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Neural Network-Based Fingerprint Matching and Human Recognition System

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Abstract:- This research presents a neural network-based fingerprint matching and human recognition system. The methods used are data collection, data processing, data extraction, and convolutional neural network (CNN). The CNN was adopted and used to develop the human identification system based on object-oriented methodology and then implemented with Simulink. The result when tested showed that the new system was able to verify humans with the fingerprint at 90% accuracy.

Keywords:- *fingerprint, Convolutional Neural Network, human identification, accuracy*.

I. INTRODUCTION

Every day begins a story and this time, the narrative was inspired by the ever-increasing rate of fraud across the globe. Fraud is simply a criminal and unlawful act to makea financial gain. This has eaten deep into the public and private sectors and has remained a major challenge. Fraud can occur in many forms such as impersonation, payroll fraud, malpractices, fabrication of fake documents, etc [1].

Today the common trend is the issue of payroll fraud [2]. Payroll fraud is an act of stealing money from an organization by the ghost worker perpetrators. Ghost workers are employeeson a payroll, but do not work for the company [3]. This has remained a challenge all over the world and has crippled many economies.[4] Reportedly in Borno state Nigeria, 22,556 ghost workers were discovered within the state government payroll system [5], further investigation revealed that the introduction of the Integrated Payroll and Personnel Information System (IPPIS) uncovered 60,450 ghost workers in the Nigerian government payroll system, among other cases mentioned in [6; 7; 8], however, the IPPIS did not address the peculiarity of the Nigerian University education system of operation.

To solve this problem,[9] presented some administrative solutions which include the use of technology, transparency in the payroll system, and accountability mechanisms, among others, however, the study revealed that the use of technology will provide a more reliable solution to ghost worker fraud when compared to the rest.

The use of technology has provided many solutions for payroll fraud using a biometric approach. Biometric technology employed the use of physical and behavioral traits of human beings such as their eyes, face, handwritten, fingerprint, voice, and iris among others, for person identification [10; 11].These biometric traits all have their advantages and disadvantages as identified in [12], but the use of fingerprint technology has been the most consistent, easy to use and affordable, reliable, and most used biometric technology all over the world when compared to other biometric counterparts.

Fingerprint-based technology employed the use of fingerprint data for human identification. Many works have employed various techniques to develop this system such as image processing, fuzzy logic, expert system, and machine learning among others, however, the use of machine learning techniques has provided a better solution when compared to others [13; 14; 15].

Machine learning according to [16] isa series of algorithms thatcan learn and do classification or regression problems. These algorithms include K-nearest neighbor, support vector machine, clustering, and Artificial Neural Network (ANN), among others, however, [17] have identified the use of the artificial neural network as the most reliable in solving image-based pattern recognition problems. [18; 19; 20] used an artificial neural network to solve the problem of human identification, but despite its success, it is not considered a solutionto the problems of payroll fraud. The solution to the aforementioned problems was proposed in this work as a development of a neural network-based fraud detection system using fingerprint matching technology.

II. METHODOLOGY

The methodology used for this system development is the object-oriented analysis methodology. The methods include data collection, data processing, feature extraction, classification, and results.

- **Data collection:** Data collation activity was done at the Enugu State University of Science and Technology (ESUT).Fingerprint data of the students and staff were collected using the KOJAK fingerprint scanner as shown in figure 1;

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Fig. 1:Setup for data acquisition

The setup was used to collect 515 fingerprint data of students and nonacademic staff as the sample size. These data were formatted using image quadratic programming-based image resizing techniques in [22] to the same size and then stored in the training dataset.

- **Data Processing**: Fingerprint data always contain noise that can originate from the nature of the query person's finger, dirty on the scanner, among other environmental sources. This results in the poor quality of the data when collected and hence the need for data processing. The data was processed using a filter developed by [23]. The filter was used to remove noise and enhance the features of the data for better classification results.
- **Feature Extraction:** This process was used to extract the fingerprint pixels into a compact feature vector. This was achieved using a sequential binarization approach to extract the image's interesting features using thinning algorithm adopted from [25]. The reason behind the feature extraction choice was because [25] has comparatively evaluated its performance with other feature extraction techniques and concluded that it is the best.
- **Classification**: This process used a feed-forward artificial neural network to learn the fingerprint data and then generate a classification algorithm. The neural network is biologically inspired neurons that have weights, bias, hidden layers, and activation functions to learn the patterns of the training data features and generate a reference verification model used for the verification of a person.
- **Result:** This is the verification output of the neural network when tested with a test fingerprint set.

III. SYSTEM DEVELOPMENT

The system development used a structural method that shows the logical interaction of the steps used to achieve the new system. The development first configured neural network architecture as shown in figure 3; using the attributes of the training dataset and then training the neuron with the data to learn and generate the desired classification reference model.

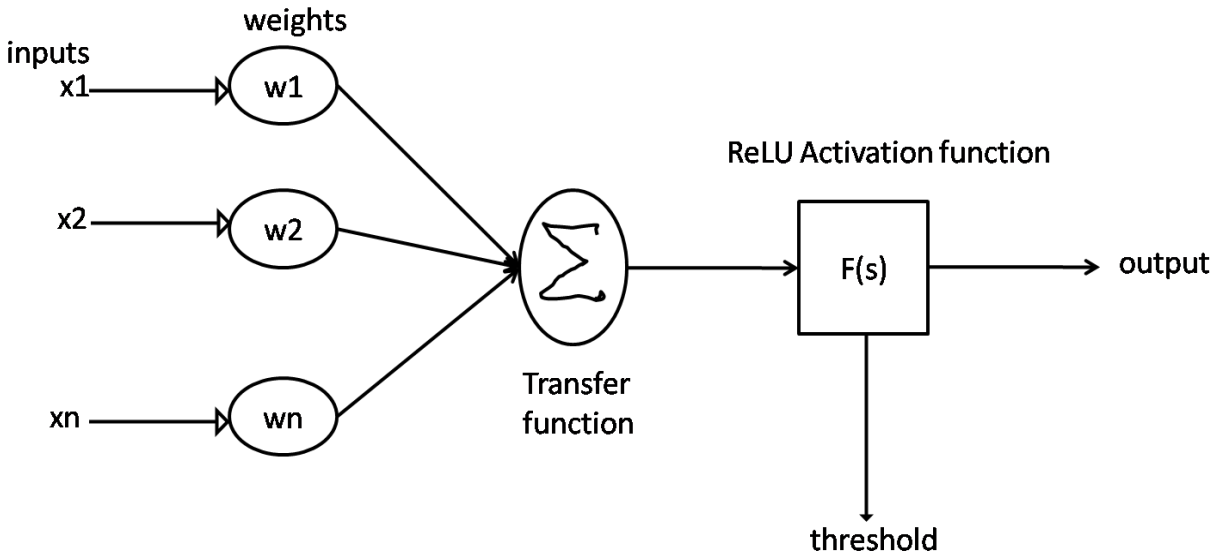

Fig. 2: The Artificial Neural Network Architecture

Figure 2 presents the structure of the neural network configured to train the fingerprint data.This was achieved using the Rectified Linear Unit (ReLU) activation function which is the most used in developing neural network structures for pattern recognition problems [27]. The neurons are trained by loading the data into the neural network as a training and test set using the neural network toolbox to generate the configured neural network model in Figures 3a and 3b.

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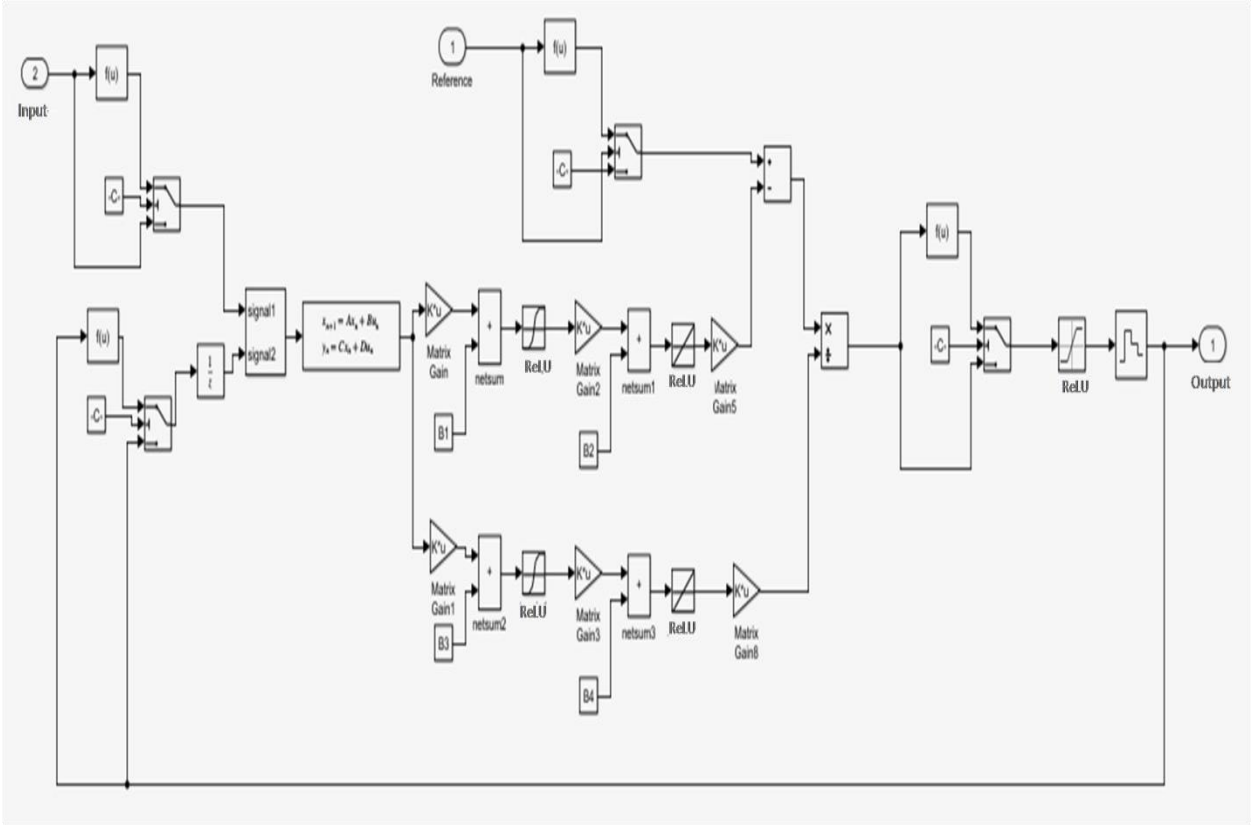
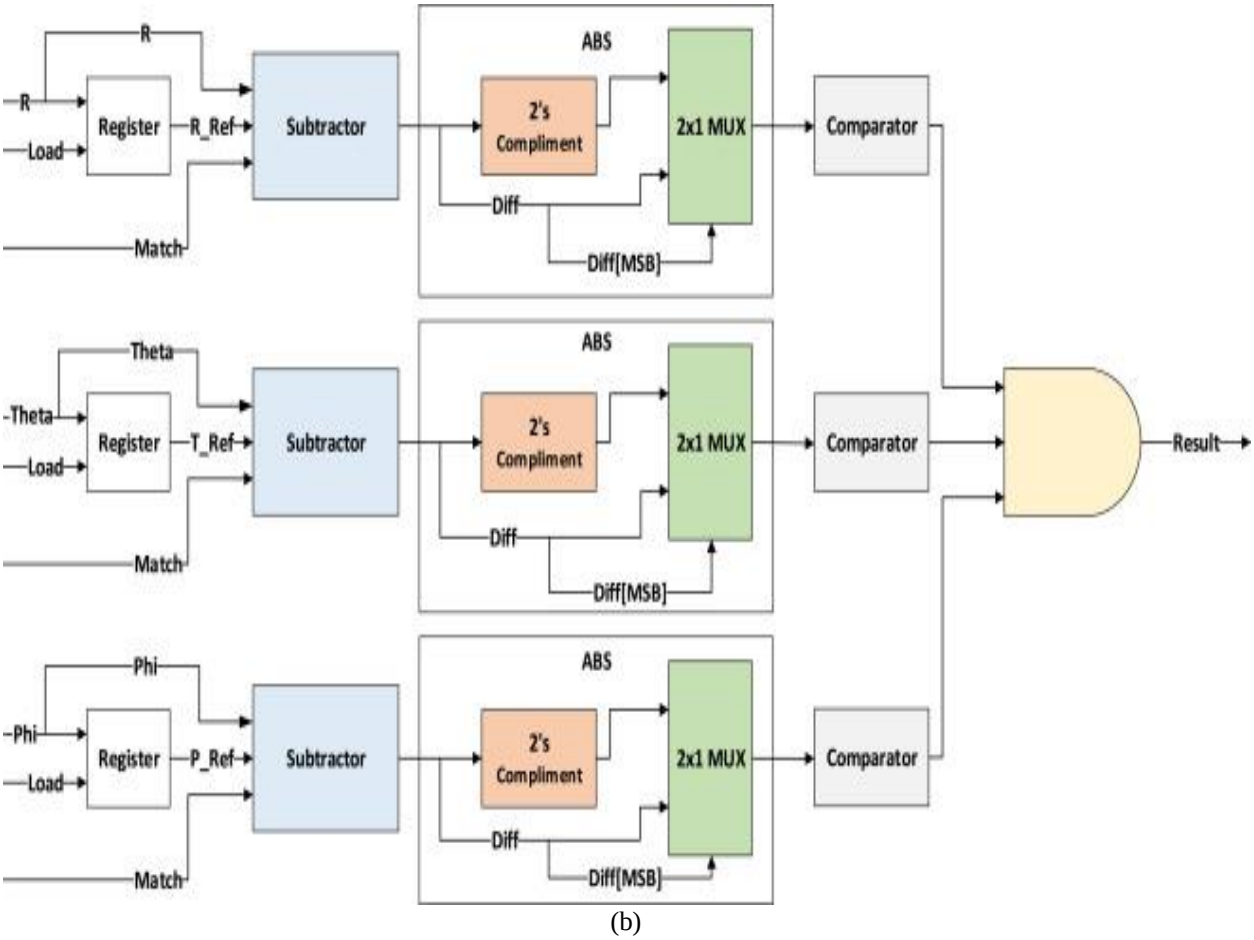


(a)



(b)

Fig. 3: Simulink model of the configured neural network

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Figure 3(a) and 3(b) present the configured neural network when loaded with the fingerprint data for training. To train the neurons, the back-propagation algorithm and the ReLU were used to learn the feature vectors until the best training result was achieved. This was evaluated using epoch parameters, Mean Square Error, and a regression analyzer embedded in the neural network tool to check the training steps at epoch intervals until the best result was achieved, indicating that the data were learned by the neurons. The training parameters and pseudo code of the fingerprint algorithm are presented in table 1;

Finger Training parameters	**Values**	**Pseudo Code Of Fingerprint Verification System**
Maximum number of epoch to train	15	***1) Start***
Epoch between display	5	***2) Load fingerprint data***
Maximum time to train in sec	Infinity	***3) Split data into train, test, and validation set***
Maximum validation failure	5	***4) Configure neural network architecture***
Scale factor for length	12	***5) Train data***
Scale factor for weight	10	***6) Initialize epoch values***
Initial step size	0.01	***7) Train data***
Minimum performance gradient	1e-6	***8) Test and validate the model***
Cost horizon	7	***9) If***
Control horizon	2	***10) Desired Mean square error and Regression is achieved***
Number of bias function	1	***11) Stop training***
Number of input	2	***12) Generate fingerprint reference model***
		13) Else
		14) Adjust bias and weight function
		15) Continues training
		16) End if
		17) End

Table 1: Training parameters of the neural network

IV. IMPLEMENTATION

The system was implemented using the neural network toolbox to load, configure and train the data as shown in figure 4;

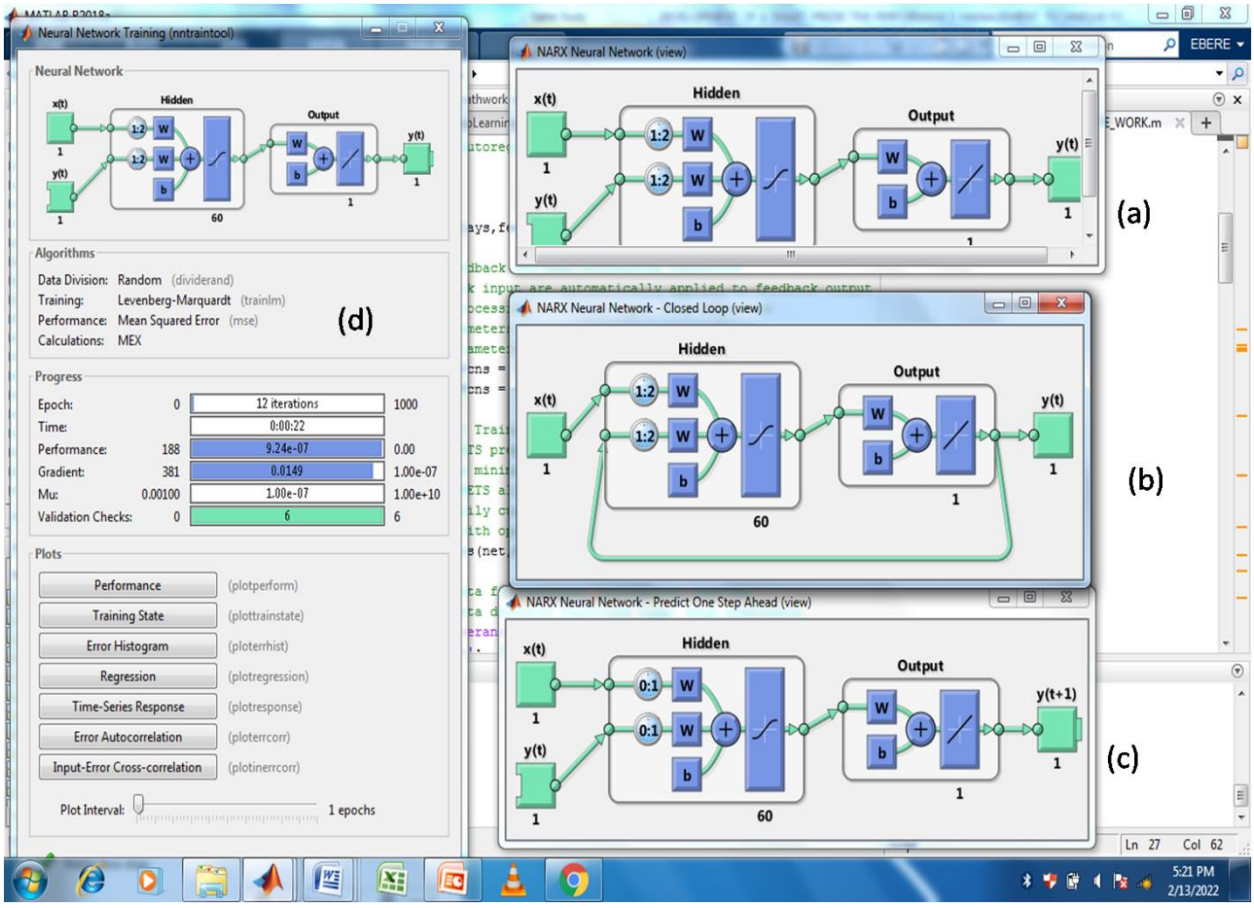

Fig. 4: The Artificial Neural Network training tool

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Figure 4 presents the neural network tool in Simulink used to train the data. When the data was uploaded into the tool, it was automatically divided into test and training sets in the ratio of 80:20 and then used to configure the neural network as shown in figure 4 (a). The (b) part of Figure 4 was used to train the neurons andthe backpropagation method was used to learn the feature patterns.The (c) part of Figure 4 was used to evaluate the training performance until the desired result was achieved. The training toolbox used to evaluate the performance is presented in The (d) part of Figure 4 and the results are discussed in the next section. The generated algorithm was deployed into Mathlab and developed as a biometric person identification system as shown in figure 5;

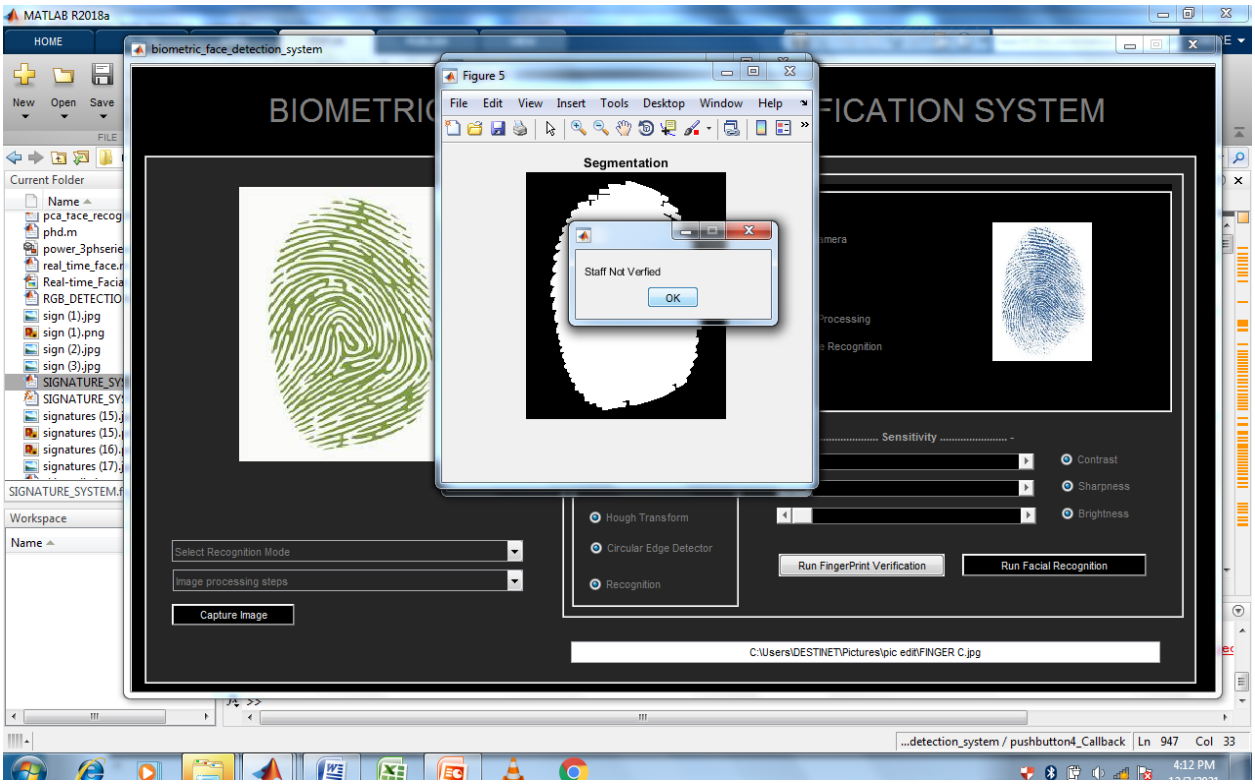

Fig. 5: The person identification system.

V. RESULTS AND DISCUSSIONS

To evaluate the performance of the fingerprint verification algorithm developed, the MSE model in [18] and Regression was used and the result of the MSE is presented in figure 6;

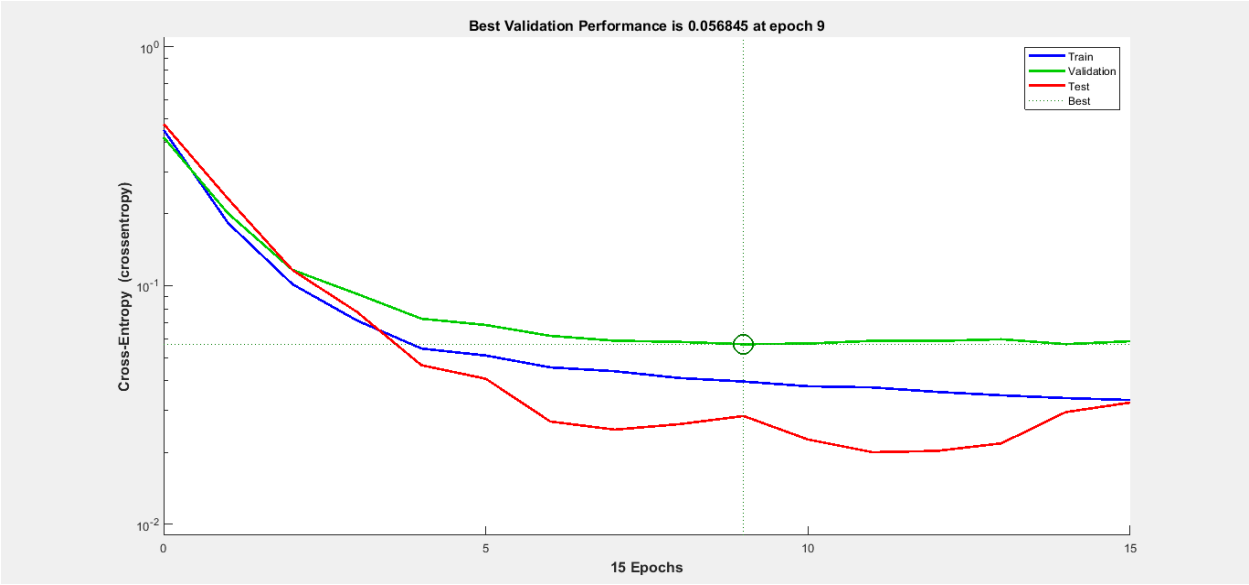

Fig. 6: MSE result of the fingerprint verification algorithm

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MSE analysis aimed to measure the training error of the system and determine how reliable it is when deployed as a verification system. The result of the MSE shows an error function of 0.056845Mu. The implication of this result showed that the error achieved is approximately zero, which is good. The regression result of the training process was also used to evaluate the performance and presented in figure 7;

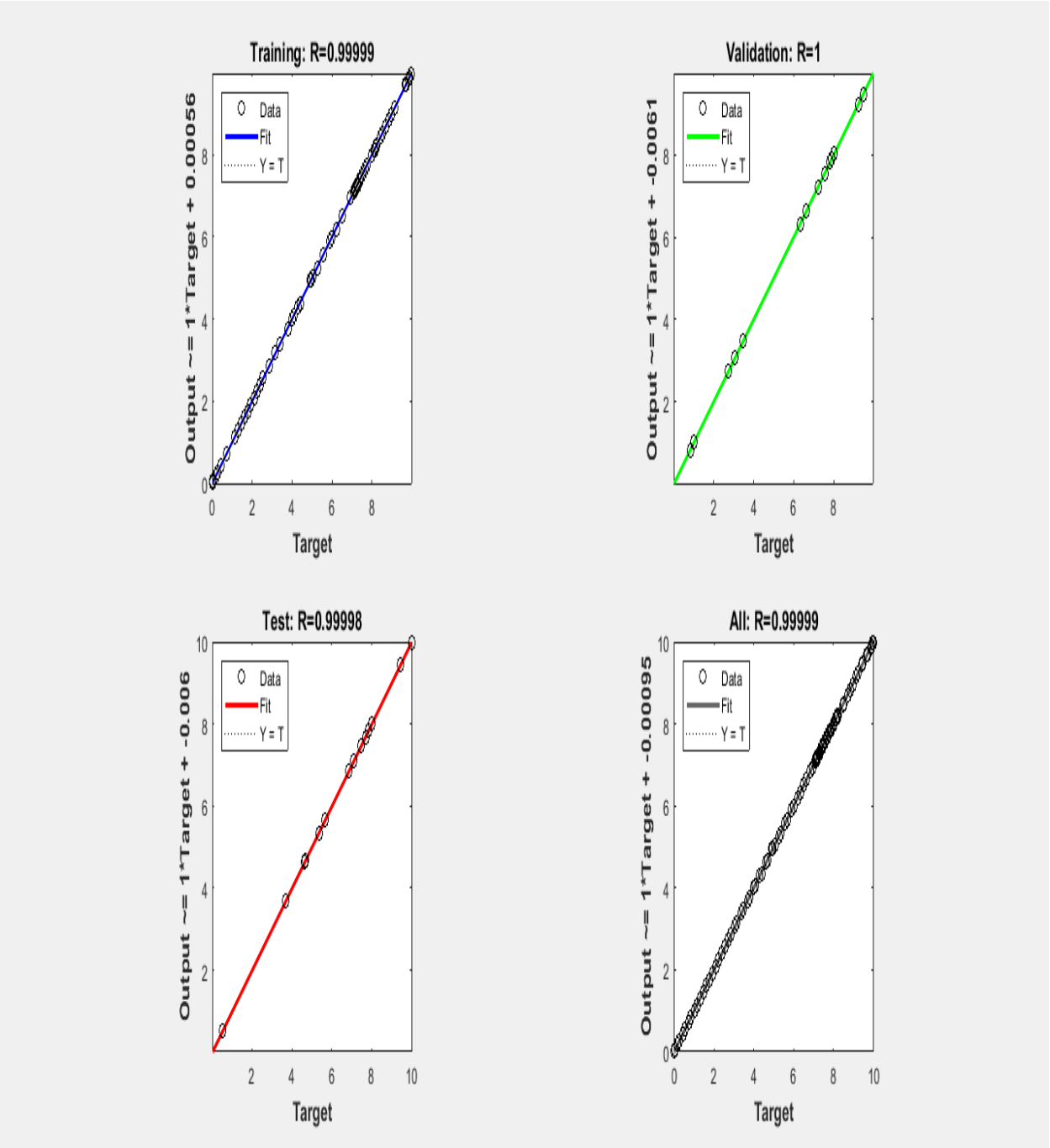

Fig. 7: Regression of the fingerprint verification system

The ideal regression (R) value is 1, however when R is approximately 1, then the system is said to be very good. From figure 7, it was observed that the overall regression result achieved using the mean of the multisets is 0.9999, which is approximately 1. The implication of the result showed that the verification algorithm was able to identify individuals based on their fingerprints. The results were validated using a tenfold cross-validation technique model in [19] and the average R results achieved is 0.9891 and MSE OF 0.050877Mu.

Having tested the verification algorithm and validated the results, the system was integrated as an expert system and tested using the fingerprint of someselected staff of ESUT institution, and the results are presented in figure 8 and 9 respectively showing the query fingerprint data and the verification result;

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Fig. 9: Query staff fingerprint data

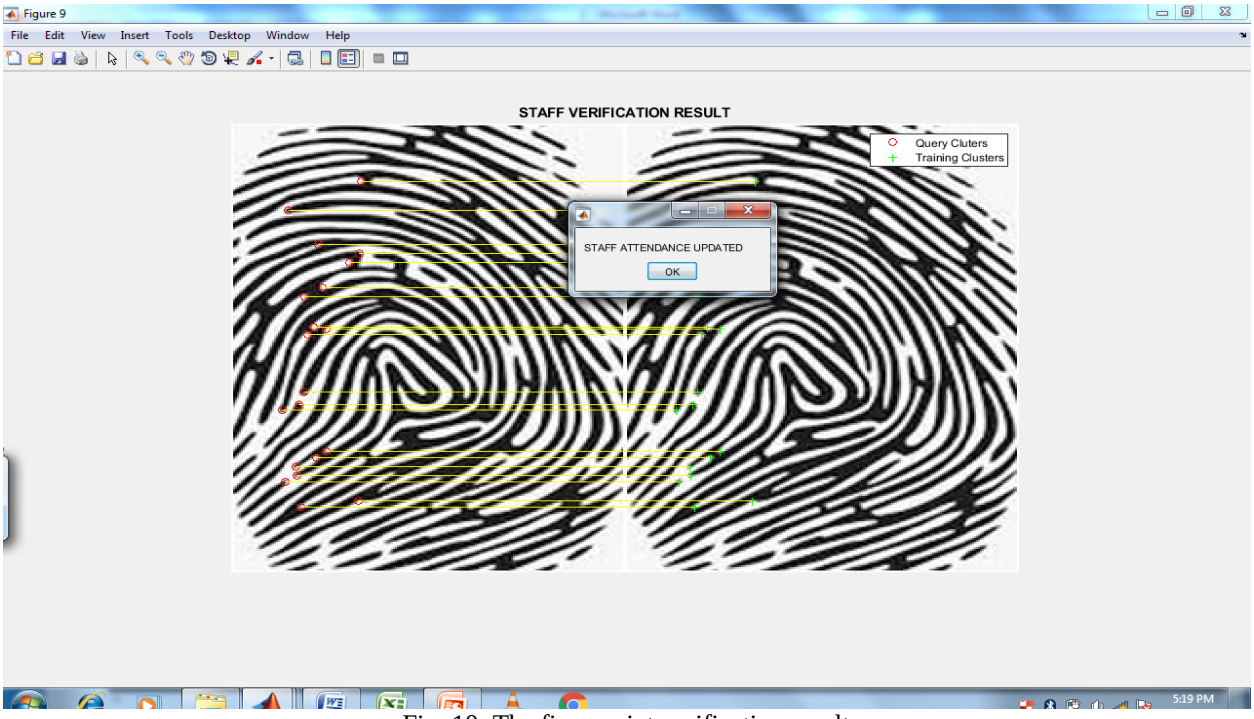

Fig. 10: The fingerprint verification result

VI. CONCLUSION

The need for a technological means of human identification has been identified by the world health organization [9] as the only reliable means to curb fraud in our society. This research has developed an artificial intelligence system that can verify the identity of individuals using fingerprint data to help address the problem of payroll fraud in our tertiary institutions. The system was tested and the result showed that it was able to verify a person's identity with approximate zero (0) MSE which is very good. The study, therefore, recommends that other institutions and related stakeholders should adopt this system and solve the problem of payroll fraud once and for all. In this work, an intelligent fingerprint verification system was developed to solve the problem of payroll fraud and ghost worker syndrome.

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