8)$$

Where CVA stands for Cross Validation Accuracy, A is the accuracy measure for each fold; the results are presented in table 2.

Table 2: Ten-fold Training Results

Training times	Accuracy (%)	Loss (%)
1	99.45	0.55
2	98.91	1.09
3	99.44	0.56
4	99.51	0.49
5	99.22	0.78
6	99.60	0.40
7	98.91	1.09
8	99.47	0.53
9	99.39	0.61
10	98.90	1.10
Average	99.28	0.72

The results in table 2 presented the Tenfold performance of the CNN algorithm using the model in equation 2. The average was computed and the result showed that the accuracy of the CNN algorithm is 99.28% which is very good. The loss function was also measured and the result showed 0.72% which is also very good, showing minimum error which is acceptable and negligible.

Having trained the algorithm, tested and validated its effectiveness to accurately recognize criminals, the algorithm was deployed as facial recognition software and tested. The result is presented in the next section.

4.2 Result of the CNN Algorithm Integrated as Facial Recognition System

This section presented the performance of the algorithm when implemented as a facial recognition system. This was tested using the query face in figure 10.

Figure 10: Result of Suspected Query Person

The figure 10 presented an input query image detected using the face detection model in figure 11. The model was developed with Viola and Jones algorithm as in figure 1 to enhance the accuracy of face detection via the tracing of the facial features. From the result, it was observed that the face was accurately detected.

According to Zeenathunisa et al. (2011), face data detected are always attributed with various forms of noise such as impulse noise, background noise and striped noise. These variations of noise induced certain nonlinearities to the quality of the image captured and when not processed with affect the reliability for the result, irrespective of the advance training algorithm used. To solve this problem, histogram equalization was used to transform the lightening intensities from the environment which affects the quality of the image and the result is presented in figure 12.

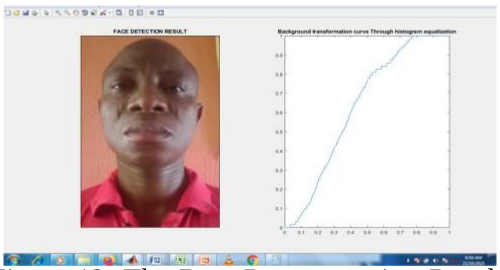

Figure 12: The Data Pre-processing Result with Histogram Equalization

Now that the pre-processing was completed to reduce background noise, the other forms of noise was processed using discrete wavelet transform, modeled in figure 5 which shows how the DWT was able to scale the face input whose wavelet coefficients are represented with equation (.2) and (3) to form the decompositions block, modeled with equation 4 which represents the LL sub section of the band containing the main part of the face data and the other equation 3.5 to 3.7 which presented the edges and other features of the image. These sub frequency bands were collectively used to process the face input and the effect of each of the band is presented in the result as figure 13.

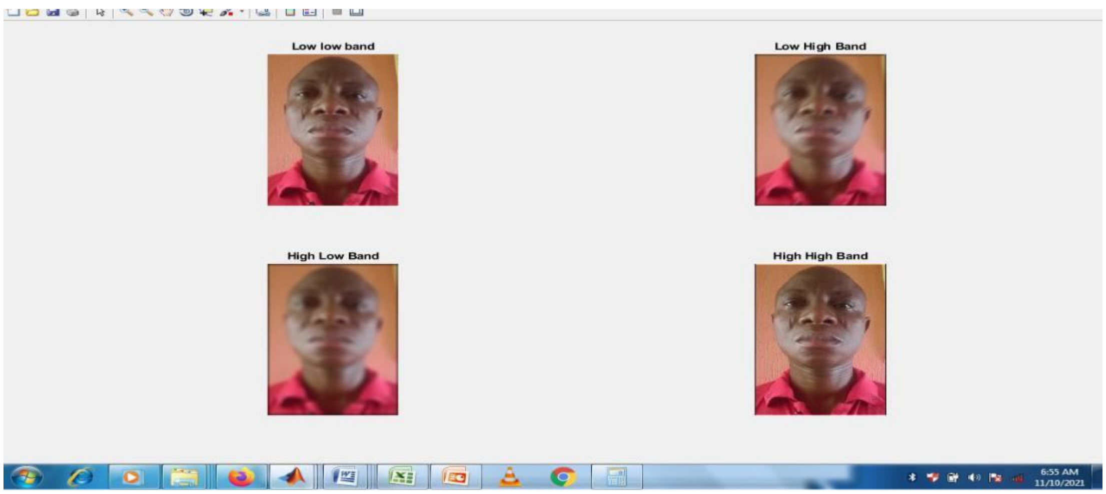

Figure 14: Wavelet image processing result

The figure 14 is the equivalent wavelet decomposition model in figure 15 which showed how each of the sub bands were collectively used to process the image and achieved high quality for training. After this process, the data are dimensioned by the convolutional neural network input.

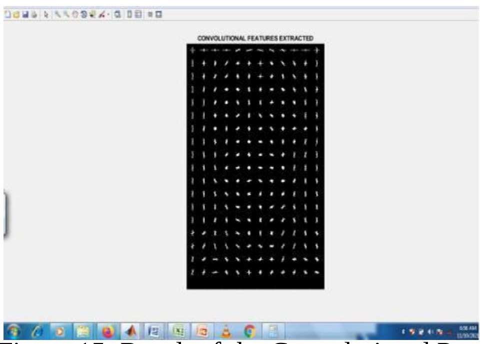

Figure 15: Result of the Convolutional Process

The figure 15 presented the convolutional process which involves the extracting or pooling of the most interesting part of the input image in a compact feature vector and arranging in a matrix which presents another convolutional layer.

V. CONCLUSION

From the result analyzed, it was observed that the use of deep learning algorithm via convolutional neural network achieved the best result in terms of accuracy when compared to other techniques like the image processing algorithms. However the new algorithm developed achieved the best result of 99.22% as against Aishwanya and Aninban (2020) which achieved accuracy of 98.70% as the best existing result before the new system. The percentage improvement achieved with the new deep learning algorithm is 0.52% which is very good improvement. Moreover, the improvement rate might be considered small by some, but the most interesting improvement recorded in the new algorithm is its reliability which was justified from the series of results achieved at varying facial expression which was the area where other algorithms fall short.

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