Sweet Potato (*Ipomoea batatas*) Variety Recognizer Using Image Processing and Artificial Neural Network

Magdalene C. Unajan, Winston M. Tabada, Bobby D. Gerardo, and Arnel C. Fajardo

***Abstract*—Variety identification can be considered an indispensable tool for ensuring quality product. Identification can be done by human experts but with their absence / rarity, technology can be put into good use. This paper proposed to develop technology that can be used to identify the variety of a sweet potato through its leaf digital image. The leaf image is segmented from its background using the Otsu thresholding method. Nine (9) color, six (6) morphological and six (6) texture features were extracted from the 28 sweet potato varieties leaf sample images. An artificial neural network (ANN) of multilayer perceptron using backpropagation method is used to train the system. The ANN has 21, 50, and 28 neurons in the input, hidden and output layers respectively. The recognizer was tested to 2 sample leaves for each of the 28 sweet potato varieties and obtained an accuracy of 71.43%.**

***Keywords*—image processing, neural network, recognizer, sweet potato variety**

I. Introduction

Sweet potato, a bio-efficient crop grown for edible roots has spread into Africa, Asia, Europe and East Indies through batatas line and to the Philippines from Central and South America. Sweet potato is a staple food crop in developing countries and serves as animal feed and raw material for many industrial products [1]. It is an important root crop in tropical and sub-tropical countries like China, USA, India, Japan, Indonesia, Philippines, Thailand, Vietnam, Nigeria, etc. Among the root and tuber crops grown in the world, sweet potato ranks second after cassava [2]. Many institutions and training centers in the Philippines breed different sweet potato varieties. Each variety of sweet potato has different quality and characteristics. High yielding sweet potatoes can lead to high production which in turn can augment income of the farmers. Farmers of sweet potato consult human expert on the variety of their crops.

Variety identification is an indispensable tool to assure tuber purity and quality [3]. Identifying variety can be done by human experts or by the help of technology. One way of recognition is through image processing.

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Nowadays, image processing is a growing field covering a wide range of techniques for manipulation of digital images. However, image processing alone is sometimes not enough for a computer program to be precise. Alongside image processing, neural networks can be very useful.

A neural network is a computational structure inspired by the study of biological neural processing. In its most general form, it is a machine that is designed to model the way in which the brain performs a particular task or function of interest. In most cases the interest is confined largely to an important class of neural networks that perform useful computations through a process of learning [4].

With these existing technologies, farmers can do the variety identification through the help of the internet and mobile devices. The image of the leaf of the crop is captured then uploads it to the system for variety identification. The result is then sent back to the farmer. This is the aim of this study.

II. Related Systems

Plant identification is an interesting and challenging research topic due to the variety of plant species. Among different parts of the plant, leaf is widely used for plant identification because it is usually the most abundant type of data available and the easiest to obtain. In their study, they introduced plant identification application on Android devices. They proved the robustness of kernel descriptor (KDES) for many object recognition applications [5].

The current work proposes an approach for the recognition of plants from their digital leaf images using multiple visual features to handle heterogeneous plant types. Recognizing the fact that plant leaves can have a variety of recognizable features like color (green and non-green) and shape (simple and compound) and texture (vein structure patterns), a single set of features may not be efficient enough for complete recognition of heterogeneous plant types. Accordingly, a layered architecture is proposed where each layer handles a specific type of visual characteristics using its own set of features to create a customized data model. Features from various layers are subsequently fed to an array of custom classifiers for a more robust recognition. A dataset involving 600 leaf images divided over 30 classes and including green, non-green, simple and compound leaves, is used to test the performance and effectiveness of the approach [6].

In the study of A.H. Kulkarni, et.al. [7], the authors proposed a novel framework for recognizing and identifying plants using shape, vein, color, texture features which are combined with Zernike movements. Radial basis probabilistic neural network (RBPNN) has been used as a classifier. To train RBPNN we use a dual stage training algorithm which significantly enhances the performance of the classifier. Simulation results on the Flavia leaf dataset indicates that the proposed method for leaf recognition yields an accuracy rate of 93.82%.

Fig. 1 shows the basic architechture of the Radial basis probabilistic neural network (RBPNN).

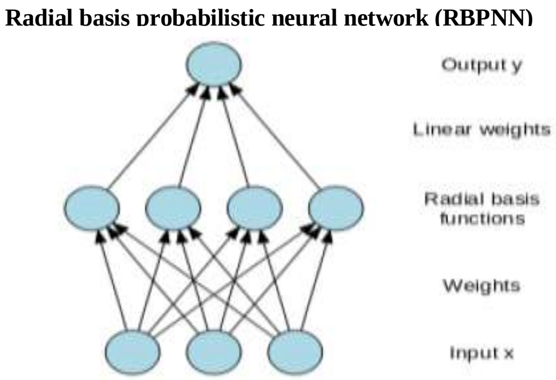

Fig. 1 Basic Architecture of RBPNN

III. Architectural Design And Proposed Mechanism

The overall architecture of the sweet potato variety recognizer system is depicted in Fig. 2.

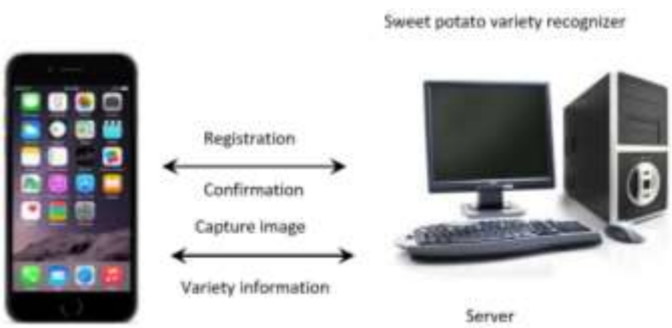

Fig. 2. Over-all architecture of the Sweet potato variety recognizer

A user registers in the system and then awaits confirmation. Once confirmed, he can now capture the image of a leaf from his camera phone. It is then sent to the server for processing.

Fig. 3 shows the System architecture of the sweet potato variety recognizer using image processing and neural network.

Image segmentation and Feature Extraction

The region of interest (ROI), which is the leaf image, is separated from the background using the Otsu thresholding method. After segmentation, color, morphological and texture features were extracted. The algorithms used in extracting the mean of red, green, blue, hue, saturation, value, luminance, chrominance-b and chrominance-r were based on the study of [8]. Fig. 4 shows the color features comparisons of the 28 sweet potato varieties.

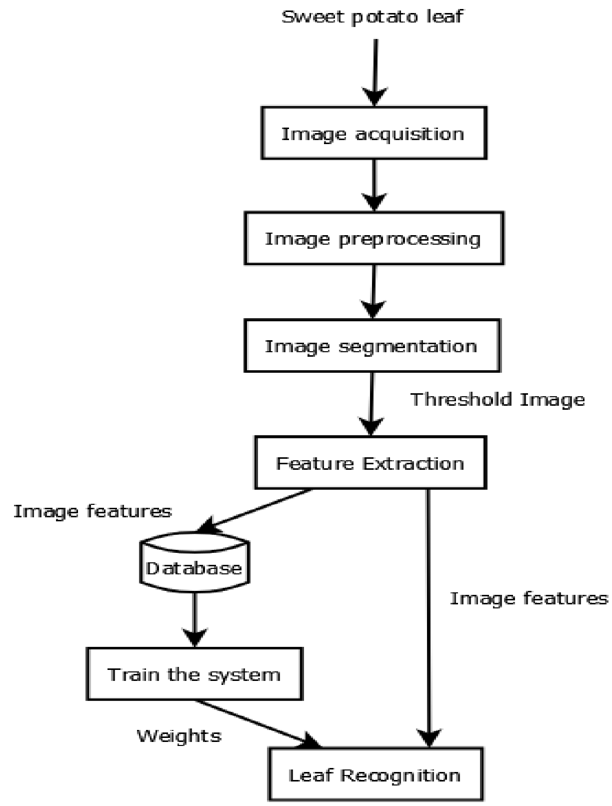

Fig. 3. System architecture of the sweet potato variety recognizer using image processing and neural network

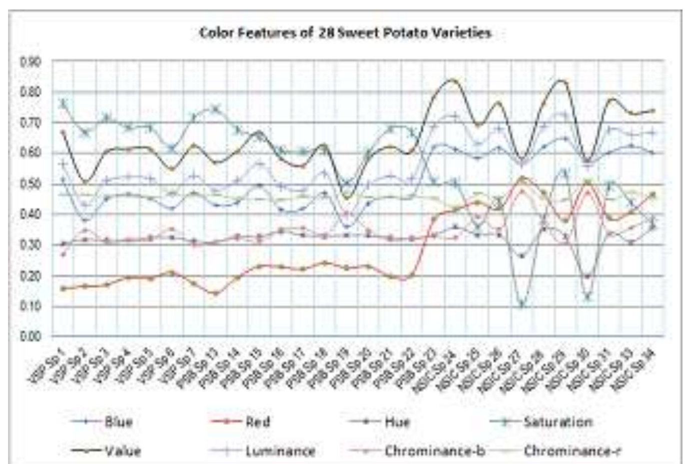

Fig. 4. Comparison of 8 color features extracted from the sample leaf images for each of the 28 sweet potato varieties.

Geometry related or morphological features such as extent, compactness and roundness were measured as suggested by [9]. The study [10] also suggested to compute three shape factors as part of the morphological features. Fig. 5 shows the comparisons of the 6 morphological features of the sample leaf images for each of the 28 varieties of sweet potato varieties.

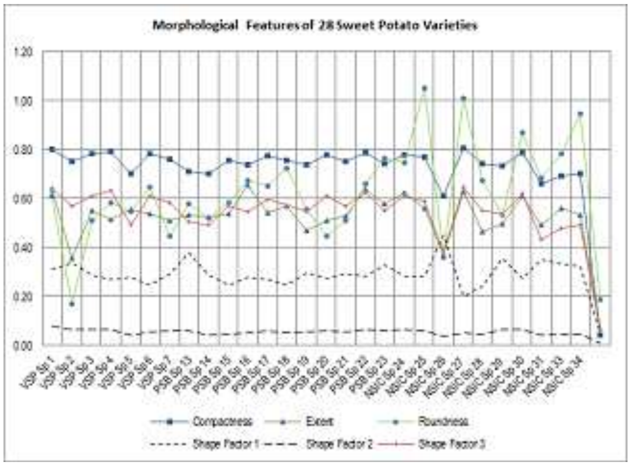

Fig. 5 Comparison of the 6 morphological features extracted from the sample leaf images for each of the 28 sweet potato varieties.

Texture features are computed from the statistical distribution of observed combinations of intensities at specified positions relative to each other in the image [11]. The Gray Level Cooccurence Matrix (GLCM) method is a way of extracting second order statistical features. In this study, the Angular Second Moment (ASM), Contrast, Inverse Difference Moment (IDM), Entropy, Correlation and Inertia texture features were used. Fig. 6 shows the comparison of 6 texture features from the GLCM of the leaf image.

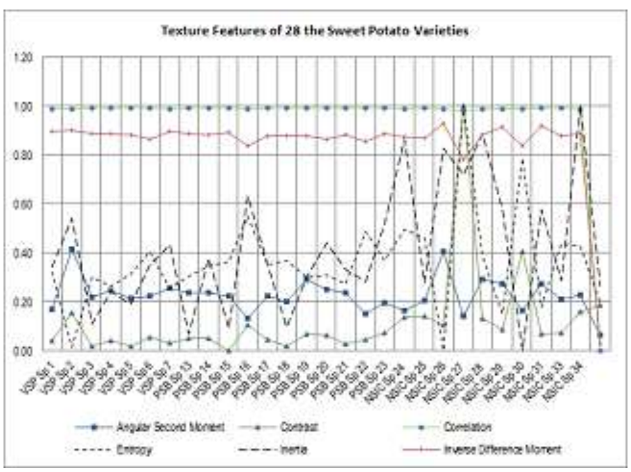

Fig. 6 Comparison of the 6 texture features extracted from the sample leaf images for each of the 28 sweet potato varieties.

Fig. 7 shows the neural network architecture of the sweet potato variety recognizer. The input layer consisted of 21 nodes which corresponds to the 21 extracted features of the leaf image. The hidden layer has 50 nodes and the output layer has 28 nodes which corresponds to the 28 sweet potato varieties.

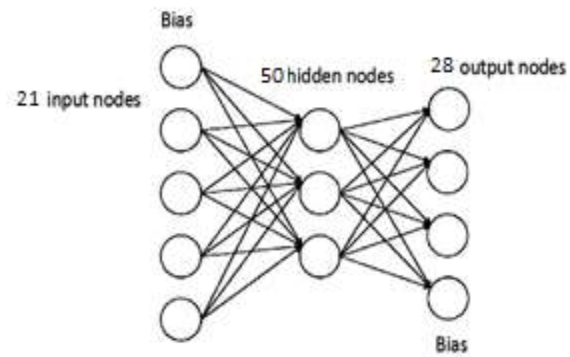

Fig. 7 The neural network architecture of the sweet potato variety recognizer

IV. Experimental Result

The artificial neural network was trained using 2 samples of leaf image for each of the 28 sweet potato varieties. Different values of the training parameters were tried to obtain the minimum error at an acceptable duration. The maximum iteration of 100,000 with a learning rate of 0.8 and a momentum of 0.01 gave a reasonable mean error of 0.00436. Fig. 8 shows the training error convergence curve.

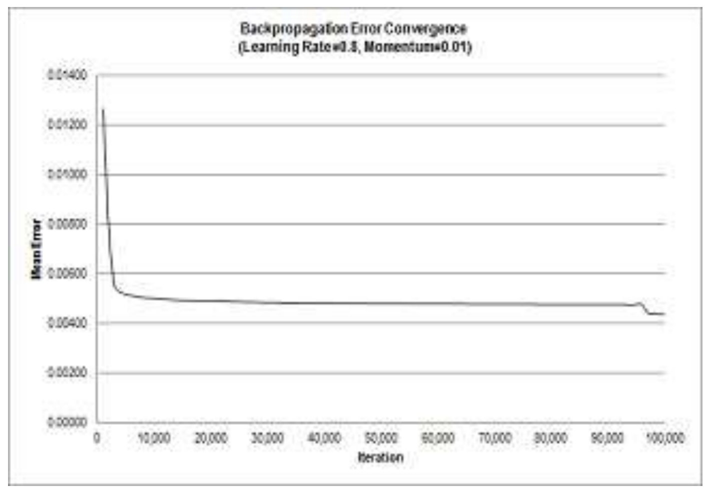

Fig. 8. The learning curve generated during the training of the neural network.

The trained sweet potato recognizer was tested with 56 samples of sweet potato leaves, 2 samples per variety and test resulted to an accuracy of 71.43%. The accuracy is computed using the formula:

$$accuracy = \frac{True\ Positive}{Total\ Samples} \times 100$$

where True Positive = number of samples whose variety is correctly identified.

A minimum error of 0.0001, learning rate of 0.5 and a momentum of 0.3 were the parameters during the training. A total of 34 nodes were used for the hidden layer. Fig. 9 shows the GUI part of the sweet potato variety recognizer with a sample image.

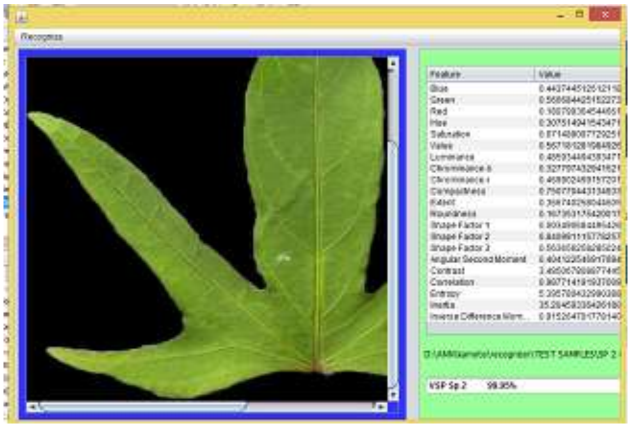

Fig. 9. Screenshot of the sweet potato variety recognizer identifying the variety of the sample leaf image.

V. Conclusion And Recommendations

The proposed system implemented an image analysis technique in extracting leaf features. Otsu method was used for image processing together with the algorithms for color, morphological and shape features extraction derived from Pazoki et al [8]. Backpropagation algorithm served as the learning process of the system.

However, the system generated an accuracy rate of 71.43% in identifying sweet potato variety using the leaves.

Low accuracy of the system can be increased by increasing the maximum iterations of training or increasing the number of nodes in the hidden layer. Accuracy can be also improved by adding more features such as the Zernike Moments for shape classification. Using more training images for each variety may also improve the accuracy of the system.

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