Classification Of Coffee Bean Degree Of Roast Using Image Processing And Neural Network

Jun Noel C. Sarino, Melvin M. Bayas, Edwin R. Arboleda, Emeline C. Guevarra, Rhowel M. Dellosa

Abstract: The purpose of this study is to classify the degree of roast of a coffee bean by image processing and artificial neural network. Commercially the degree of roast detection of the coffee bean is done by human inspector according to the color and texture of the coffee bean. The coffee bean degree of roast is assessed just by using sight and touch to determine the color and texture of the coffee bean. But the decision making of capabilities of human inspectors is subjected to external influences such as light, fatigue, environment, emotion, etc. Using image processing these factors will be eliminated and secure the accuracy of detecting the roast level of coffee bean. The methodology was developed taking only one coffee variety i.e. Excelsa, coffee origin (Indang, Cavite). The image of roasted Excelsa coffee beans is acquired through the use of a smartphone. Features such as R, G and B components are extracted. We use the method of artificial neural network to classify the coffee beans degree of roasts into a light roast, medium roast, and very dark roast using the RGB values as the input in artificial neural network. The result showed that the proposed method is able to identify the coffee beans degree of roasts with an accuracy of 97.22%.

Index Terms: Coffee bean degree of roast, artificial neural network, RGB values

1. INTRODUCTION

The degree to which coffee beans are roasted is one of the most important factors that determine the taste of the coffee in the cup[1]. Prior to roasting, the softness of green coffee beans is observed, with a “grassy” smell. Roasting resulted in chemical changes with the use of very high temperatures. When the green coffee bean reaches the maximum temperature, they are cooled down to stop the roasting process[2]. Roasting green coffee beans resulted in deduction in weighing, additional of smells and ready to brew[3]. The color of roasted coffee bean is the best way to describe it[4]. Lightly roasted coffee beans have the highest acidity and caffeine. Medium roast is darker brown. Oil from roasted coffee bean may be present in some cases. The color of the roasted coffee bean is the best indicator of its taste, aroma, and acidity[5]. Very dark roasts are flat, bitter, very strong smoky flavor. The roasting of coffee bean should not be very dark in color because it essentially destroys the coffee bean's characteristics. Classifying the coffee beans into its degree of roast is based on inspection of physical quality attributes such as color and texture[6]. The use of bean color to determine when to end the roasting process, however, is not without difficulty. Part of the challenge lies in determining if the color human eye sees is the true color before because of three phenomena, namely the optical properties of the light source (illuminant), what's being examined (coffee bean), and the observer (roast master). These properties together affect the colorfulness, saturation, and hue of coffee beans and any real or perceived changes could lead to inaccuracies in bean color detection and subsequently, the “wrong” coffee for consumers[5].

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Image processing is a rapidly growing area of computer science. The growth of image processing has improved by technological advances as well as affordability and availability. Digital image processing has an expanding area with applications in our daily life[7]. Such technology is also employed to grade agricultural products[8]. In roasting processing, a real-time and analytical tool based on infrared spectroscopy to predict sucrose, and the color was developed. It was supported by with the aid of adaptive-network-based fuzzy inference system to determine and monitor the color throughout the roasting period. The Artificial Neural Network (ANN) has shown suitable for application in the pattern classification context, especially where the limits of classification are not exactly established[9][10]. The neural network has many advantages: Capacity of approximation of any smooth function, Capacity of generalization under situations where the network was not trained, Capacity to learn from examples and robust over errors in training. So it has become an important technique in this field[11][12]. In our research by using image processing technique and artificial neural network coffee bean can be classified into different roasts level based on parameters extracted in the image. So in this paper, an algorithm is presented to measure the parameters such as RGB values of each coffee bean to identify the degree of roast and compare the differences with the model parameters.

2 RESEARCH METHODS

The general framework of the research methodology consisted of 4 steps. The first step was the acquisition using the camera of a smartphone in which image acquisition results will be used as training images and test images. The second step was processing of images consisted of reading and generating images using Matlab. The third step was the extraction of color feature from the coffee beans. The last step was ANN based classification of coffee beans.

2.1 Image Acquisition

A Myphone my36 smartphone with a 13 – megapixel rear camera, Samsung sensor, phase-detection AF was used to record coffee bean images. When images were taken, the camera was placed at a location situated with a plane normal to the object’s path. The white background was used. The environment was controlled to improve the data collection with
simple plain background. Images were captured and stored in JPG format automatically. The size of image is 3120x4160 pixels. The number of pixels is also determined by means of distance which depend on the focal length and distance of coffee beans of the camera.

2.2 Image Processing
Image processing processed the image, in order to capture an enhanced image to become more useful data[13]–[16]. The main objective of this project is to determine or identify the roasting levels of coffee bean based on its color. Images depend on the experimental conditions because there is heterogeneity in the scene (every point of the image receive neither the same quantity nor the same quality of lighting). For image reading, the imread function was used. To generate the image, imshow function was used.

2.3 Color Feature Extraction
Color feature extraction is the basis for identifying the degree of roasting of coffee beans. In getting the RGB (Red, Green, Blue) values, the impixel function was used to select and mark the coffee beans in the image. The gathered RGB values were then placed in Excel. Then in Matlab, “input = []” was used for making the input file. And for the output file, “output = []” was used. For the test file, “test = []” was used. Brackets ([]) were used to make matrix in Matlab. The RGB values and their corresponding output that were gathered and placed in the Excel were placed in the input file and output file respectively for classification.

2.4 ANN Classification
Artificial Neural Network (ANN) is the process of learning to separate samples into different classes by finding common features between samples of known classes. The RGB values in the excel will be used for the input values. The training of input values is necessary for making a logic network that would classify the roasting levels of coffee beans. Output values are the target values represented by numbers. The output of the inputted combination values would tell the level of roasting in the logic network. Random coffee beans were gathered for testing. The impixel function was used again for gathering RGB values of random coffee beans. Testing is necessary to determine the accuracy of the logic network.

3 RESULT AND ANALYSIS
In this study research, Red, Blue, and Green values could extract successfully from the three roast levels of Excelsa coffee bean image. Artificial neural network was used to analyze the three quality parameters. Tests conducted to determine the ability of the artificial neural network in identifying 3 levels of coffee roast beans in Excelsa. The ability of the system to identify the level of roast depends on Feedforward backpropagation training process for generating weight training process that will be used in the testing phase. Feedforward backpropagation parameters used in the training phase can be seen in Table 1.

### Table 1
<table>
<thead>
<tr>
<th>No.</th>
<th>Parameters</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Input Neuron</td>
<td>180 (from feature extraction)</td>
</tr>
<tr>
<td>2</td>
<td>Hidden Neuron</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Output Neuron</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Function Activation</td>
<td>Tan-Sigmoid transfer function</td>
</tr>
<tr>
<td>5</td>
<td>Minimum Error</td>
<td>0.002</td>
</tr>
<tr>
<td>6</td>
<td>Learning Rate</td>
<td>0.91</td>
</tr>
<tr>
<td>7</td>
<td>Epoch</td>
<td>1000</td>
</tr>
</tbody>
</table>

By using the parameters in Table 1, the data testing used 60 coffee bean image training for every coffee bean roast levels in Excelsa. This means that we used a total of 180 for all image training. The accuracy of the data testing result can be seen in Table 2. Table 2 shows the actual amount of output corresponding to the desired output at every roast coffee beans level.

### Table 2
<table>
<thead>
<tr>
<th>Excelsa</th>
<th>Level of roast coffee</th>
<th>Actual number of outputs in accordance with the desired output</th>
<th>Overall Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Light Roast</td>
<td>60</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>Medium Roast</td>
<td>60</td>
<td>95%</td>
</tr>
<tr>
<td>3</td>
<td>Very Dark Roast</td>
<td>60</td>
<td>96.66%</td>
</tr>
</tbody>
</table>
Based on the results in table 2, the overall accuracy can be calculated by adding the appropriate amount of actual output to the desired output of the overall accuracy divided by the total number of coffee beans roast levels.

4 CONCLUSION

In this paper, an intelligent system based on combined image processing and machine learning techniques was developed for classifying the degree of roast of the coffee bean. A highly efficient classifier ANN (Artificial Neural Network) was introduced. Through image processing, the RGB values of the image were extracted and become the input for the classifier. According to results, the ANN classifier had a correct classification of 100%.

REFERENCES


