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DEVELOPMENT OF PATTERN RECOGNITION SYSTEM FOR NIGERIA FABRIC

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ABSTRACT

The study acquired and analyzed Nigeria fabric patterns, developed a recognition model for the patterns and implemented a prototype of the model for mobile devices. This was with a view to addressing the problem of information failure constraining the development of commerce and business in Nigeria. Collected Nigeria fabric patterns were analyzed using image processing and wavelet analysis techniques to extract the relevant features for recognition purposes. The recognition model was a multi-layered artificial neural network with an adaptive back-propagation learning scheme. The fuzzy inference engine was used to extract the subset of matching images to reduce storage computation time. The model was designed in a Matlab environment. The performance evaluation of the model with respect to the accuracy of extracted images was done using the sensitivity and specificity analyses.

The study concluded that the model has a strong capability to recognize the patterns of the fabrics used in the study. It will also provide timely information in decision making process. Results from simulation experiment indicated that the recognition model obtained 100% correct detection rate for all the fabrics. The model also obtained correct rejection rate of 100% for and Aso-oke fabric and 86% correct rejection rate for Adire fabric.

INTRODUCTION

Fabric production is a booming industry world-wide. In Africa for instance, the fabric industry has been identified as a major employer of labour (Toye, 2005). In addition to satisfying human needs for protection and adornment, fabrics provide media for artistic expression for weavers, dyers, tailors and clothing designers (Vanderhoff et al., 1985).

The decision making processes of human being are related to the recognition of patterns; for example, the next move in a chess game is based upon the present pattern on the board, and buying or selling stocks is decided by a complex pattern of information. Fukunaga et al. (1990) revealed that the goal of pattern recognition is to clarify these complicated mechanisms of decision-making processes and to automate these functions using computers. However, because of the complex nature of the problem, most pattern recognition research has been concentrated on more realistic problems, such as the recognition of Latin characters and the classification of waveforms (Fukunaga et al., 1990).

Pattern recognition as a field of study developed significantly in the 1960s. It was very much an interdisciplinary subject, covering developments in the areas of statistics, engineering, artificial intelligence, computer science, among others. Many people entered the field with a real problem to solve. A pattern is defined as entity, vaguely defined, that could be given a name e.g. fingerprint image, handwritten word, human face, speech signal (Jain et al., 2000). Given a pattern, its recognition/ classification may consist of one of the following (Watanabe, 1985):

1) Supervised classification (e.g., discriminant analysis) in which the input pattern is identified as a member of a predefined class.

2) Unsupervised classification (e.g., clustering) in which the pattern is assigned to a hitherto unknown class.

Pattern recognition is the study of how machines can observe the environment, learn to distinguish pattern of interest and make sound and reasonable decisions about the categories of patterns (Selim et al., 2005).

Pattern recognition can also be defined as the act of taking in raw data and taking action on the category of the data. It aims to classify data based on statistical information extracted from the patterns. The patterns to be classified are usually groups of measurements or observations, defining points in an appropriate multidimensional space (Wikipedia, 2007).

As shown in Figure 1.1., the system gathered the data to be classified, which may undergo several separate transformation stages before a final outcome is reached. These transformations (sometimes termed pre-processing, feature selection or feature extraction) operate on the data in a way that usually reduces its dimension (reduces the number of features), removing redundant or irrelevant information, and transforms it to a form more appropriate for subsequent classification. The term intrinsic dimensionality refers to the minimum number of variables required to capture the structure within the data. Feature selection is the process of selecting a subset of a given set of variables. In many cases, however, it will be necessary to perform one or more transformations of the measured data.

Figure 1.2 shows a flow chart of how a classifier is designed. After the data is gathered, samples are normalized and registered. Normalization and registration are important processes for a successful classifier design. However, different data requires different normalization and registration. After normalization and registration, the class separate data is measured. This is done by estimating the Bayes error in the measurement space. Since it is not appropriate at this stage to assume a mathematical form for the data structure, the estimation procedure must be nonparametric. If the Bayes error is larger than the final classifier error to be achieved**;** the data does not carry enough classification information to meet the specification. Types of data analysis techniques that can be used include feature extraction, clustering, statistical tests, modelling, etc (Young et al., 1986).

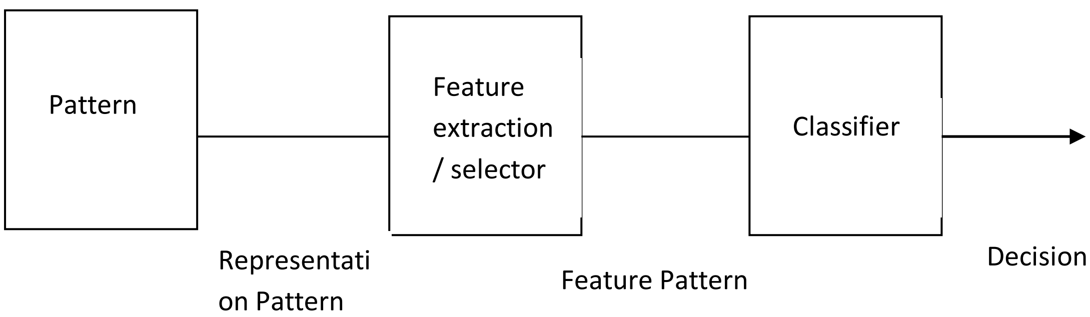

Figure 1.1: Stages in classification/recognition process

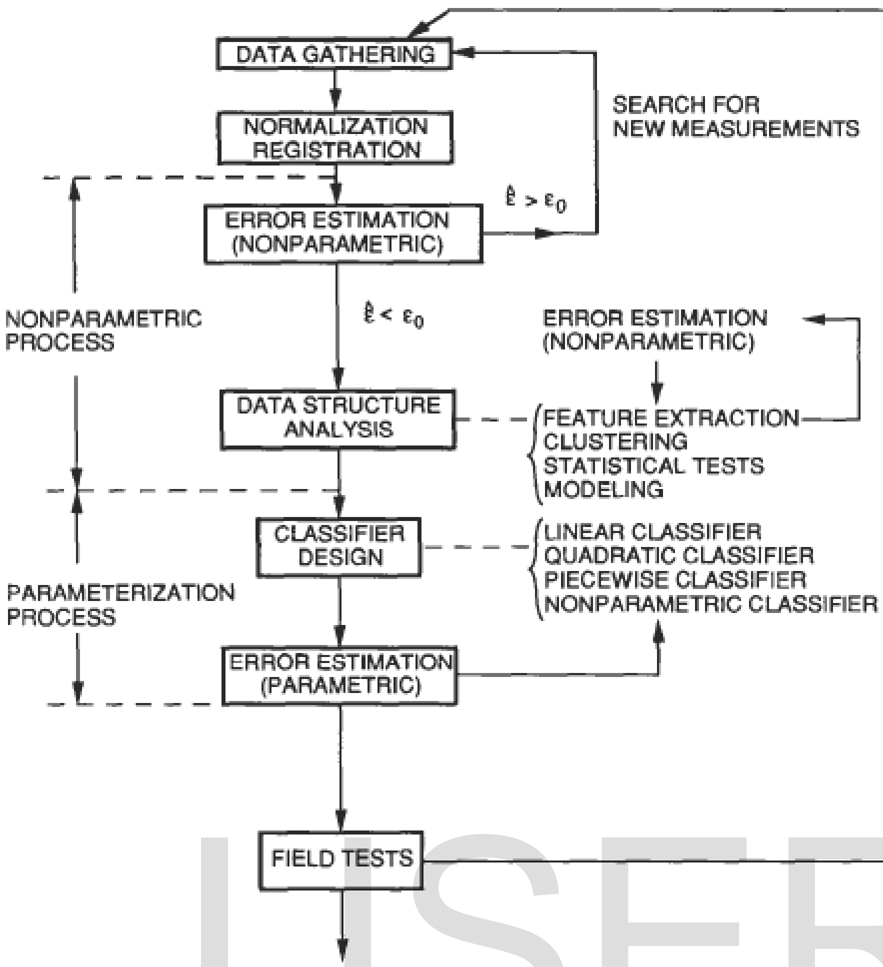

Figure 1.2 Process of a classifier design.

NIGERIA FABRICS

Nigeria's fine art and craft traditions are known throughout the world. The textile arts are among one of Africa's most significant craft forms. People all over the world wear these bright colourful fabrics having intricate patterns due to the fact that Nigeria clothes are usually loose fitting and very comfortable. Nigeria cloths have distinct patterns, and depending on the type of textile the patterns are woven, printed, dyed, or drawn onto the fabric (Brooklyn, 2008).

The term textile simply represents woven cloth or fabric. In Nigeria, the textile industry has been identified as a major employer of labour (Toye, 2005). Textile has become a general term for fibres, yarns and other materials that can be made into fabrics or cloths and the resulting material itself (Corbman, 1983). Thus thread, cords, ropes, laces, nets and fabrics are all textiles, and in addition to satisfying human need for protection and adornment, Vanderhoff et al., (1985) described textiles and garments as providing media for artistic expression for weavers, dyers, tailors and clothing designers. Cloth ranks among the most basic necessities of life, such as food, and shelter. It is, therefore, necessary for man (Olaoye, 2005). There are many types of Nigeria textiles but detailed description of the common ones is made in this study.

Adire Fabric

Adire is the best known and most valuable colourful dyed cloth found throughout Africa (Brooklyn 2008). The fabric is a deep blue cloth made by the Yorubas in Nigeria. The design is created by a process called Resist Dying, which prevents dye from being absorbed by some parts of the cloth (Brooklyn, 2008). There are different types of resist dying methods used to create adire cloth designs. Oniko is a method of tying patterns into the cloth. An example is shown in Figure 1.3(b), (a) are stencilled or painted onto the cloth with starch (usually from cassava or yam). While another method, called Alabere, uses raffia to stitch designs into the fabric. Once the designs are complete, the white cloth is then dipped into a deep blue dye. When dry, the fabric is untied, the starch and stitches are removed, to reveal a beautiful design. The fascinating part of Adire pattern is that each different design has unique symbolic meaning or story. The pattern and stories are messages expressed by the person or society that created the cloth (Rung, 2001). Adire pattern is a complex pattern that is not recognized from physical and geometric properties alone but rather structural and aesthetic.

Aso-Oke Fabric

Aso-oke as depicted in Figure 1.3 (c) is a fabric hand loomed made of strips that are joined together, and having beautiful geometric patterns worked into it. Aso Oke is commonly used by the Yorubas in Nigeria for important occasions such as wedding,

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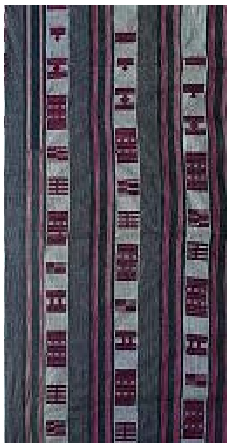
funeral, birthday, and child naming ceremonies. The popular types of Aso-Oke are the “Sanyan” (beige with white stripes) and the “Alaari” (red).


(a) Adire Eleko


(b) Adire Oniko


(c)Aso Oke

Neural networks are composed of many simple elements operating in parallel. These elements are inspired by biological nervous systems. There are several inputs to each neuron; these inputs are multiplied by some connection weights. The expression $\sum_{i=1}^{n} x_i w_i$ serves as an input to the transfer function. Then the output of the transfer function can be the final predictor of the model or the input to another layer of the neural network. Figure 2.3 illustrates how several neurons are connected. Each of these neurons has a set of input weights, transfer functions and outputs as shown in Figure 2.2. The neuron model and the architecture of a neural network describe how a network transforms its input into an output.

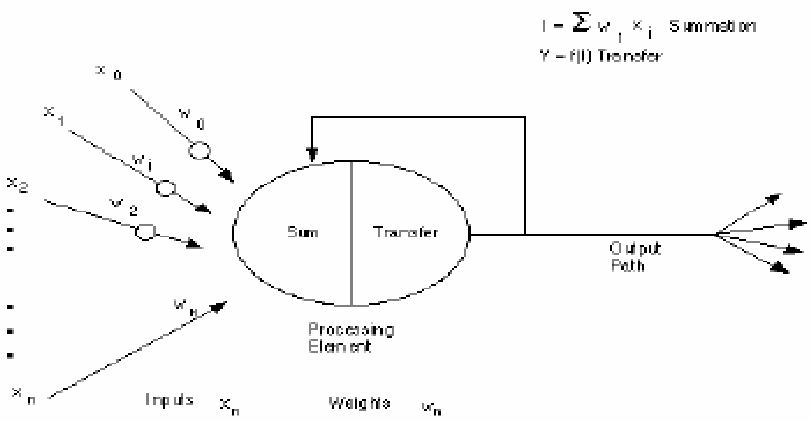


Figure 2.2: A Neuron

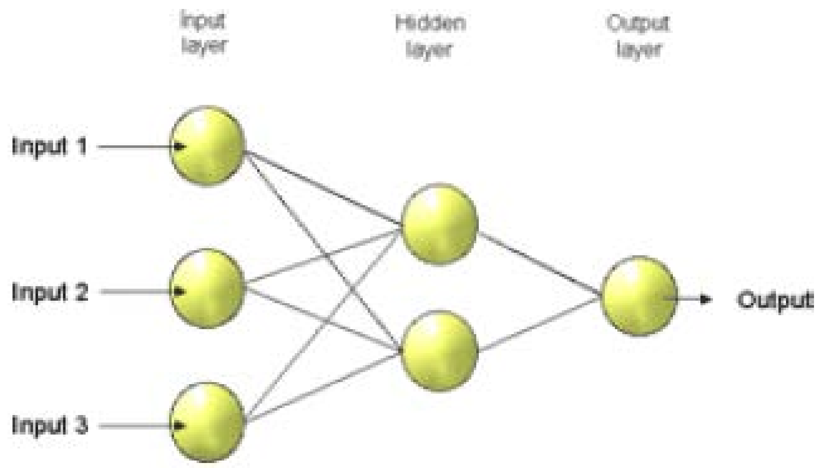


Figure 2.3: Basic neural network architecture

Fuzzy Logic Model

Fuzzy Logic (FL) is a way to make machines more intelligent and enabling them to reason in a fuzzy manner like humans. According to Luger (2002), Fuzzy logic provides a simple and easy way to draw a definite conclusion from ambiguous, imprecise or vague information. It can be implemented in hardware, software, or a combination of both. They are used in several wide-ranging fields (Gou *et al.*, 2004; Meyer and Popel, 2003), including: linear and nonlinear control, pattern recognition, financial systems, operation research, and data analysis.

The concept is based on the theory of fuzzy sets and fuzzy logic. The principle behind the technique is that imprecise data can be classified into sets having fuzzy rather than sharp boundaries, which can be manipulated to provide a framework for approximate reasoning in the face of imprecise and uncertain information. Given the universal set U, a fuzzy set A is defined as the ordered pair

$$A = \{x, M_A(x)\} \text{ where } x \in X \text{ and } 0 <= M_A(x) <= 1.$$

The membership function $M_A(x)$ describes the degree to which the object x belongs to the set A. It assumes the following values:

$$M_A(x_i) = \begin{cases} 1 & \text{if } x \in A \\ 0 < M_A(x_i) \le 1 & \text{if } x \text{ partially belong to } A \\ 0 & \text{if } x \notin A \end{cases}$$

Fuzzy sets are often given descriptive names (linguistic variables) such as TALL; the membership function M_{TAll} (x) is then used to reflect the similarity between values of x and a contextual meaning of TALL. A fuzzy logic system is a knowledge based system characterized by a set of linguistic variables and fuzzy if-then rules. Fuzzy rules are defined by their antecedents and consequents, which relate an observed input state to a desired control action. Most fuzzy logic expert systems employ the inference method proposed by Mamdani in which the rule consequence is defined by fuzzy sets (Mamdani, 1974). A typical type fuzzy rule R^n has the form:

$$R^n : if \quad X^1 = A^{1n} \quad and \cdots\cdots X^m = A^{mn} \quad then \quad Y = B^n$$

The fuzzy output of a rule depends on the degree of activation of its antecedent. The Mamdani inference scheme aggregates these outputs into a single fuzzy set for the variable Y. Lastly, deffuzification process is applied to transform the output fuzzy set into a crisp control variable usually by calculating its centroid. Figure 2.4 depicts a fuzzy logic model. It consists of *fuzzy rule base*, *fuzzification*, *inference engine*, and *defuzzification module*. The fuzzification module pre-processes the input values submitted to the fuzzy logic system by converting the discrete crisp input values into fuzzy sets (linguistic terms) so that rules can be applied in a simple manner to express a complex system. The inference engine uses the results of the fuzzification module and accesses the fuzzy rules in the fuzzy rule base to infer what intermediate and output values to produce. The final output of the fuzzy expert system is provided by the defuzzification module.

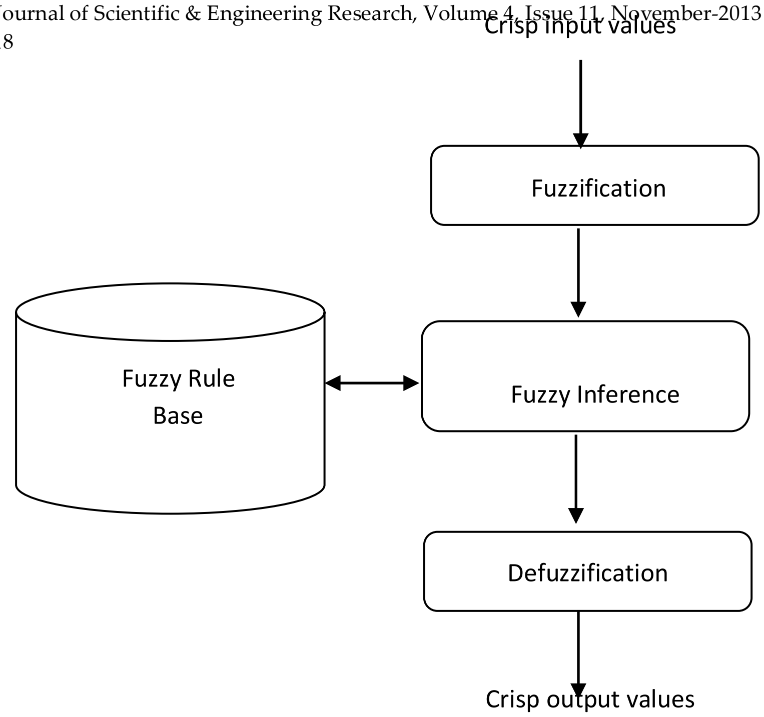


Figure 2.4: Fuzzy logic model

METHODOLOGY

Collection of Nigeria Fabrics Patterns

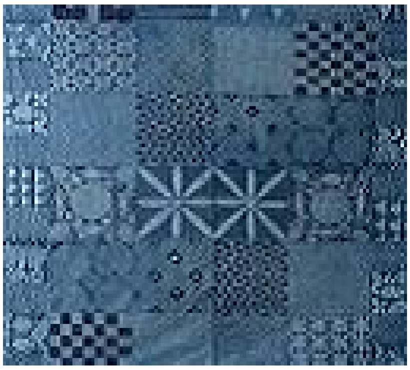
Nigeria fabrics patterns were collected from experts who engage in Nigeria fabrics making for example Ministry of Art and Culture, Osogbo, Adire dyers in Itoku, Abeokuta, Aso-oke weavers in Ekiti. Figure 3.1 shows examples of Nigeria fabrics used in this study with their characteristic designs having irregular composition style. The style has an orderly repetition on motifs which are interrupted by a shift in texture, direction or scale (Adams 1991:35). The style gives ample chance for the distribution of some design variations. The design elements in the composition are made of irregularities and regularities and these provide a source of vitality for the people to behold (Akinwumi, 2008). The asymmetry (i.e. the irregularity) style also activates a sense of movement for its beholder unlike the symmetrical design characteristics of European and other traditions (Adams, 1991).

When one looks at an outfit of traditional Nigeria clothes, one may not realize the cultural importance that they have. The beauty and quality of the fabric is apparent to anyone with or without knowledge of textiles, with small details bringing out the splendor of the larger pattern, which is enhanced by the brilliant colors.

MATLAB as a Computational Tool

A rapid application development (RAD) approach will be employed in order to produce results quickly. MATLAB provides an excellent RAD environment which supports high-level programming, simulation, and visualization of science and engineering applications. It also has large number of specialized toolboxes, such as statistics, image processing, neural networks, fuzzy logic, and so on that aid in the design of complex systems.

The powerful software enjoys popularity in many different disciplines (Larkins and Harvey, 2009) due to its multi-platform feature and a broad support base, with an active user community and sample code repositories. A key benefit of using MATLAB is that while much of the programming can be done at a high-level, it also supports general programming constructs such as conditionals, loops, and functions which correspond to other popular programming languages such as C++ or Python. MATLAB was adopted in this study because of its user friendliness, scalability, popularity, and many other support features it provides.


Adire pattern


Aso-oke pattern

Figure 3.1: Nigeria fabrics with patterns

MEASUREMENT AND DISCUSSION OF RESULTS

Figure 3.2 shows the simplified activity diagram (model) representing Nigeria fabrics patterns classification and recognition system. From the diagram, fabrics images are first scaled to 128 by 96 pixels, and converted to greyscale images. Edge detection technique is applied to the image to locate the edge pixels. The first-order statistical measures and properties of image region (eccentricity) are employed for classification purpose. These data are fed to the ANN as input to classify the fabric pattern into clusters in terms of their shape relationship and pattern. The classification and recognition model is composed of the following modules: input module, pre-processing module, neural network module, fuzzy expert module, and output module.

The input module accepts fabrics image, the pre-processing module performs certain transformation (scaling) to reduce image size, converts the color image to grey-scale type, and then performs edge detection operation on the image to create first-order statistic and image region property data describing the texture of the image, and then sends this information to the neural network module. The neural network module clusters fabrics patterns in terms of their shape relationship and pattern, identifies matching fabric images by comparing the structural properties of the fabrics, and then sends these matching fabrics to the fuzzy expert module, which extracts the subset of the matching images in order not to incur additional processing operations on mobile devices as a result of the limitation in their storage and processing capacity.

The output module describes all the pattern knowledge recognized from input data.

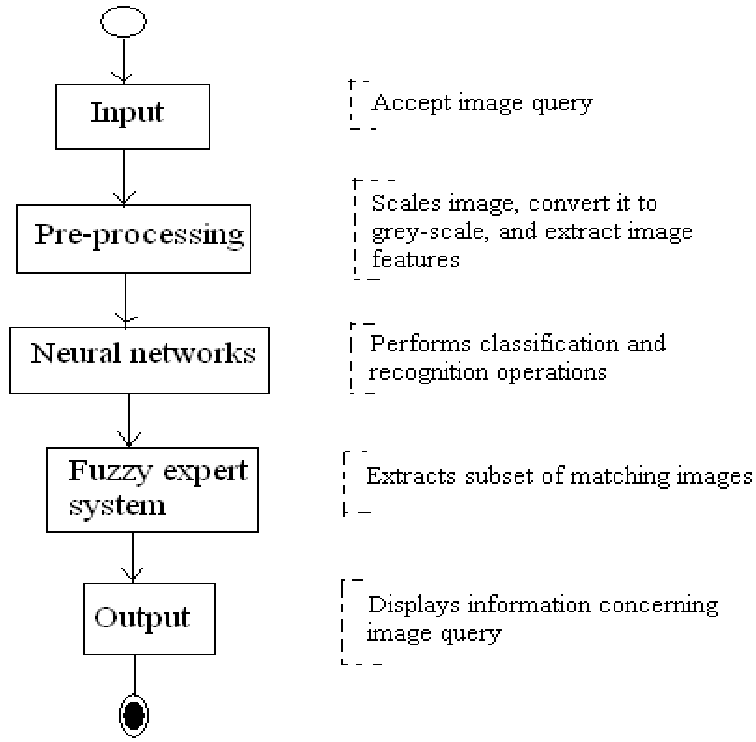


Figure 3.2: Simplified model of the Nigeria fabrics patterns recognition system

Artificial Neural Networks Module

Two neural networks are used in this study to classify and recognize three major Nigeria fabrics. The first is the global network (fabricNet) that groups Nigeria fabrics in any of the 2 major fabrics (Adire and Aso-oke). The other networks are local networks that classify and recognize patterns in each of the three fabrics. The complexity of the design of the ANN is related to the construction of the type of neural network that is best suited for the model. A model with one input layer, one hidden layer, and one output layer for the networks. Though, a neural network may have any number of hidden layers, this study uses a feed-forward perceptron to keep the structure of the network as simple as possible. Feedforward network only allows connections to travel in one direction throughout the ANN. The hidden layer for the Adire network (AdireNet) shown in Figure 3.6a for instance has 8 neurons (representing clusters of Adire patterns). All the neural networks use a single layer log-sigmoid feedforward network which is followed by an output layer of linear neuron ('purelin') to identify and output value corresponding to the target output.

As shown in Figure 3.6. The local networks (adireNet and asokeNet,) receive an input as a 2 by 1-element vector containing the image summary statistics: the mean, the variance, and the eccentricity property of the processed image as discussed.

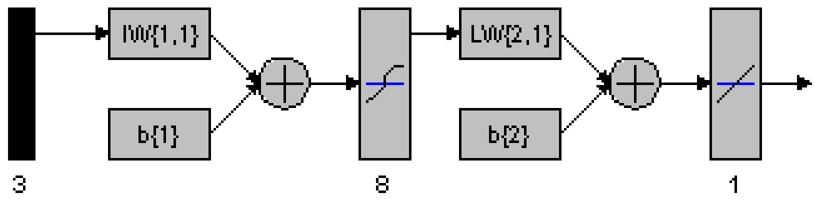


Figure 3.6a Adire network architecture (adireNet)

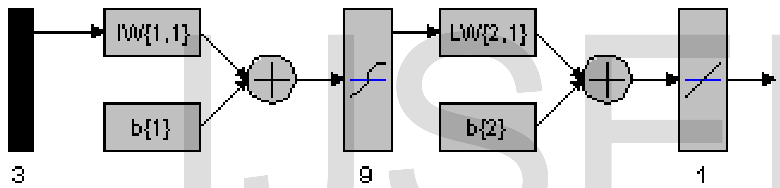


Figure 3.6b Aso-oke network architecture (asokeNet)

Fuzzy Expert System Module

The fuzzy expert module, extracts subset of the matching images supplied by the neural network module in order not to incur additional processing delay on mobile devices as a result of the limitation in storage and processing capacity.

The parameters used to achieve this consisted of linguistic variables and fuzzy sets, while control action was described by a set of fuzzy conditional rules. The input variables to the fuzzy logic model are:

a) diff- the Euclidian difference between two images
b) traffic- the current condition of network traffic

and the output variable was extract- this gives the subset of the matching records to return

The two local networks (AdireNet and AsoOkeNet) group related/similar patterns within the Nigeria fabrics used in this study into clusters by using Euclidean distance measure defined as follows:

$$d = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

And based on the similarity, data vectors are clustered such that the data within a cluster are as similar as possible, and data from different clusters are as dissimilar as possible.

The training method used in this study is supervised. The back propagation algorithm provides a way to send error information through the system. This process enables adjustment of connection weights between layers and improvement in performance. The learning rule associated with this type of knowledge propagation is the Delta Rule which is based on the idea of continuously modifying the strengths of the input connections to reduce the difference (delta) between the desired output value and the actual output of a neuron

A high performance adaptive learning rate (implemented with the function 'traingda') that converges from ten to one hundred times faster than the standard gradient descent and gradient descent is used to train the network. The training data use the actual response to alter connections and corresponding weights. The network was trained for a maximum of 1000 epochs or until the network sum-squared error falls beneath 1e-2. The training procedure is repeated k times, each time with 70% of the samples in the dataset as training and left 30% for testing. Figure 3.7 illustrates the performance of the network that recognizes pattern on Adire fabrics. The networks for the other Nigeria fabrics (Aso-oke) is similarly defined and trained.

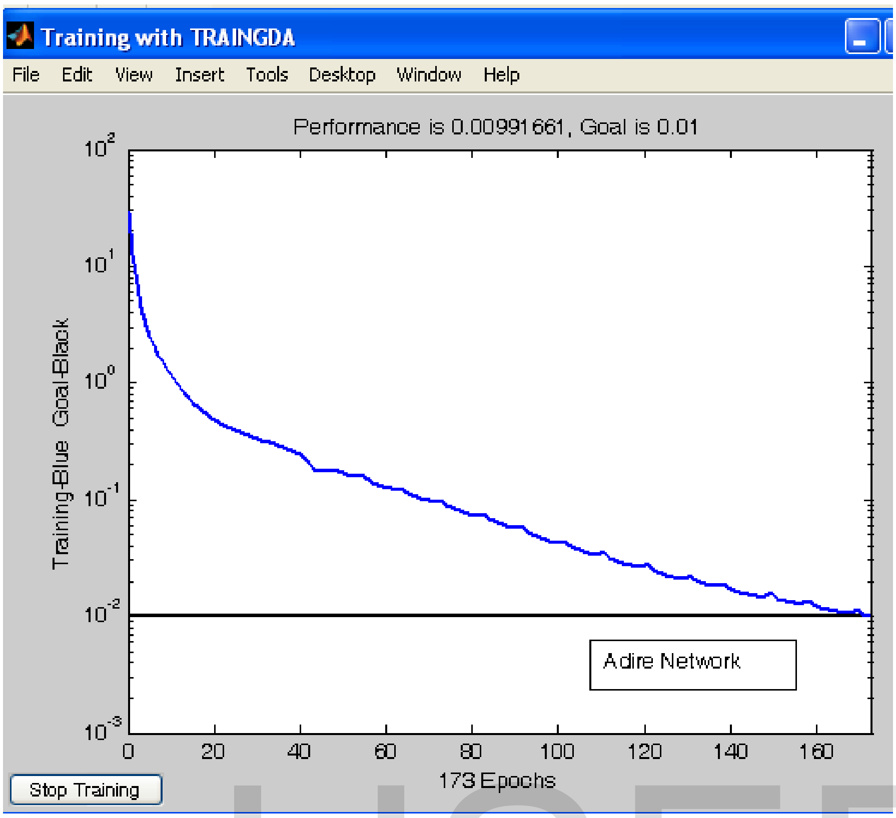


Figure 3.7: Plot of network performance for network that recognizes 'Adire' patterns

Performance Evaluation

To test the system, the test data set of 128 * 98 pixels ninety (90) greyscale Nigeria fabrics images (30 for each of the three fabric used as case study) are used as inputs. The system employs Canny edge detection method on the image query (input) to generate an edge map. From the edge map, first-order statistical measures and properties of image region are obtained as the feature image texture representation for classification purpose as discussed. This information obtained is fed to the neural network to classify and recognize the fabric, and the subsets of the matching images are extracted using the fuzzy expert system. Figures 3.13 illustrate sample outputs from the proposed fabrics patterns recognition model.

To evaluate the performance of the neural networks based Nigeria pattern recognition system, the following types of errors (Table 1) are used.

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- Correct Detection (CD)- the system recognizes a given fabric when indeed one was present.
- Correct Rejection (CR)- the system recognizes the absence of a given fabric when indeed it was absent.
- False Positive (FP)- the system recognizes a fabric that was not present.
- False Negative (FN)- the system fails to recognize a fabric that was present.

Similarly, the performance of the system was evaluated in terms of sensitivity (S), specificity (SP), and efficiency (E), (Subasi, 2007) as follows:

$$S = \frac{CD}{CD + FN} \qquad [Eqn\quad 4]$$

$$SP = \frac{CR}{CR + CD} \qquad [Eqn\quad 5]$$

$$E = \frac{CR + CD}{CD + FN + FP + CR} \qquad [Eqn\quad 6]$$

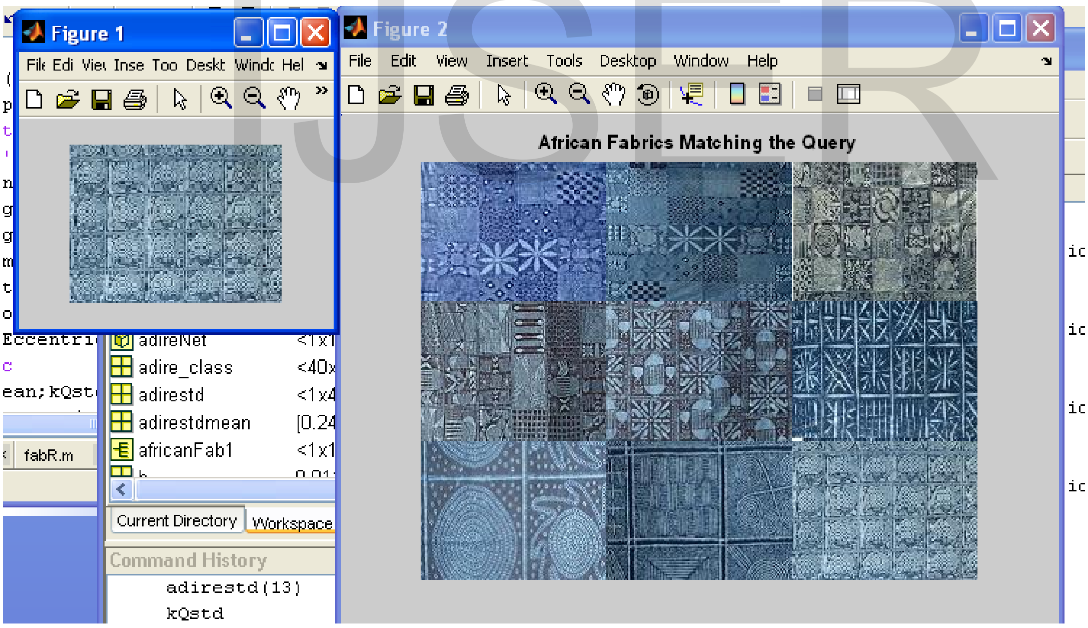

Figure 3.13 (a) Matching results for Adire oniko fabric

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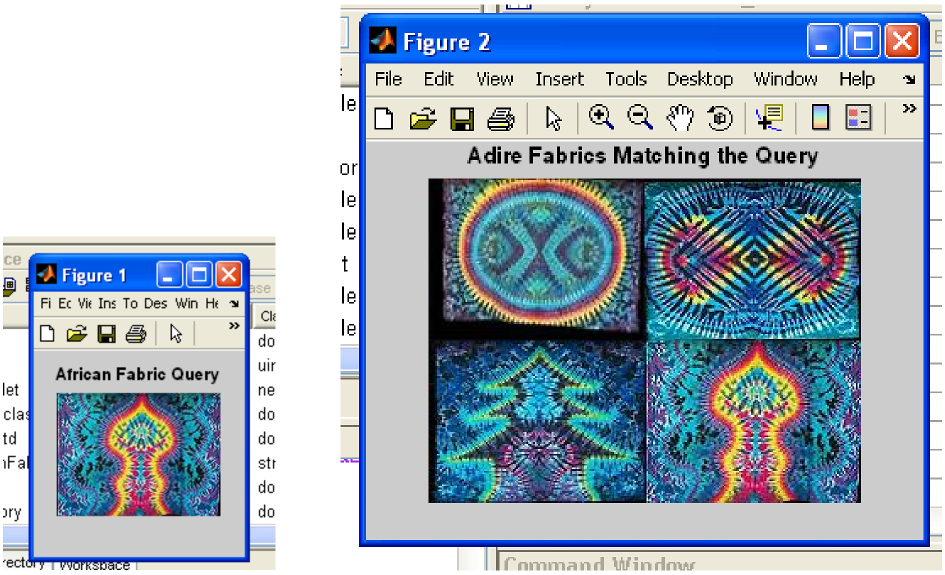

Figure 3.13 (b) Matching results for Adire eleko fabric

Figure 3.13: Sample results for the Adire queries

TABLE 1

Performance Matrix

		Disease condition	
		Present	Absent
Decision	Present	CD	FP
	Absent	FN	CR

TABLE 2
Performance Matrix

Fabric	Recognition		S	SP	E
	Present	Absent			
Adire	100	0	1.00	0.46	0.93
	0	100			
Aso-oke	100	14.29			
	0	85.71	1.00	0.46	0.93

Sensitivity (S) is a measure of the ability of the system to recognize fabric patterns, while specificity (SP) gives a measure of the ability of the system to identify a given Nigeria fabric. The efficiency, sensitivity, and specificity the system is shown in Table 2, the neural networks produce reliable and consistent fabrics recognition results. The shaded portions of Table 2 are computed using Table 1. Generally, the results obtained indicated that the neural networks and fuzzy logic based Nigeria fabric recognition system has a strong capability to recognize the patterns of all the three fabrics used in this study.

CONCLUSION AND RECOMMENDATION

Nigeria are complex pattern that encode complex messages at various levels of abstraction, they have richer colors and more variations than other kinds of textiles. In addition there is lack of insufficient information for those seeking to buy or sell these fabrics, thereby constraining the development of commerce, business, and markets in many developing countries. To solve these challenges, a simple but robust recognition model which combines wavelet transform, image processing technique, neural networks and fuzzy logic is presented in this research to classify, recognize, and give detailed information on Nigeria fabrics.

To evaluate the performance of the model, the sensitivity, specificity and efficiency values of the model were computed in an experiment that was performed. The proposed model produced reliable and consistent results in recognizing the fabrics used in this study. The efficiency of the model on the average to recognise the fabric types used in the study was 96%. The training method used was supervised, and the back propagation algorithm provided a way to send error information through the system for performance improvement. A high performance adaptive learning rate (implemented with the function 'traingda') that converges from ten to one hundred times faster than the standard gradient descent was used to train the network. Each network (Two) was trained for a maximum of 2000 epochs or until the network sum-squared error falls beneath 1e-2. The training procedure was repeated *k* times, each time with 70% of the samples in the dataset as training and 30% of the dataset for testing. Based on the findings of this research work, we can recommend that theirs need for telecommunication industries to support the platform to host local content application. Integration of online Nigeria fabric stores' databases to allow for extensive searching of information. Government should endeavour to reduce the cost of sending and retrieving multimedia files to encourage people to use the application.

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