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The Effects of Segmentation Techniques in Digital Image Based Identification of Ethiopian Coffee Variety

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Abstract

This paper presents the effects of segmentation techniques in the identification of Ethiopian coffee variety. In Ethiopia, coffee varieties are classified based on their growing region. The most widely coffee growing regions in Ethiopia are Bale, Harar, Jimma, Limu, Sidamo and Welega. Coffee beans of these regions very in color shape and texture. We investigated various segmentation techniques for efficient coffee beans variety identification system. Images of six different coffee beans varieties in Oromia and Southern Ethiopia were acquired and analyzed. For this study Otsu, Fuzzy-C-Means (FCM) and K-means segmentation techniques are considered. For classification of the varieties of Ethiopian coffee beans back propagation neural network (BPNN) is used. From the experiment 94.54% accuracy is achieved when BPNN is used on FCM segmentation technique.

Keywords*: FCM, K-means, Otsu, BPNN*

1. Introduction

In Ethiopia, coffee production is concentrated in the Oromia and Southern regions of the country. Yirgacheffe, Sidamo, Limu, Bebeka, Harar, Jimma, Bale, Wellega and Illubabor are the major areas of coffee production. In each area has a specific physical and chemical property which attributes to distinct characteristics of the region [1].

The knowledge of computer vision is gradually finding applications in different problem domains such as medical diagnosis, industrial automation, aerial surveillance (biometrics), remote sensing (satellite observation of Earth) and agriculture [2]. There is no particular image segmentation technique method that is appropriate to all image processing applications [3]. Technologies of Computer vision applications require segmentation techniques to extract the representative regions of the image. The objective of efficient image segmentation is independent partitioning of regions that are visually different, meaningful to image characteristics and properties [4]. In depth, image segmentation techniques based on the different factors are presented in this paper.

Otsu Image Segmentation: Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum [5].

Algorithm steps:

a. Compute histogram and probabilities of each intensity level.
b. Set up initial class probability and initial class means.
c. Step through all possible thresholds maximum intensity.
d. Update qi and μi.
e. Compute between class variance.
f. Desired threshold corresponds to the maximum value of between class variance.

FCM image segmentation: In FCM, it is possible for a data sample to belong to multiple clusters at the same time. The similarity is indicated by the membership value. In FCM a data sample is assigned with a membership value based on its similarity with the cluster center. The membership values are between 0 to 1 and more the similarity, higher the membership value. Defuzzification is applied at the end of the clustering process to decide the clustering. FCM is a repetitive algorithm and the solution is achieved by repetitively updating the cluster center and membership value [6].

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K-means image segmentation: K-Means is least-square partitioning methods that divide a collection of objects into K groups. The algorithm iterates over two steps:

a. Compute the mean of each cluster.
b. Compute the distance of each point from each cluster by computing its distance from the corresponding cluster mean. Assign each point to the cluster it is nearest to.

Iterate over the above two steps till the sum of squared within group errors cannot be lowered any more. The initial assignment of points to clusters can be done randomly. In the course of the iterations, the algorithm tries to minimize the sum, over all groups, of the squared within group errors, which are the distances of the points to the respective group means. Convergence is reached when the objective function (i.e., the residual sum-of-squares) cannot be lowered any more [7].

R. Vijaya Kumar Reddy & etal, studied on Edge detection using image processing techniques. In this research paper, several standard segmentation methods have been widely used for edge detection. However, due to inherent quality of images, these methods prove ineffective if they are applied without any preprocessing [8].

Dagnachew Melesew Alemayehu & etal, in their work entitled as “Computer Vision for Ethiopian Agricultural Crop Pest Identification” stated that there is no single technique that is appropriate to all image processing applications. In this paper, the authors tested two segmentation techniques towards to crop pest identification and from the experiment K-means has better results towards crop pest identification[9].

Siva Sangari A & etal, conducted a study on segmentation techniques towards identification of whitefly pests on agricultural plant leaf. In this research the author compared FCM and watershed transformation segmentation techniques. From the experiment the result showed that FCM has better performance than watershed transformation segmentation [10].

On research [11], the authors stated that image segmentation is a challenging process. In this research the authors used region growing segmentation techniques with thresholding segmentation. All the studies showed that Image segmentation is the basic parts in computer vision processing. So this research paper focused on the performance analysis of segmentation techniques towards to classification of Ethiopian coffee varieties based on growing regions.

2. Research Method

To collect the data set, canon EOS 600d camera is used to capture the image. A total of 6 coffee varieties (Bale, Harar, Jimma, Limu, Sidamo and Welega) each having 200 are considered for this study. Once the data set collected, pre-processing and noise filtering steps are performed to achieve the goal of the study through MATLAB, 2014.

Figure 1. Varieties of Ethiopian coffee beans

3. Image Processing System

Image processing and pattern recognition performed by analyzing the image of coffee beans using a computer [12]. The phases of activities for identification of coffee bean varities process were shown in Figure 1. It consists of the following components:

Input image: Load image was the process of retrieving image data stored in any of image format in the same size, which were 512 x 512 pixels. In this paper 80 x80, 100 X100, 300 X300 and 512 X 512 the experiment showed that as the size increased the accuracy also increased.

pre-processing of image, generally used for removing low frequency background noise, normalize the intensity of the individual particles on a given image, removing reflection and masking portion of image. These helps to increase the accuracy in identification of Ethiopian coffee beans [13].

Image segmentation is an important component of image processing technique that determines the accuracy of the system. Image segmentation is defined as the partitioning of an image into none overlapping, constituent regions that are homogenous with respect to some characteristic such as intensity or texture [14]. FCM, K-Means and Otsu segmentation techniques are considered in this paper.

The purpose of feature extraction is to reduce the original data set by measuring properties, or features, that distinguish six varieties coffee bean [15]. In feature extraction stage, the features of coffee beans are extracted to feed into the classifiers.

In this paper, there are three groups of features these are Texture, Color and morphological features. Morphological features are the geometric property of an image that contains shape and size. They are physical dimensional measures that characterize the appearance of an object. For instance, area and perimeter are some of the most commonly measured size features and similarly circularity measures the shape of image compactness [16].

Color is one of the most widely used features for image classification. In an image, each pixel records a numeric value that is often the brightness of the corresponding point in the image. In Ethiopian coffee beans verity identification computed by taking HSV values [17].

$$\mathrm{I} = \frac{1}{3(\mathrm{R+G+B})}$$

$$\mathrm{S} = 1 - \frac{3}{(\mathrm{R+G+B})}[\min(\mathrm{R,G,B})]$$

$$\mathrm{H} = \arccos\{\frac{[(\mathrm{R-G})+(\mathrm{R-B})]/2}{[(\mathrm{R-G})\text{^}2+(\mathrm{R-B})(\mathrm{G-B})]\text{^}1/2}\}$$

The texture based features are calculated using Gray-Level Cooccurrence Matrix (GLCM) from the input. The GLCM calculates the occurrence of a pixel with gray-level value “i” horizontally adjacent to a pixel with the value “j” Every element can be mentioned by (i, j) in GLCM which specifies the number of times that the pixel with a value “j” occurred horizontally adjacent to a pixel with value “j” [18].

Figure 2. Otsu, K-means and FCM segmentation

4. Results and Analysis

The word network in the term 'artificial neural network' refers to the inter–connections between the neurons in the different layers of each system. An example system has three layers. The first layer has input neurons, which send data via synapses to the second layer of neurons, and then via more synapses to the third layer of output neurons. More complex systems will have more layers of neurons with some having increased layers of input neurons and output neurons. The synapses store parameters called "weights" that manipulate the data in the calculations. [19].

The most popular neural network model is the rnultilayer perceptron (MLP), which is an extension of the single layer perceptron proposed by Rosenblatt [16]. Multilayer perceptrons, in general, are feedforward network, having distinct input, output, and hidden layers [20].

In this paper, the neural network needs 21 inputs of the combined feature vectors of morphological, color and texture and 6 neurons in its output layer to identify varieties of Ethiopian coffee beans. The hidden layer has 14 neurons .This number was picked by trial and error methods, if the network has trouble of learning capabilities, and then neurons can be added to this layer. There is a significant change when we increase the number of hidden layers neurons until 14 but there is no change when the number of hidden layer neurons increases above 14. Each value from the input layer is duplicated and sent to all of the hidden nodes. In this experiment, the neural network is tested by sigmoid activation function and TANh function.

The performances of recognition were tested by ANN (Artificial Neural Network using three different techniques of segmentation. In order to train the classifiers, a set of training coffee beans image was given to the model in addition to the class label of coffee beans, 1200 coffee plant diseases image were collected from the regions of Ethiopia From the total of 1200 data sets, 70% were used for model training and 30% were used for performance testing. In this experiment, 15 features (6 texture, 5 color features and 4 morphological features) are considered and these features are used to classify verities of coffee beans. In pattern classification, there are two phases called training and testing. For training the classifier needs input features with their class labels. In this research, ANN (Artificial neural network) is considered for this study. In order to train the classifiers, a set of varieties of coffee beans image was given to the model. In this phase, data is repeatedly presented to the classifier.

In testing phase, the trained is challenged to new data that has never seen during training phase. The training has been done with random picked hidden neurons. In this research 1, 5, 10 and 15 hidden neurons are used. As shown in the experiment, the performance of the Model increases as the hidden neurons increase from 1 up to 15. But after the performance registered with 15, 20 and 25 are similar. Therefore, the authors have used 15 hidden neurons that has been registered maximum performance. In this research, experiments are conducted under three scenarios using FCM, K-means and OTSU segmentation. The result indicated that there was 94.5% using BPNN with tanh activation function. After conducting the above experiments 94.5% success achieved when backpropagation artificial neural network with tanh activation function over FCM segmentation are combined. The aim of the research paper is to identify the effects of segmentation techniques in classification of verities of coffee beans In this paper, BPNN are used and the accuracy of the system are presented, and the results of BPNN with TANH activation function were discussed and promising results were obtained.

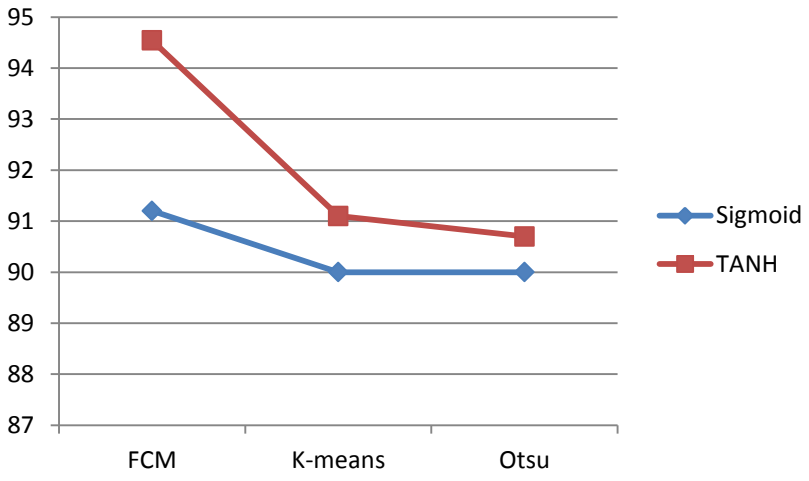

Figure 3. Results of Otsu, K-means and FCM segmentation

5. Conclusion

The aim of this research paper is to analyze the performance of segmentation techniques towards for digital image based identification of Ethiopian coffee variety. In addition,

In this paper, Otsu, K-means and FCM Segmentation are tested and the accuracy of the system are presented, and the results of the combined FCM approaches were discussed and encouraging results were obtained.

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