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A SCIENTIFIC APPROACH FOR CLASSIFICATION OF COCOA BEAN

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ABSTRACT

It is interesting to observe that both public-and private-sector are increasingly partnering to dedicate funding and expertise to improve sustainable cocoa farming and the commercial conditions of the local developing economics. Production of cocoa significantly impacts the economics of many developing countries and provides livelihood for millions of people globally. The farmers who engage in cocoa production need to understand the classes of cocoa especially in foreign exchange trading. Neural network technique was adopted to classify cocoa data set into classes. The attributes considered are slate, mould, free fatty acid, foreign matters, bean count. The data set was divided into training data and test data for the neural network to train. At implementation, the neural network classified cocoa into three classifications: "Good", "Fair" and "Bad" to address the challenges confronting global cocoa production. With classification of cocoa beans, it translates into better livelihood at the farmers' level, increased resources and investment at the national level especially for the cocoa-producing countries and a safer environment of cocoa production for the world's consumers at the world's exchange market.

KEYWORDS: *classification, neural network, weka, bean count*

1.0 INTRODUCTION

There are an estimated 5 million households that farm cocoa as a cash crop, mostly in tropical geographies of West Africa, Southeast Asia, and Latin America.

Cocoa beans as the dried and partially fermented fatty seed of the cacao tree need to be classified based on its qualities from which market value can be determined. Cocoa has a wide variety of uses, from chocolate to cocoa butter to coloring agents for food products. Cocoa butter is used in chocolate bar, manufacture, other confectionery, soaps, and cosmetics (International cocoa organization, 2014). The application of cocoa can also be used in beverages,

cosmetics, pharmaceuticals and toiletries products (Ardhana and Fleet, 2003).

The United Nation (UN) Food & Agriculture Organization provides information on the impact that cocoa production and cultivation have on local markets and indigenous people of growing regions (Beckett, 1994). Exchanges where cocoa futures are traded also offer resource materials. As consumption continues to increase on an annual basis, it becomes more difficult for the industry to keep up with demand. In 2011, the chocolate confectionery industry surpassed \$100 billion in value for the first time. The world cocoa market includes exports valued at more than \$1.2 billion from Côte d'Ivoire, the world's top-producing country; \$840 million from Indonesia, the number two

producer; and \$650 million from Ghana, the number three producer. The industry also serves as a significant economic engine in Europe and the United States. (<http://worldcocoafoundation.org/>.)

In cocoa grading in the world market according to the Federation of Cocoa Commerce Limited (FCC) an exclusive consideration is given to cocoa bean classifications. The standard specifies the criteria for quality of cocoa bean that is used in price determinant of cocoa at export. In cocoa grading, Federation of Cocoa Commerce Limited (FCC) distinguishes two grades: good fermented cocoa beans and fair fermented cocoa beans.

The economic value of countries like Nigeria, Indonesia, Ivory Coast etc that are into high production of cocoa beans also should know about this classification of cocoa beans, as the good category of cocoa beans rest solely on the quality. The good quality is a determinant factor of the economic value.

This paper examines the classification of cocoa bean using neural networks approach. The attributes of cocoa bean product are used to classify the categories of cocoa bean using neural network since there has also been some interest in applying computational techniques, such as artificial neural networks, in the area of classification. The neural network is developed to perform intelligent tasks that could be performed by human brain. Both biological and artificial neurons are elementary information processing units which are also fundamental building blocks of a neural network (Grothmann, 2002).

2.0 LITERATURE SURVEY

The literature contains the percentage production of cocoa in cocoa-producing countries, background of neural networks and some related works on cocoa

2.1 Cocoa Production

There were 3.54 million tonnes of cocoa beans produced in the 2008–2009 growing year, (International cocoa organization, 2011) which runs from October to September (World Cocoa Foundation, 2011). Of this total, African nations produced 2.45 million tonnes (69%), Asia and Oceania produced 0.61 million tonnes (17%) and the Americas produced 0.48 million tonnes (14%). Two African nations, Cote d'Ivoire and Ghana, produce more than half of the world's cocoa, with 1.23 and 0.73 million tonnes respectively (35% and 21%, respectively) (International cocoa organization, 2011). In 2012, the largest cocoa-bean producing countries in the world are as follows. Cote d'Ivoire produced 1.65 million tons (33.0%) of the world production of cocoa beans, Indonesia produced 936 thousand tons (18.7%) of the world production of cocoa beans, Ghana produced 879 thousand tons (17.6%) of the world production of cocoa beans, Nigeria produced 383 thousand tons (7.7%) of the world production of cocoa beans,

Cameroon produced 256 thousand tons (5.1%) of the world production of cocoa beans, Brazil produced 253 thousand tons (5.1%) of the world production of cocoa beans, Ecuador produced 133 thousand tons (2.7%) of the world production of cocoa beans and Mexico produced 83 thousand tons (1.7%) of the world production of cocoa beans. 72% of world production of cocoa beans in the 2005/2006 crop year came from Africa (United Nations, 2008)

2.2 Artificial Neural Network

An artificial neural network is modeled as a massively parallel-interconnected network of elementary processors or neurons. It is highly interconnected network of information-processing elements that mimics the connectivity and functioning of the human brain. There are many types of artificial neural networks. One of them is Multilayer Perceptron.

An MLP consists of multiple layers of nodes, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called backpropagation for training the network. MLP is a modification of the standard linear perceptron, which can distinguish data that is not linearly separable (Schalkoff, 1997).

2.3 Related Work

Olunloyo et al (2011): In their study on neural network-based electronic nose for cocoa beans quality assessment designed a prototype electronic nose for monitoring the quality of cocoa beans. The performance was enhanced by pre-heating the raw beans to 60°C in a sample chamber. Principal Component Analysis (PCA) was employed mainly for data visualization, which showed the discrimination of the dataset into distinctly separable points, with the data pre-processed with 'fractional' baseline correction method giving the best discrimination on the data. The datasets were further classified using Artificial Neural Network (ANN) - based techniques. The results show that 95% of the cocoa beans data can be classified into two quality classes successfully. The research basically establishes the efficacy of the smell sensor techniques for quality monitoring of cocoa beans. The strength of the study was that an electronic nose was developed for monitoring the quality of cocoa beans. The weakness of the study was that only two classes were classified instead of three classes as the standard of grading cocoa

Russell and Paul (2019) wrote on the cocoa processing. The processing cocoa includes harvesting; fermentation; cleaning, roasting, and grinding; conching and molding. They further stated the Cocoa bean products: Cocoa powders, chocolate powder.

Ranjana (2018) looked into the taxonomy and classification of cacao. The cacao varieties have been

classified into three general groups: ‘Criollo’, ‘Forastero’ and ‘Trinitario’, based on morphological descriptors and geographic origin (Engels, 1981; Enriquez and Soria, 1967).

‘Criollo’ refers to a group of genetically similar trees which produce lightly pigmented seeds and share several other morphological traits. ‘Trinitario’ refers to hybrids of the ‘Criollo’ and ‘Forastero’ strains. Forastero refers to any trees that are not Criollo or a hybrid and which usually produce deep purple seeds. The limitation of the work was that no scientific approach was adopted.

Adelson *et al.* (2016) researched on molecular genetic diversity in a core of cocoa (*Theobroma cacao* L.) clones with potential for selection of disease resistance, plant height and fruit production. This study aimed to assess the genetic variability in groups of 11 clones of *Theobroma cacao* L., from different geographical regions, based on microsatellite markers, with the interest to characterize germplasm for breeding. The products of the amplification of these materials with 15 simple sequence repeat (SSR) markers were separated into ABI377 sequencer. The genotype encoded data were analyzed by means of Roger’s genetic distances, which was employed in the main coordinate’s analysis. The high heterozygosity observed in this group of clones ($H_o = 0.7276$) and genetic distances between pairs of clones (average 0.75) showed that there was a high diversity among these clones.

Vázquez-Ovando *et al.* (2015) worked on sensory descriptors of cocoa beans from cultivated trees in Mexico. The odor and taste profile of cocoa bean samples obtained from trees cultivated in southern Mexico were evaluated by trained panelists. Four attributes of taste in terms of sweetness, bitterness, acidity and astringency were considered and nine attributes of odor such as chocolate, nutty, hazelnut, sweet, acidity, roasted, spicy, musty and off-odor were evaluated. A sample with higher scores in sweet taste and sweet and nutty odors was detected, as well as a high association between these descriptors and the sample, analyzed through principal component analysis (PCA).

Rusconi and Conti (2009) considered a scientific approach beyond myths and claims of *Theobroma cacao* L. The paper reviewed many qualitative differences of cocoa and chocolate, in particular dark chocolate, aiming to establish the different implications for public health through the use of the analyzed concentration of polyphenols in cocoa products. The paper did not consider some attributes of cocoa bean

3.0 METHODOLOGY

The neural network is multi-layered configuration that operates in two modes: Training and

Testing. In the training mode, a set of training data is used to adjust the weights of the network interconnections so that the network responds in a specified manner. In the testing mode, the trained network is evaluated by the test data.

The data set contains one thousand (1000). Eighty percent (80%) of the data set are used as training data while twenty percent (20%) are used as test data for the neural network. The data set for the implementation of the neural networks contains both numeric attributes (slate, mould, foreign matter, bean count) and nominal-valued attributes (Free fatty acid). The data set is based on the qualities of cocoa bean which classify cocoa bean. In classification, the inputs as the attributes are used to determine class of a given instance.

The classification of cocoa bean adopts this rule of conditionality to classify cocoa according to the Federation of Cocoa Commerce Limited. A rule of conditionality is used to model the classification of cocoa bean as being good, cocoa bean, fair cocoa bean and bad cocoa bean:

```

If (Slate < 0.05 && mould < 0.05 &&
    free_fatty_acid = "Low" &&
    foreign_matter < 0.15 && (bean_count < 110))
    cocoa_price_condition = "Good";
elseif ((Slate > 0.05 && slate < 0.1) && (mould >
    0.05 && < 0.1) &&
    free_fatty_acid = "Partially Low" && (foreign_matter
    < 0.15) &&
    (beans_count < 110))
    Cocoa_price_condition = "Fair";
Else Cocoa_price_condition = "Bad";

```

The neural network approach performs a classification task. Therefore, the network has output variable(s), when the inputs are mapped from input layer to hidden layer to output layer. It further involves deriving a function that will separate data into categories, or classes, characterized by a distinct set of features/attributes. This function is mechanized by a network classifier, which is trained using data from the different classes as inputs, and vectors indicating the true class as outputs (Carlo *et al.*, 2004). A network classifier typically maps a given input vector to one of a number of classes represented by an equal number of outputs. They indicate the degrees of participation of a given input over the output classes (Jonas, 2005).

Multilayer Perceptron (MLP) is used as a type of artificial neural network. The artificial neuron is best illustrated in figure 3. The connections (synapses) w_i transfer the signals (stimulus) x_i into the neuron. w_i can be interpreted as a weight representing the “importance” of that specific input x_i . Inside the neuron the sum of the weighted inputs $w_i x_i$ is taken. Given this sum w is greater than an externally applied threshold θ , the neuron emits an output y . The output, y is either

continuous or binary valued, depending on the activation function (or squashing function).

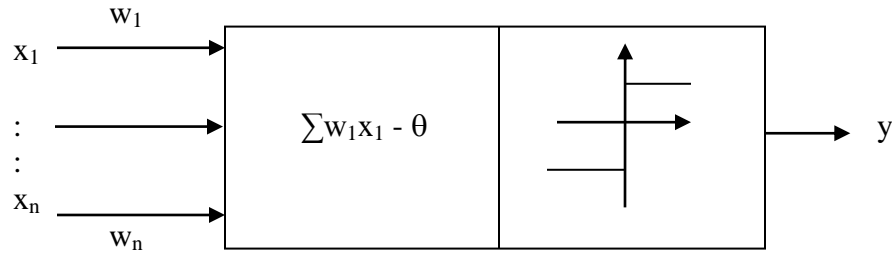


Figure 2: The artificial neuron with a threshold function.

In mathematical terms, the following equations give a dense description of the neuron (Karl, 2004)

$$y = \sum_{i=1}^n w_i x_i - \theta \quad \dots\dots\dots (1)$$

$$\text{and } y = \phi(y') \quad \dots\dots\dots(2)$$

where y is the net input and $\phi(y')$ the activation function.

The network is calculated using summation in equation (3)

$$y = b^7 + \sum_{i=1}^7 w_i^7 \sigma \left(b_i^1 + \sum_{j=1}^7 w_{i,j}^1 x_j \right) \quad \dots\dots\dots (3)$$

where x is the input, w is weight, b is bias which is unity (1.0), σ is the transfer function, X_n is the summation in the input layer.

Weka was used as a tool for implementations of learning algorithm (neural network) that could easily be applied to dataset. The graphical interface for the implementation is shown in Figure 2

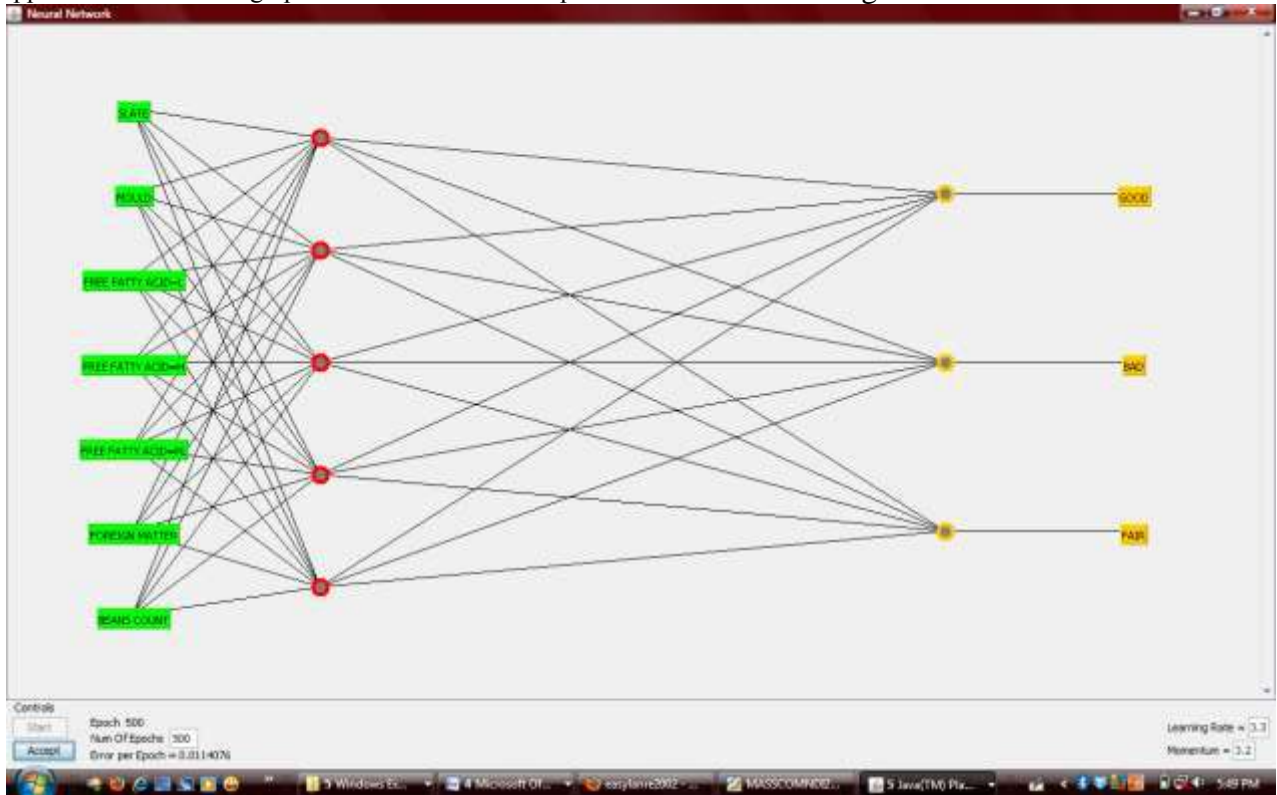


Figure 2: Graphical User Interface

4.0 CONCLUSION

The neural network has got more and more attention in the economic situation owing to its non-linear mapping ability and approaching ability for any function. The paper uses the artificial neural network to classify cocoa bean from a number of attributes. Neural network is a feasible method that classifies cocoa bean based on the degree of its attributes/features to produce output (class) whether a cocoa bean is good, fair or bad in area of grading of cocoa on export basis.

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