A NEURAL NETWORK SYSTEM FOR DETERMINING THE OPTIMAL PROFITABILITY OF SMOKED FISH BUSINESS IN NIGERIA

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ABSTRACT
Small scale smoked fish business is a lucrative business venture in Nigeria as market fish sellers especially women living in riverside areas of the country earn a living from this business. However, these fish sellers they may not know the combination of smoked fish type that will yield optimum profit. In this research, a neural network model was designed for achieving this purpose and was used to predict the profitability of smoked fish business based on the analysis from the sample survey of smoked fish sellers/retailers in selected markets in Ota, in Ogun State, Nigeria, and its environs, . This prediction results could help government and small scale smoked fish retailers to fashion out best practices to help achieve maximum profitability in the smoked business.

Keywords: Neural Network, Profitability, Smoked Fish Business, Voice Communication, Ogun State, Nigeria

1. INTRODUCTION

Smoked fish are fish that have been cured by smoking, a method considered to be the oldest for fish preservation. The continuation of this practice today is due to a number of factors, chief amongst them is the unique taste and flavour which is imparted by the smoking process. Smoked fish business is the process of commercializing smoked fish for general consumption in return for profit as a gain. It is in this research, this is termed ***the economics of smoked fish business.*** The business is a lucrative venture in Nigeria as it is also an export commodity to the western community (especially United Kingdom) which generates huge income for the nation and dealers engaged in the business [1]. However, the retailers, which are small business owners (SMOs) in the country, are affected by different factors in the running of the business, resulting often in monetary loses. These factors include Government policies, Business outlets & location, Weather and Seasons, Capital, Transportation, Rodents' management etc**.**

The aim of this research is to design a neural-network-based system to analyze and predict optimal profitability of smoked fish business using data gathered on the above factors from smoked fish business owners and retailers. The methodology adopted for this research include the (i) Design of a questionnaire to capture relevant research data, (ii) Design of a Neural Network model for the analysis data and prediction purposes, (iii) Implementation of the model via the development of a windows system that applies the model in analysis and prediction (iv) generate and discuss the result obtained.

2. LITERATURE REVIEW

Fish is used either as singular noun or to describe a group of specimens from a single species. Fishes describes a group of different species [2]. The types of fishes commonly smoked for sale and often reared in the south western geographical region of Nigeria are but not limited to those listed in Table 2.1 and Table 2.2 below.

Table 2.1: Commonly Smoked Fish Types In Ota: Their Scientific And Local Names.

FISH TYPE (COMMON NAME)	SCIENTIFIC NAME	LOCAL/MARKET NAME
Blue whiting	*Micromesistus poutassous*	Panla
Herring (Atlantic)	*Clupea harengus*	Shawa
Mackerel	*Scomber scrombus*	Titus
Horse mackerel	*Trachurus trachurus*	Kote

Table 2.2: Uncommonly Smoked Fish Types in Ota: Their Common, Scientific and Local Names.

FISH TYPE (COMMON NAME)	SCIENTIFIC NAME	LOCAL/MARKET NAME
Croaker	*Micropogonias undulatus*	Croaker
Catfish	*Clarias gariepinus*	Catfish/Aro
Tongue sole (Senegalese)	*Cynoglossus senegalensis*	Abo
Tilapia	*Oreochromis niloticus*	Tilapia/Fresh fish

2.1 Fish as food and the Fishing Industry

[3], [4] indicated the importance and fish and it's nutritional value to human diet, animal feed and other purpose. In [5], fish was noted to be one of the safest and cheapest sources of calories, protein, fat, calcium, iron, vitamin and essential amino acids in Nigeria. Fish consumption accounts for about 35 percent of animal protein consumption in Nigeria. In 2007 alone, Nigeria produced just over 600,000 metric tons of fish. Consumer demand, on the other hand, was reported at 2.66 million metric tons, and was met only in part by imports of about 740,000 metric tons that same year. The average fish demand in Nigeria is however put at put at 1.2 million metric tons [6]. This makes fish farming a vibrant and dynamic commercial sector in Nigeria, particularly the Atlantic coastal area of the southern part of the country, riverine and inland part of Nigeria, and servers as a source of employment for the artisan fisherman as a survival strategy since majority of them lack infrastructural facilities and adequate funds for the procurement of large fishing equipments.[1], [7].

[8] reported that fish accounted for about one-fifth of world total supply of animal protein sources. Fish has been found to be low in cholesterol content, which allows for the enhancement of improved of human nutrition [9]. However, according to researches; the smoking of fish does not diminish the nutritive value of the fish.

2.2 Fish Preservation and Processing

The quality of fish decline rapidly after they die because fish is susceptible to tissue decomposition, development of rancidity and microbial (bacteria) spoilage. As a result, a number of processing methods have been developed through the years to prolong the freshness of fishes. Drying, salt curing and smoking have been used to process fish for thousands of years. All three methods reduce the moisture content of fish and thus slow the growth of bacteria and the breakdown of protein. However, a high degree of fish spoilage occurs due to the absence of storage facilities and serves as a major constraint to the development of fishing industry in Nigeria [7]. Militating against this is one reason for the smoking of fish.

Fig 2.1 Fish Processed By Smoking

2.3 Fish Smoking

In [10], smoking was noted to be the most popular method of fish processing in Nigeria and involves the application of heat to remove water and inhibit bacterial and enzymatic action on fish. It imparts aroma, taste and colour on processed fish [11]. Traditionally, fish is smoked in pits or on raised smoking "tables" where the control of heat is difficult and at times impossible [12]. [13] noted that variations in fish product quality stem from the differences in the freshness of the raw material and the preparation of the fish prior to smoking. Differences between fish species may also be reflected in the quality of the smoked fish [14].

Fish may be hot-smoked or smoked-dry. The choice depends on the type of fish to be smoked and how long the product is to be stored. [14] noted that both processes are carried out at temperatures of 80°C and above, which is high enough to cook the fish. [15] showed that the hot smoked process takes about 1 -3 hours and yields a product with about 35 - 45 % moisture content, but with a limited shelf-life of 1 - 3 days at ambient temperatures. The smoke-dry process takes about 10 - 18 hours, and sometimes 3 – 4 days and yields fish of 10 - 15% moisture content, sometimes even below 10% with a shelf-life of 3 - 9 months when stored properly. [13] found that the shelf life of the smoked fish depends more on the cooking and the state of dryness of the fish than the smoke itself. Traditionally, fish is not filleted before smoking, but large fish (e.g. catfish) is normally cut into portions, soak in brine, then placed in a large oven, where smoke and heat from smouldering wood chips dries the fish. This method also improves the flavour of the fish. Wood contains three major components that are broken down in the burning process (pyrolysi) to form smoke. The major wood components are cellulose, hemicellulose and lignin [16].

2.4 Methods of Smoking Fish

[16] noted that two main methods exist for smoking fish, viz the traditional and the mechanical methods. The traditional method described above, involves the fish being suspended in smokehouses over slowly smoldering wood shavings. The fish are left for hours to be naturally infused with smoke.

While in the mechanical method, smoke is generated through the use of smoke condensates, created by the industrial process of turning smoke into a solid or liquid form. The flow of smoke in the mechanical kiln is computer controlled and the fish generally spend less time being smoked than in a traditional kiln. Laminar air-flow technology allows mechanical kilns to achieve a higher production rate, while the use of micro-processors has allowed mechanical kiln smokers increased sensor coverage within the kiln. Traditional smoker, however, argues that the mechanical process removes the human element from the production, that fish smoking is a qualitative process, making traditional smoked fish a high end product sought after by restaurants, whereas mechanical kiln smoked fish represents a quantitative approach where supermarkets represent the main market [17].

2.5 Reason for Adopting Smoked Fish Business

In Nigeria, people go into smoked fish business, for on or more of the following reasons: (i) Ancestral inheritance: their forefathers have been in the business for long, so they believe they have to succeed the business. (ii) Profit: they need to earn a living by profit making from the business, (iii) Survival: people especially those living in the riverine areas have no other job to do, hence they fish and smoke it for preservation then sell it for income.

2.6 Artificial Neural Network

An Artificial Neural Network (ANN) consists of a large number of simple processing elements called neurons, units, cells, or nodes. Each neuron is connected to other neurons by means of directed communication links, each with an associated weight. The weights represent information being used by the network to solve a problem. An ANN is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. They are mathematical simplifications of complex physiological systems. [18]. In the ANN model given by [18], a neuron multiplies each of its inputs by a weighting term, adds these products, and then passes this sum through a hard limiting threshold function, the activation function. Mathematically, this process is described in Figure 2.2 below.

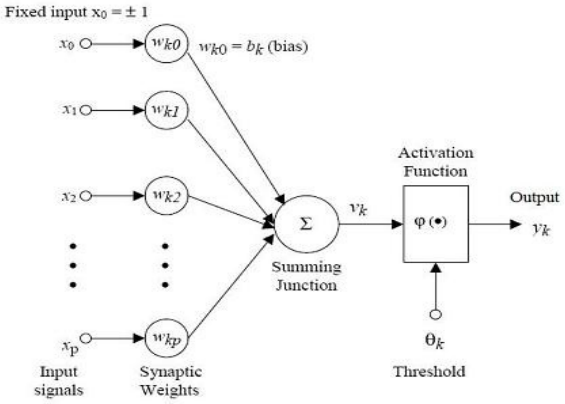

Figure 2.2: A Basic Artificial Neuron

From this model the interval activity of the neuron can be shown to be:

$$v_k = \sum_{j=1}^{p} w_{kj} x_j \quad \text{----------(1)}$$

The output of the neuron, yk, would therefore be the outcome of some activation function on the value of v_k. This weighted sum (v_k) of the input is transformed to working output for the next stage using a activation (transfer) function. The activation function used in this research is the sigmoid transfer function such that Out = $1/(1 + e^{-Net})$, thereby giving the equation:

$$y_k = f(v_k) = 1/(1+e^{-v_k}) \quad \text{----------(2)}$$

This sigmoid function produces output that can range between 0 and 1 (as shown in Fig 2.3), but it is also sometimes useful to use the -1 to 1 range.

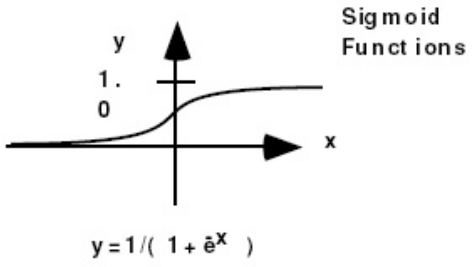

Fig 2.3 Log-Sigmoid Transfer Function

Fig 2.4 shows a schematic diagram illustrating a Multilayer Perceptron Neural Network mode with 1 hidden layer.

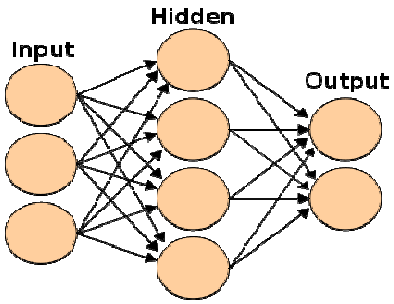

Figure 2.4 Multi-layer Perceptron Architecture

The ANN model used in this research is the Multilayer Perceptron architecture having one hidden layer and using back propagation. Generally, ANNs are characterized by the following: (i) its architecture which is the pattern of connections between the neurons, (ii) Its activation function, (iii) Its training (learning, adjusted), that is, method of determining the weights on the connections.

The training process for the Neural Network used is depicted in Figure 2.5 below.

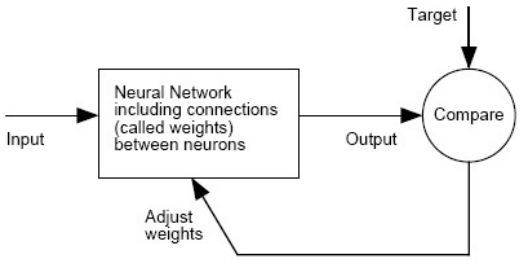

Fig 2.5 Training A Neural Network with Back Propagation

The Back Propagation Algorithm applied was as followed:

1. Propagation phase: For each propagation;
   i. Forward propagation of a training pattern's input through the neural network in order to generate the propagations output activations.
   ii. Backward propagation of the propagations output activations through the neural network using the training patterns targets in order to generate the deltas of all output and hidden neurons.
2. Weight update phase: For each weight synapse;
   i. Multiply its output delta and input activation to get the gradient of the weight.
   ii. Bring the weight in the opposite direction of the gradient by subtracting a ratio of it from the weight.

Repeat phase 1 and 2 until the performance of the network is good enough.

3. RESEARCH METHODOLOGY

3.1 Data Collection: In carrying out this research, data was collected via questionnaires from smoked fish business owners and retailers, in addition to personal interviews with, from selected markets in Ota, Ogun State and its environs. In each market, there are about approximately 40 retailers and questionnaires were distributed to all retailers to ensure not less than 50% sampling intensity. The study questionnaire was divided into two group of sections. The first group of sections was mainly composed of questions structured to a five-point Likert scale, where 1 = very untrue and 5 = very true. The first set of question. The second group of sections was in table and captured data on quantity, fish types, cost of procurement, and cost of sale in the market amongst other.

3.2 Neural Network Model: The Neural Network model used in this research is the multilayer Perceptron with back propagation. The Model was implemented in the developed System.

4. ANALYSIS OF DATA AND PRESENTATION OF RESULT

Data gathered from the questionnaire were entered as weighted inputs into the NN based system and analysed, using a derived analytical formula that transformed the total input weights to percentage (%) values as shown below:

Percentage (%) analysis value = [∑ (Value of Option ticked in questionnaire) / (Last Option ID {number}) * (Last question ID {number} in section) * (Total number of response)] * 100

The profit determination was derived using the formula:

Profit determination = [∑ (Average sales per month) - ∑ (Cost per carton * Size of carton bought per week * 4) – ∑ (Cost of fuel used per week * 4)]

Values obtained in the prediction section of the system was presented as (Percentage (%) value analysis) Prediction generated is assigned to each weighted scales formulated to be used in determining the effect of the factor considered as shown in Table *.

Table 4.1

Weighted scale (%)	Prediction generated
70 - 100	Factors affect the smoked fish business positively/Business tends to yield maximum profit
50 - 69	Factors moderately affects the smoked fish business positively/Business tends to yield moderate profit
30 - 49	Factors moderately affects the smoked fish business negatively/Business tends to yield moderate loss
0 - 29	Factors moderately affects the smoked fish business negatively/Business tends to yield maximum loss

4.1 Implementation of the ANN-Based Window System for Data Analysis and Prediction

A Neural Network –based Window system was designed to specifically analyse data extracted from the questionnaire and for showing the impact of each factor on the profitability of the business based on the collected data. The system was modelled using UML and implemented using Visual Basic.net 2008. The Database was implemented using Microsoft SQL Server 2008. The architecture of the system comprises of the following parts: (i) User Interface, (ii) Neural network engine, (iii) Database (iv) Operating system. Below is a logical diagram of the system component.

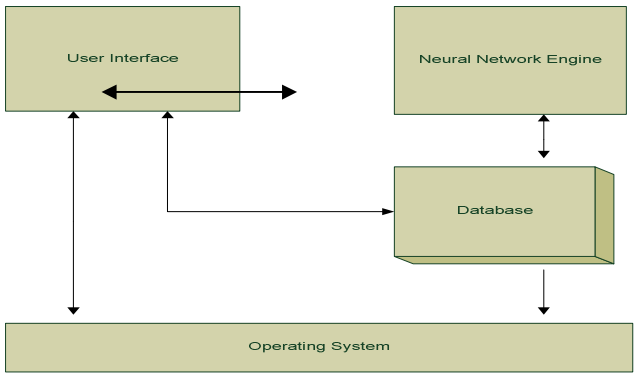

Fig 4.1 System Architecture

i. User interface: This provides a means through which users can enter the data, set parameters as well as obtain results of the system's processing. The user-interface interacts with the operating system, neural network engine and designed database respectively, thereby increasing flexibility. It incorporates the following sections

a. **Login interface:** user is expected access the system with a login credential. If no login credential has been created, user will need to create a new account before proceeding to next stage of system.
b. **Parameter setup interface**: this interface allows the administrator to setup questions for survey.
c. **Analysis/Prediction interface:** interface allows administrator to run the analysis of the survey and view generated prediction of result.

ii. **Neural network engine:** It interacts with the user interface to receive data from user, analyse the data using the multilayer perceptron neural network model with back propagation discussed above. It then displays and store the result of analysis in the database.

iii. **Operating system:** This NN-based Windows system was developed for the Windows Operating System (Windows XP and later). The user interface and database depends on the services and resources of the operating system so as so enable them run efficiently and effectively on the system.

iv. **Database:** The database was implemented using Microsoft SQL Server 2008, and servers as repository for user and the Neural Network-based system data. It contain the following tables:

a. **Option table**: Stores the option values and id given to a topic or factor (from the questionnaire).
b. **Prediction Table**: Where prediction values from analysis will be store.
c. **Question Table**: Where the survey questions are stored
d. **Topic Table**: Where a topic and topic values are stored when created.
e. **Profit Table**: Stores the actual prices for analysis
f. **Section table**: Where sections in the survey are stored.
g. **Question Log Table**: Questions attached to each secions are created and stored.
h. **Register Table**: Allows the registration of new users/client/admin

5. SYSTEM MODELLING

A formal model of the proposed system was built using Unified Modelling Language (UML). Below is a Use-Case diagram of the system, the Data Transformation process, and the Data Flow Diagram.

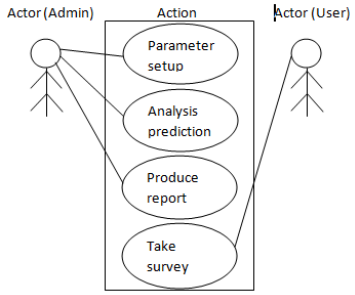

Fig 5.1 Use-Case Diagram

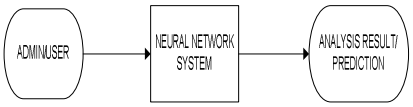

Fig 5.2 Data Transformation Process

1. Admin/user: responsible for inputting the data into the system.
2. Neural network system: this is the system that is been designed along with its corresponding database.
3. Analysis/Prediction: The end result of the processed input in the system.

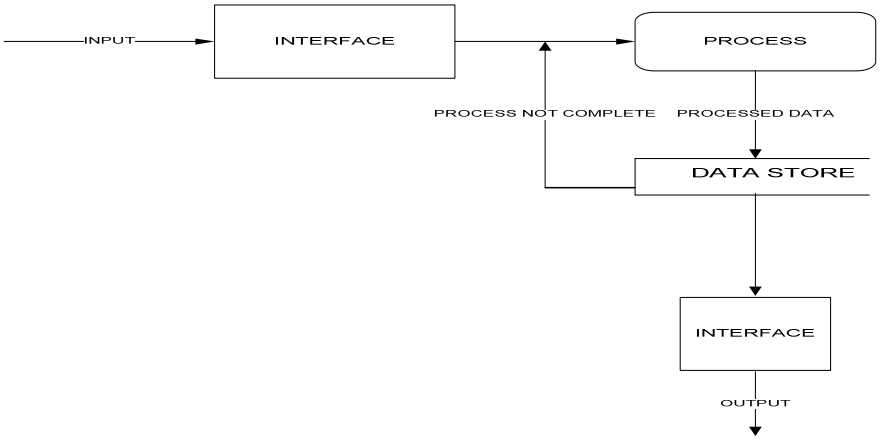

Fig 5.3 Data-Flow Diagram

iii. **Database/Entity-Relationship Diagram**: The data model used for the database design is shown using the database/entity-relationship (ER) diagram shown below:

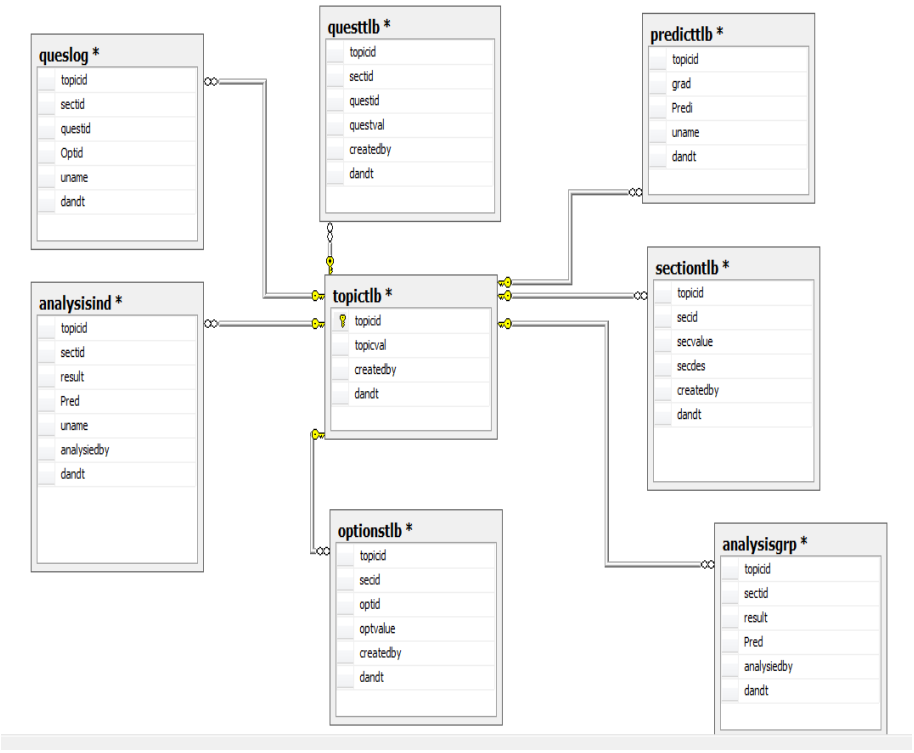

Fig 5.4 Database (Entity-Relationship) Diagram

6. RESULTS AND INTERPRETATION

The output from the neural network is presented in a range from 0 to 100%. Based on the analysis carried out on the smoked fish market survey (total of 120 responses) using the smoked fish analysis/prediction system, the following results and predictions where deduced:

TABLE 6.1 Results Of Analysis

Section	Percentage (%) Analysis Value	Prediction
Section 1 (Profit Factor)	73%	Factors affect the smoked fish business positively/Business tends to yield maximum profit
Section 2 (Location Factor)	60%	Factors moderately affects the smoked fish business positively/Business tends to yield moderate profit
Section 3 (Govt/Coop agency Factor)	83%	Factors affect the smoked fish business positively/Business tends to yield maximum profit
Section 4 (Financial Factor)	51%	Factors moderately affects the smoked fish business positively/Business tends to yield moderate profit
Section 5 (Family Involvement Factor)	35%	Factors moderately affects the smoked fish business negatively/Business tends to yield moderate loss

From above table:

Mean/Average Percentage analysis value (from section 1-5) = Sum total of percentage analysis values from each section / Number of section

= (73 + 60 + 83 + 51 + 35) / 5

= 60.4%

6.1 Inference(s)

According to the analysis by factors in section 1-7, the results of analysis shown in the table above simply show that:

In section 1:

1. Combination of smoked fish types yield about maximum profit.
2. Smoked fish smoked are sold overtime.
3. The demand for smoked fish is high.
4. Fish sellers prefer to smoke and sell their fish without assistance without employing paid labourers.

In section 2:

1. The environment/location moderately suitable for smoked fish business.
2. Expansion of business will moderately increase the profitability of business.
3. There are moderate transport channels to business location.
4. Smoked fish sellers tend to sell/make more profit during the dry season.

In section 3:

1. Government policies affect the growth of their business.
2. They frequently pay their taxes and dues.
3. They belong to co-operative societies and have access to loan benefits.

In **section 4**: They are averagely willingly to expand the business due to less adequate funding. In **section 5**: Family members are less involved in smoked fish business. According to the analysis by general price profit determination, it predicts and shows that small scale smoked fish businesses in Ota and environs are profitable.

7. CONCLUSION

After a critical look at the results of analysis, inferences and predicted outputs, Section 1 to 5 in the analysis of questionnaires, shows that the factors that is, policies of government, location of business, willingness to expand business, family, combination of fish types, etc moderately affect the smoked fish business positively. Thus, business tends to yield moderate profit. This prediction corresponds to Mean/Average Percentage analysis value (60.4%) which states moderate profitability from the given range in the prediction scales table (TABLE 3.1). When properly utilized, the system can definitely make the smoked fish business more profitable.

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