Android Based Ripening Stage Identification for Peppercorns

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Abstract. India is an agricultural country with over 58% of income is earned through agro-based environment. Out of all, the major crop produced in India is Black pepper. The production of black pepper has played a very important role in enhancing the economic growth of our country. To help in enhancing the production and the export of black pepper from India, this study proposes a method to detect the ripening stages of peppercorns. An android application is developed to predict the maturity and ripeness of the peppercorns. This will help the cultivators to produce peppercorns as per the global market requirement.

The pepper images, representing various stages of maturity are collected from various agricultural resources. These images are trained and classified by extracting, the color features like RGB value. The training and classification is done using Support Vector Machine Algorithm. SVM classifies the images into three classes. The images in these classes are used as the dataset to further identify the maturity or ripen stage of the peppercorns in the input image captured by the android application.

Keywords: Peppercorns · Agriculture · Maturity · Image processing · SVM algorithm

1 Introduction

Black Pepper is one of the most priced spices in the world. It is known to add flavor and taste to any bland food. Black pepper is also extensively used for its medicinal value in curing digestive issues, bronchitis, improving blood circulation etc. Manufacturers are focusing on continuous new product innovations such as essential oils, black pepper spray and fragrances. Recent research shows that there will be a significant impact on growth of the global market for black pepper. In 2017 global black pepper market was approximately valued at more than 3,700 million US$, which is estimated to increase at a CAGR of 6.1% over the forecast period to reach more than 5,700 million US$ by the end of 2024 [1].

In India, Kerala is the largest producer of black pepper. However, the tropical climate in major parts of the India is suitable for the cultivation of this popular spice. According to the department of agriculture, the harvesting time of black and white peppercorn in India, comes in the month of December and January, which does not

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coincide with the harvest period of other major pepper producing countries in Asia [2]. Figure 1 shows the harvesting period of all the major pepper producing countries in Asia. Increasing the production of black pepper during this time would be favourable for the economic growth of our country.

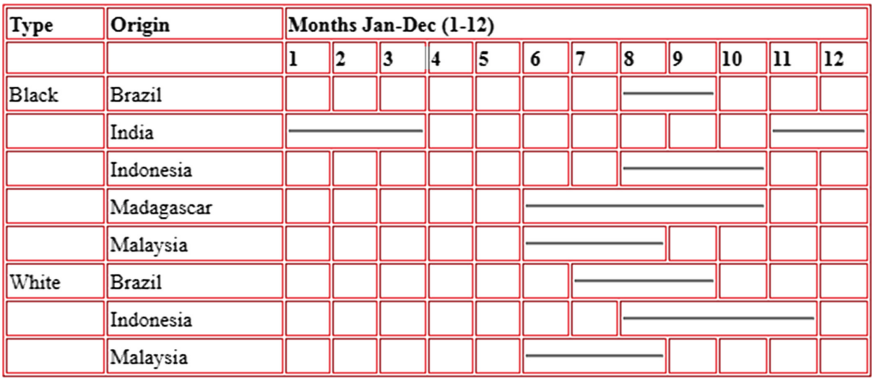

Fig. 1. Harvesting calendar of pepper producing countries in Asia [2].

Peppercorns are the fruits from the plant called Piper Nigrum. There are black, green and white peppercorns, which simply indicate the different ripen stages of the same peppercorn. Harvesting the peppercorns at the right stage of maturity is necessary for producing different kinds of pepper products with good colour, appearance, weight and taste [3]. Table 1 shows the optimum maturity stage needed for different pepper products at maturity. Here the canned peppers are immature, fresh (green) peppercorns [4].

Table 1. Optimum maturity stage needed for pepper products [4]

Product	Stage maturity at harvest
Canned pepper	4–5 months
Dehydrated green pepper	10–15 days before maturity
Oleoresin and essential oil	15–20 days before maturity
Black pepper	Fully mature & 1–2 berries start turning yellow to red in each spike
Pepper powder	Fully mature with maximum starch
White pepper	Fully ripe

There is a need for simple, easy and cost effective technique for identifying the ripening stages of the peppercorns. Smart phones are nowadays widely used for solving real time problems related to agriculture and industries. This paper discusses on developing an android application to identify the maturity stage of the peppercorns and

also predict the time required for the peppercorns to reach the next ripen stage and thereafter fully ripen stage. The system would help the cultivators to predict the time needed for ripening and hence plan a better marketing strategy to increase sales and profit.

2 Literature Survey

Lim and Gopal [5] developed an automated harvest system, based on computer vision to classifying the ripe peppers in a farmhouse. Firstly, a pepper detection algorithm was used to identify the area of interest from the image captured. The area of interest was determined by extracting the features like color, intensity and orientation. This actually gives the exact coordinate position of the pepper in the given image. Next the region containing the red color components were identified, as they are more likely to be the ripe pepper region. Lastly active contour method is applied to the extracted red region for form extraction. This is followed by the testing step to confirm the identification of ripe pepper region. Hence a fully automated harvest system was developed to identify and classify ripe peppers in the farm.

Ji et al. [6] a machine based computer vision system for harvesting apple. Here the images of the apple farm are captured using a color charge coupled device. The basic principle of color charge couple device is to represent the pixel value in the image in the form of an electrical charge. The electrical charge here determines the intensity of the color. However the main point here is to identify the intensity of red color value in the input image. In the meantime the images are processed to remove the noise, image segmentation method is used to identify edges. Once the color and shape feature is extracted from the images, the color quality is thoroughly investigated to identify and classify ripen apple for harvest. An improvised SVM algorithm was used for ripen apple classification.

Rupanagudi et al. [7] introduced an economical method for identifying the maturity stage of tomato. The six stages of tomato ripening process include immature green mature green, breaker, turning, red ripe, and overripe. The image processing algorithms were used to identify these six important stages of ripening. Simulink, integrated with Matlab was used to design model based image detection algorithm for identifying the ripen stage. An overall 98% of accuracy was obtained in successful classification.

Salunkhel et al. [8] used two methods to classify Alphonso mangoes. The two methods are based on the two color models: RGB and HSV respectively. In the RGB model, the classification is done based on the color intensity levels of Red, Green and Blue pixel in the images, while in the HSV model, the Hue, Saturation, Value is used to represent colors, which is quite similar to the way humans perceive color. Both the methods are insensitive to the ambient light quantity, if the images are taken under normal light conditions. Compare to the manual methods, the RGB and HSV method precisely gave 90.4% and 84.2% accuracy.

Dadwal et al. [9] developed a system where basically three steps were used to determine the threshold level for some selected parameters in the images. The steps include histogram equalization, image segmentation, and relative estimation of segmentation based on parameters. The training set was created for determining the

appropriate threshold value. The three steps were applied to any input image, and the parameters were compared with the threshold to detect the maturity of fruits or vegetables in the input image.

Gokul et al. [10] developed a system that utilizes the spherical shape of the sweet lime to detect the fruit and volume of the sweet lime to detect its ripeness. The radius here plays a major role in identifying the sweet lime in the pictures. Radius calculated can be used to determine the maturity level also. Volume is approximately measured based on the RGB color ratio.

Saadl et al. [11] developed a strategy to classify banana into three classes ripe, unripe and overripe depending on the histogram RGB value. Artificial Neural technique was used for effective classification. 32 training sample images were collected for applying the ANN algorithm. 28 images were used in the testing phase. Out of 28, images 25 images were accurately classified.

Kipli et al. [12] developed an application to predict the ripeness of banana. Here sample images representing three different ripen state of banana is sent through Google Cloud Vision Application Programming interface. The Google Cloud platform is used to analyze the attributes of the images. Thus a database is formed. For any input image of banana, the application compares the attributes with the database and the image is thus classified into either of the three states unripe, ready and overripe. Image processing and data mining algorithms are utilized.

3 Methodology

The proposed method identifies the maturity or ripeness stage of the peppercorns using image processing and SVM algorithm. The Fig. 2 shows the steps involved in the proposed system. The method involves two phases. The first phase is called the training phase and the second phase is called the testing phase. The basic steps involved in both the phases are Image Acquisition, Pre-processing, Feature Extraction and Classification using SVM algorithm.

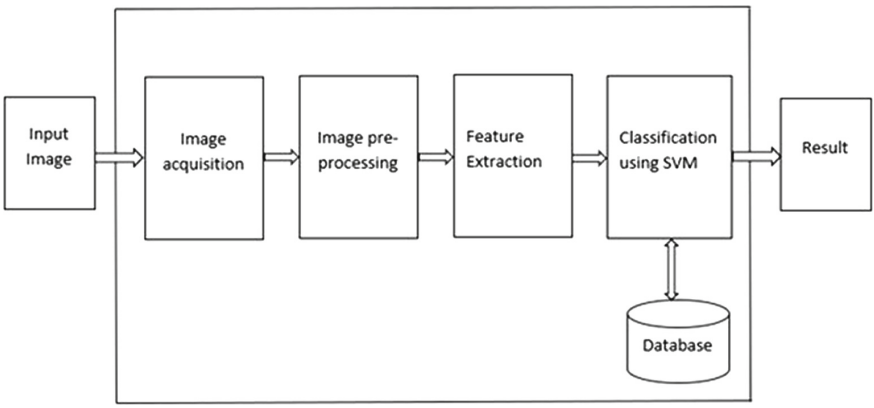

Fig. 2. Proposed system design.

In the training phase, the images representing various stages of maturity or ripeness of peppercorns were collected from authorized agricultural resources [13]. Around 50 images representing 4–5 months maturity stage of peppercorns, 45 images representing 6–7 months maturity stage, and 55 images representing 8 months fully ripe red peppercorns were collected. These datasets were pre-processed using histogram equalization and then the image processing methods were used to extract the RGB features. Based on the average value calculated on these features, the datasets were classified into three classes using SVM algorithm. The three classes here represent the three stages of maturity of the peppercorns. The 4–5 months mature green peppercorns represents class C1, the 6–7 months maturity stage peppercorns represents class C2 and fully ripe red peppercorns represents class C3. The images in these classes form the trained dataset and are stored in the database. These images will be further used in the testing phase to identify the maturity stage of the peppercorns in the input image captured through the Android App developed. The following steps explain the testing phase in details.

A. Image Acquisition and Collection

In this stage the image of black pepper fruit is captured through the camera of the smart phone.

B. Image Pre-processing

In pre-processing, histogram equalization is used as the primary method for noise reduction, cropping and smoothing of the input image. Edge detection and shape detection is carried out as the secondary method for pre-processing.

C. Feature Extraction

In the proposed method, image processing technique is used to extract the RGB value of the pixels in the input images. The Red, Green and Blue value of the pixels in the images determines the color intensity of the given image. The average of the R, G and B component of each pixel in an image is calculated. The Average RGB value is a threshold value or descriptor. The following are the equations for computing the average of the R, G, B component of an image, where I is the image, w - width of image I, h - height of image I, $I(x, y)$ - the pixel of image I at row y, column x, $R(p)$, $tt(p)$, $B(p)$ - the red, green and blue color component of pixel p, r_a, g_a, b_a - the average red, green and blue component of image I_a and (I_a, I_b) - the distance measure between image I_a and I_b.

$$r = \sum_{x=1,y=1}^{x=w,y=h} \frac{R(I(x,y))}{w \times h} \tag{1}$$

$$g = \sum_{x=1,y=1}^{x=w,y=h} \frac{G(I(x,y))}{w \times h} \tag{2}$$

$$b = \sum_{x=1,y=1}^{x=w,y=h} \frac{B(I(x,y))}{w \times h} \tag{3}$$

The equation for distance measure of image I_a and I_b is calculated using the weighted Euclidean distance. The distance between two exact images will be 0 and the distance between two most dissimilar images will be 1 depending on the range of RGB i.e. from 0–255.

$$d(I_a, I_b) \sqrt{\frac{(r_a - r_b)^2 + (g_a - g_b)^2 + (b_a - b_b)^2}{3}} \tag{4}$$

D. Classification

In classification the images are classified using SVM (Support Vector Machine) algorithm. The distance measure calculated is used as the threshold value, to decide the class to which the input test image belongs. Since SVM is the binary classification method as a research it can be applied even for the multiple classes. So here the test images would belong to the class, based on the closest match to the cluster class C1, C2 or C3. The Fig. 3 represents the test image that closely matches to class C1, Fig. 4 represents the test image that closely matches to class C2, Fig. 5 represents the test image that closely matches to class C3.

4 Experimental Results

The android application is developed using Java and by implementing the MVC architecture. The trained datasets are stored in the cloud platform. The Fig. 6 shows the snapshot of the android application. Both, images from the gallery and real time images of peppercorns captured from the smart phone camera were tested and accurately classified. The proposed system provides an accuracy of approximately 80%. Out of ten images tested for classification, eight images were accurately classified into its corresponding class, thereby efficiently identifying the maturity or ripen stage of the peppercorns.

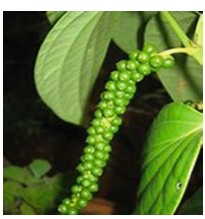

Fig. 3. Class C1

Fig. 4. Class C2

Fig. 5. Class C3

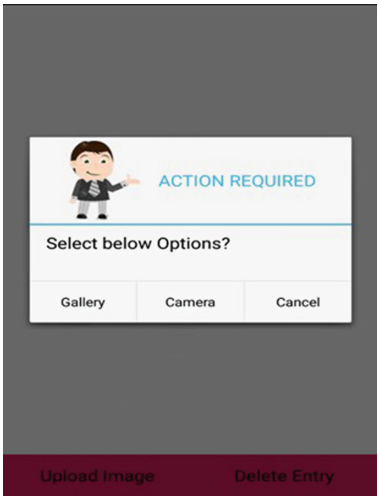

Fig. 6. Snapshot of android application

5 Conclusion and Future Work

The proposed framework will be useful for peppercorns cultivators to efficiently identify the maturity stages of the peppercorns. This is necessary in order to harvest the peppercorns at the right stage of maturity and thereby produces quality pepper products for sale and export. In future work, the system could be developed to predict the time required to reach the next stage of maturity. Also, this method can be applied to predict the maturity of the other fruits.

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