CHAPTER 7

RESULTS AND DISCUSSION

The increased use of digital images in fruit export industries and the requirement of using computers for fast inspection have generated the need to automate the process of defect detection. These experiments were planned in three stages and this chapter presents the results obtained.

Stage 1 : To evaluate the performance of the proposed preprocessing algorithm and to study its effect on defect detection

Stage 2 : To evaluate the performance of the proposed segmentation algorithm and to study its effect on defect detection

Stage 3 : To evaluate the proposed feature extraction and defect detection methods on their ability to identify defects in mango fruit.

7.1. DATASET

In order to study the performance of the proposed algorithms, a mango fruit image database was self-created with mangoes collected from the local markets. The mango fruit images were acquired using digital camera and were stored in JPEG image format. Care was taken to create the database with both defective and defect free or healthy mangoes. All the images were captured in RGB format.

Table 7.1 presents the details regarding the mango dataset. The mangoes were captured in a controlled environment with proper lighting and illumination at six different angles, in order to capture the front, back, top, bottom, left and right surfaces of the mango.

7.2. PERFORMANCE METRICS

Different performance metrics were used to analyze the performance of the algorithms proposed. They are discussed in this section.

7.2.1. Preprocessing

To evaluate the proposed methods, two performance metrics were used. They analyze the algorithm's effectiveness in terms of image quality (Peak Signal to Noise Ratio) and time complexity (Speed of noise removal). The method to calculate these metrics are presented below.

PSNR is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. The PSNR is most commonly used as a measure of quality of reconstruction images. A high PSNR indicates better the quality of denoised image. To compute the PSNR, the block first calculates the mean-squared error using the following equation:

$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M * N} \tag{7.1}$$

In the above equation, *M* and *N* are the number of rows and columns in the input images, respectively. Then the block computes the PSNR for gray scale images using the following equation:

$$PSNR = 10 \log10 \left[\frac{R^2}{MSE} \right] \tag{7.2}$$

For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE, which will be the sum over all squared value differences divided by image size and by three. Typical values for the PSNR in lossy image and video compression are between 30 and 50 dB, where higher is better. The PSNR for color images with color components, R, G and B is given as below:

$$\mathrm{PSNR} = 10\log_{10}\left[\frac{255^2}{\frac{\mathrm{MSE(R)} + \mathrm{MSE(G)} + \mathrm{MSE(B)}}{3}}\right] \quad (7.3)$$

the previous equation, *R* (=255) is the maximum fluctuation in the input image data type.

Denoising time is the execution taken by the filters to perform the operation of impulse noise removal on the noisy image and obtain the reconstructed image. The time is measured in seconds. Generally, the desired behavior is to have increased speed during recognition process.

7.2.2. Segmentation

The second stage of experiments evaluates the proposed segmentation algorithm using three metrics, namely, Stability criterion, anti-noise criterion and segmentation speed.

The stability criterion metric is used to ascertain the stability of the segmented regions while using the two enhanced corner detection algorithms. The formula for calculating the stability criterion is given in Equation (7.4).

$$\eta = \frac{A_1 \cap A_2 \cap \ldots \cap A_n}{\min(|A_1|, |A_2|, \ldots |A_n|)} \mathrm{x}100 \quad (7.4)$$

Here, A_i is the number of corners obtained during n runs and the intersection results with the number of common corners obtained. $|A_i|$ represents the number of elements in A_i set. The greater the η is, the higher is the stability of the corner detection algorithm.

The anti-noise criterion is used to predict the segmentation performance in the presence of noise and is calculated using the Equation (7.5).

$$\eta = \frac{A_1 \cap A_2}{\min(|A_1|, |A_2|)} \mathrm{x}100 \quad (7.5)$$

While calculating the anti-noise criterion, A_1 represents the corners detected by the original image, A_2 represents the corners detected from the noisy image. The higher η denotes that the algorithm has high anti-noise resistance.

Speed is used to determine the time complexity of the proposed segmentation algorithms. It is calculated as the execution speed of the algorithm, from the start of input till the algorithm produces the segmented results, and is calculated in seconds.

7.2.3. Feature Extraction and Defect Detection

The performance of the feature extraction and defect detection algorithms is analyzed in the third stage of experiments. This stage of experiments uses five metrics, namely, sensitivity, specificity, accuracy, error rate and speed.

Sensitivity is defined as proportion of actual positives which are predicted positive (Equation 7.6). In other terms, it is the correct detection of defective fruits.

$$TP / (TP + FN) \qquad (7.6)$$

Specificity is defined as the proportion of actual negative which are negative (Equation 7.7). In other words, it is correct detection of defect free fruits.

$$TN / (TN + FP) \qquad (7.7)$$

Accuracy is the ratio of number of samples correctly prediction to the total number of fruits (Equation 7.8).

$$\text{Accuracy} = (TP + TN) / (TP + TN + FP + FN) \qquad (7.8)$$

Error rate is the ration of number of incorrect prediction to the fruit dataset size (Equation 7.9.

$$\text{Error Rate} = \frac{\text{No. of incorrect prediction}}{\text{Total Number of Images}} \text{x}100 \qquad (7.9)$$

The definitions TP (True Positive), TN (True Negative), FP (False Positive) and FN (False Negative) is according to Table 7.2, which presents the confusion matrix.