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Full Length Research Article

DETECTION OF OPTIMUM MATURITY OF MAIZE USING IMAGE PROCESSING AND ARTIFICIAL NEURAL NETWORKS

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ABSTRACT
Maize is one of the most widely cultivated crops in Nigeria having good contents of protein, carbohydrate and fat. The leaves of maize are also very good source of food for grazing livestock like cows, goats, sheep, etc. However, in Nigeria the leaves are left in farm lands to dry up completely (brownish) or even rot with little or no nutritional value to livestock. At the maturity of maize the leaves are still maintaining green coloration and the stalk are still fresh. Changes in the maize leaf coloration during maturity were studied. A CCD camera for image acquisition of the different green colorations of the maize leaves at maturity was used. Different color features were extracted from the image processing system (MATLAB) and used as inputs to the artificial neural network that classify different levels of maturity.

Keywords: Maize, Maturity, CCD Camera, Image Processing, Artificial Neural Network.

INTRODUCTION
The need for increase in food production in the entire world is eminent due to the increase in population of both humans and livestock. One of the most popular source of food for both humans and livestock is the maize commonly referred to as Corn or ZeaMays (Botanical Name).Maize is grown all over the world. It is a common source of carbohydrates, protein and fat. In developed countries like the United Kingdom (UK) and the United States of America (USA) it is mostly used as a source of feeds for livestock, poultry and industrial foods, but in developing countries like Nigeria it is a staple food (Olaniyan, 2015). In Nigeria, Maize is consumed in several ways. In fresh form, it is either roasted on naked coals or cooked and sold to consumers who purchase it from street vendors or hawkers. In dry form, maize is grinded into flour used for preparing meals. In recent times in Nigeria, herdsmen and farmers have been in conflict due to the problem of grazing reserves. This problem is causing the loss of lives and properties on both sides. In all of these, little or no consideration is given to the leaves of maize during its maturity.

Photosynthesis is the process of making food in the presence of sunlight and chlorophyll. The organ that primarily serves this purpose is the leaf. Chlorophyll is the pigment from which green leaves obtain their coloration. Transpiration, guttation and respiration are other functions performed by leaves. Certain leaves store food, water and structurally support the plant. Livestock basically feed on green grass, of which the maize leaf is a usual grass leaf.

The life span of a leaf is usually short especially in maize plants that lives for only a single growing season. However, maize makes use of energy from sunlight more effectively than other crops, and its output per hectare outperform the output of other grain crops (Plessis, 2003; Olaniyan, 2015). The need to utilize the maize leaves in feeding livestock is as important as the output of the maize kernel used as food in Nigeria. In Nigeria it is a common practice for maize farmers to leave the maize crop up to biological maturity. However, at biological maturity, the maize leaves have turn into brownish color. The brownish color signifies the absence of chlorophyll, water, minerals and other essential elements for photosynthesis. Livestock that utilizes the brown leaves of maize and the entire maize plant after harvest for grazing get little or no nutritional value.

In maize plant, optimum maturity is usually attainable between the hard dough stage when sugar rapidly disappears from the maize kernel and starch accumulation takes place at the kernel; and the physiological maturity when the maximum dry mass of the kernel has been attained and the kernel base contains a layer of black cells. At optimum maturity the leaves still maintain their greenish coloration and the stems are still relatively fresh. Livestock that utilizes leaves at optimum maturity and the maize stem for grazing obtain higher nutritional value. However, to determine the precise time of optimum maturity of maize, the human eyes may not be very reliable as it varies from individuals to individuals because of differences in vision, human weariness factors and intuition differences concerning crops (Damiri and Slamet, 2012). Image processing (IP) is amongst the techniques that is commonly used for enhancing agricultural activities (Fakhri *et al.*, 2012). IP methods make important assessments of food value characteristics and improve the independent and regularity of measured outputs. IP works on the basis that light is visible to the spectrum of humans. In human eyes, there exist color stimulus focal point, which are red, green and blue (RGB). Color classification are commonly done using the RGB color model and the hue, saturated and value (Intensity) (HSV) color model. The RGB components each has 0 to 255 binary digits (Damiri and Slamet, 2012). The RGB color model is able to distinguish between millions of colors, however, it is not a representative of the way humans understand colors (Taghadomi *et al.*, 2015). The HSV color model ranges from 0 to 1 for each of the components. The HSV color model can be transform into the RGB color model. A better way to represent the way human eyes understand color is to use the HSV color model (Taghadomi *et al.*, 2015). The hue component gives a dominant color in an image. The ability of image processing techniques to process images without external interference and convert them into picture elements (pixel). These pixels serves as inputs to the artificial neural network (ANN). ANN rely on parallel processing and focus on modeling a human brain. The ability of ANN to exhibit uncertainty and imprecision tolerance, adaptability, learning, knowledge discovery and maintainability on data makes it suitable for the purpose of classification (Dayanand, 2012).

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MATERIALS AND METHOD

a) Maize Leaf

In a maize plant the leaves ranges from eight (8) to twenty (20) arranged spirally on the maize stem. Their occurrence is alternating on opposite sides of the maize stem. The leaf is assisted by a conspicuous center-rib throughout its whole stretch. The leaf is a characteristic grass leaf. The leaf is made up of an outer covering or sheath, ligules, auricles and a knife-edge.

The leaf surface have stomata which are present in rows. There are more stomata beneath the leaf surface than on top of its surface. On top of the leaf surface, motor cells are arranged in rows, parallel and in between the stomata rows. The motor cells absorb water speedily during conditions of moisture and become turgid. However, during draught, the motor cells rapidly lose their water contents resulting in the leaves curling inward to expose a small surface that reduces the rate of evaporation (Plessis, 2003).

b) Image Acquisition

A Panasonic Full High Definition (1920X1080p) Intelligent 50X Zoom with 32.4 mm wide optical zoom video camera was used to capture 60 samples of the maize leaves. The maize farms were planted at different times signifying the different maturity levels. The samples were categorized into three parts of 20 samples each which are the low (soft dough stage), the medium (hard dough stage) and the high (optimum stage).

c) Image Processing

The images acquired were first rescaled using paint brush software, this was necessary to enable proper focusing of the images. The images were converted from RGB to HSV. The individual components of HSV were extracted and then a random de-noising to maintain the key features of the images by using average filters in MATLAB R2012a (Rafeal and Richard, 2008).

In improving the image, the value (intensity) component of HSV color model of each image was sharpened which preserves the originality of the image. These results were later combined with the hue and saturated components of the respective images. There was no segmentation because the entire image was required (Rafeal and Richard, 2008).

In this research, color and texture features were extracted and used for better accuracy and identification (Pratap *et al.*, 2014 and Garima, 2014). The Grey Level Co-occurrence Matrix (GLCM) was used to extract the texture features of leaf's image (Dayanand, 2012). GLCM represents the relationship between a pixel reference point and its neighboring pixels. In each image, the standard deviation and mean of the hue, saturated and value were obtained for the color features. In the case of the texture features, the standard deviation of Contrast, Correlation, Homogeneity and Energy were obtained. There were ten features for each leaf image.

d) Image Classification

The prediction of the inputs class based on 60 samples of 10 elements and the targets class based on 60 samples of 3 elements. The 60 samples were divided into 3 parts of 42 samples (70%) for training, 9 samples (15%) each for both validation and testing. The training samples allow the network to adjust according to its error. The validation samples are used to measure the network generalization and to halt training when generalization stops improving. The testing data has no effect on the training, it provides an independent assessment of the network performance during and after training. The classification was achieved by the use of a two layer feed-forward, with 13sigmoid hidden layer and 3 output neurons to classify the input to outputs (figure 1.).The training was done using Trainscg training function that updates weight and bias values according to the scaled conjugate gradient back propagation method.

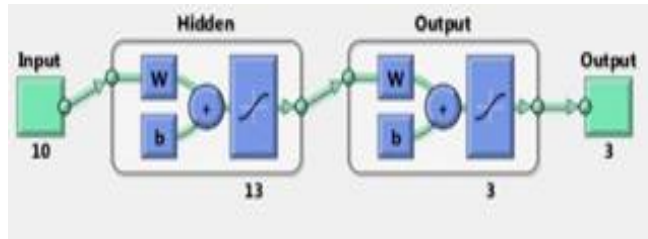

Figure 1: Neural Network Diagram

RESULTS AND DISCUSSION

(a) Confusion Matrix

Figure 2: Confusion Matrix

In the training samples, the precision of the classifier, which is the proportion of positive cases that were correctly identified are 75%, 86.7% and 100% for output classes 1, 2 and 3 respectively. The Sensitivity (Recall) which is the proportion of actual positive cases correctly identified in the training set are 85.7%, 86.7% and 84.6% for target classes 1, 2 and 3 respectively.

In the validation samples, the precision are 66.7%. 100% and 66.7% for the output classes 1, 2 and 3 respectively.

In the test samples, the precision are 50%, 50% and 100% for output classes 1, 2 and 3 respectively.

(b) Error Histogram

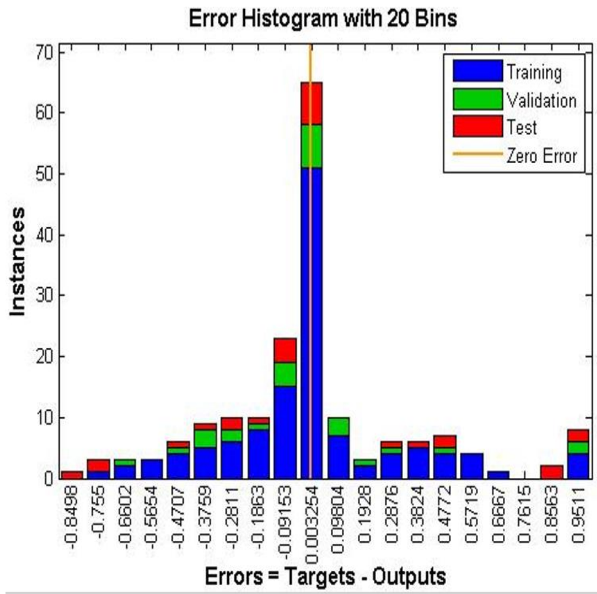

Figure 3: Error Histogram

In the error histogram above, it is clearly seen that the instances gave a minimal errors as the values are close to zero.

(c) Performance

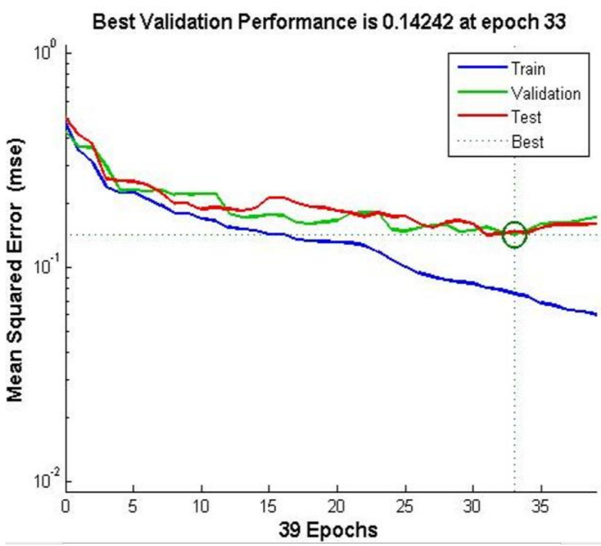

Figure 4: Performance

In the performance diagram it shows that all the data sets are close to the best fitting line.

(d) Receiving Operating Characteristics

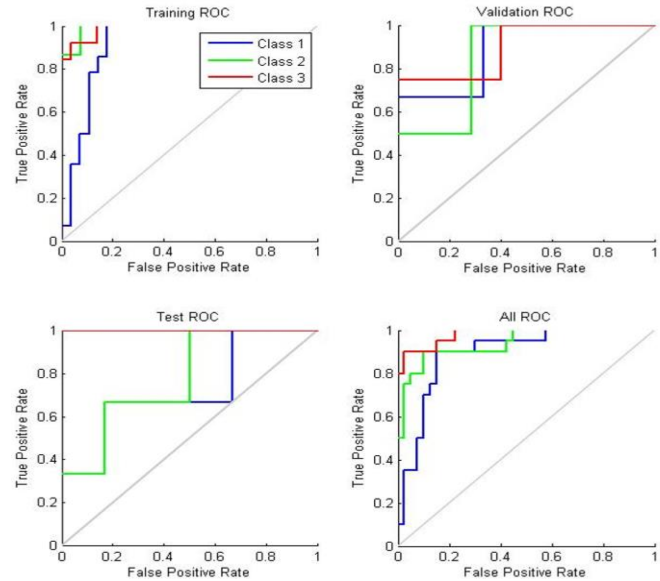

Figure 4: Receiving Operating Characteristics

The diagram of the Receiving Operating Characteristics tends towards the true positive rate which is a good sign that the classification is very good.

Conclusion

In the all confusion matrix, which is the overall assessment of the performance of the classifier in predicting the optimum maturity of maize it shows that, the network was able to achieve a very good accuracy of 80% generalization based on the sample set.

The leaves of maize are very good source of nutrients to livestock as they utilize more energy than any other crop for photosynthesis. The need to harvest maize at optimum maturity to provide source of grazing for livestock in Nigeria will go a long way to increase not only food but also meat production.

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