Fruit Detection and Grading System

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***Abstract*: Agriculture is one of the largest economic sectors and it plays the major role in economic development of any country. In our country, the ever-increasing population demands high quality of fruits, but in turn there are losses involved in processing the quality of fruits with good appearance. This arises need for the development of accurate, fast and focused quality determination of food and agricultural products like fruits and vegetables. This work aimed to develop an algorithm for detecting and grading fruits. From the acquired image, automated detection and grading system is designed to combine three processes such as feature extraction, detection and grading. For detection of fruit Feature vector is calculated with the help of discrete wavelet transform. These features will be stored in database with name of fruit. With the help of linear kernel base SVM classifier type of fruit detected. Fruits grading and ripening based on the morphological feature, and color feature. Size has been identified using machine vision by measuring area of fruits. Morphological features are extracted from fruit images such as Area, perimeter, Major -Axis Minor -Axis major axis. Classification of the fruit was judged by the area of fruit which is size by using Feed forward neural network and Fruit was classified according Grade-I, Grade-II and Grade III. For ripening Mean values extracted from the color space like RGB and CMYK. Fruit color change on the skin of the fruit was classified according unripe, partially ripe and fully ripe fruit by using KNN classifier.**

***Keywords*: Image processing, computer vision, artificial neural network, K-NN, support vector machine**

1. Introduction

In today's technological era, it is necessary to have a good quality of fruit for good health of human being, and it is possible by grading the fruits according to size, test, or we can say quality of fruit. But for such grading large man power is required. To overcome, this it is necessary to have an automatic fruit grading system for quality fruit production. This work aims to develop an algorithm for detecting and grading fruits. The system used image-processing techniques to classify and grade fruits. Image processing can play a vital part in this automation. Color, size and shape parameters are extracted from the image of the fruits and can be taken as the feature parameters for the grading. For this work Banana and apple fruit images are used .Fruit image was captured by using digital camera. The proposed automated classification and grading system is designed to combine three processes such as feature extraction, detection and grading. The fruits are detected using DWT feature extraction technique using SVM and fruit graded based on size and color. The entire system was designed to examine closely the color and size of the fruit. Banana and apple is graded on the base of size and ripeness is measured by color feature. Different classifiers likes, Feed-forward neural network and KNN is used for the Purpose of classification.

2. Literature Study

G.Kandalkar et al [1] proposed Classification ofAgricultural Pests on pest on various crop such as cotton, pigeon pea, chickpea, etc. Using DWT and Back Propagation Neural network after segmenting the image feature are extracted and accordingly energy is calculated .BPNN is used as pest classifier. V. Chaudhary et al. [2] proposed disease detection of Cotton leaves using image processing based on clustering algorithm implemented for segmentation DWT is used for feature extraction and further reducing those feature using PCA algorithm classification is done by using neural network analysis .They offered 98% of Accuracy in classification on various of learning rate. R. S. Zambre et al [3] proposed Classification and Grading of Wheat Granules. For this work Images are acquired using digital camera. After the image acquisition morphological operation was perform on images, canny edge detection technic used for detection of edge. Classification and Grading of wheat grain is carried out by extracting morphological, color and texture features. These features are fed to SVM and Naive Bayes Classifier for classification. Showed that overall accuracy of SVM and Naive Bayes classifier is 94.45%, 92.60%, respectively. W. Seng et al. [4] proposed method of fruit recognition. Fruit images are analyzed and classified base on various feature such as color shape and size .KNN classifier is used for classification of fruit which gives 90% accuracy of classification. M. Kaur et al [5] proposed the system using image-processing techniques to classify and grade quality of fruits. Fruit images are classified on the basis of shape and color feature. To increase the accuracy of the fruit quality detection they used color, shape, and size based method with combination of artificial neural network (ANN).The proposed technique accurately detects the quality of fruits. The results are good for the three chosen lemon fruits of different color, shape and size. A.M Vyas et al [6] develop an algorithm for the automated grading mangoes. The dataset of the mangoes are collected in Unripe, Semi Ripe and Ripe phases. They are given as the input to the system for processing. From the image of the mango the color and size feature extraction takes place. The length of the major axis accounts for the size feature. Extracted parameters with grading rules, the mango is

classified into grade1, grade2, grade3 or rejected which gives grading accuracy 94.97%.M.Dadwal et al. [7] proposed the system to measure the ripeness level of the fruit. The two techniques had been used for this purpose are color image segmentation and fuzzy logic technique. The system developed is managed to classify fruit in ripe, under ripe and overripe categories. After calculating mean values of primary colors (Red, Green and Blue) of segmented parts it give as input to FIS and gives decision whether this part of fruit is ripe, under ripe, about to ripe, about to overripe or overripe. NurBadariah et al. [8] Proposed automated grading system to classify four types of fruits and a vegetable such as apples, bananas, oranges, mangoes and carrots. The morphological features such as area, major axis, minor axis and perimeter have been used to classify the samples. In this work, support vector machine is used to classify the samples and fuzzy logic to grade the classified samples.

3. Methodology

3.1 System Architecture

In this proposed work Banana and Apple fruit are used for detection and grading .Different Banana and Apple images which are used in this experiment are captured by using digital camera.3level decomposition using discrete wavelet is performed on the input images. Fruit are graded on the basis of size by using morphological feature and ripeness measured by using color. The overall system architecture for fruit detection and grading system is shown in figure 1, and the proposed work flow shown in figure 2

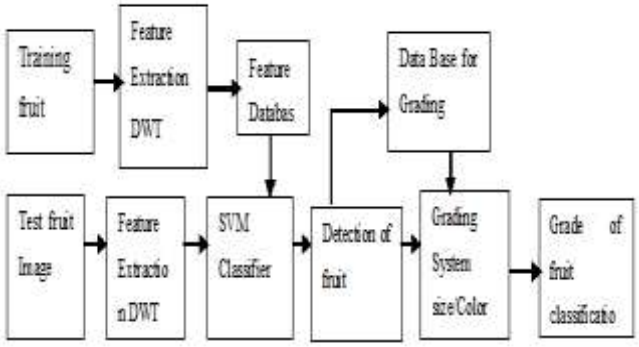

Figure 1: Proposed work flow

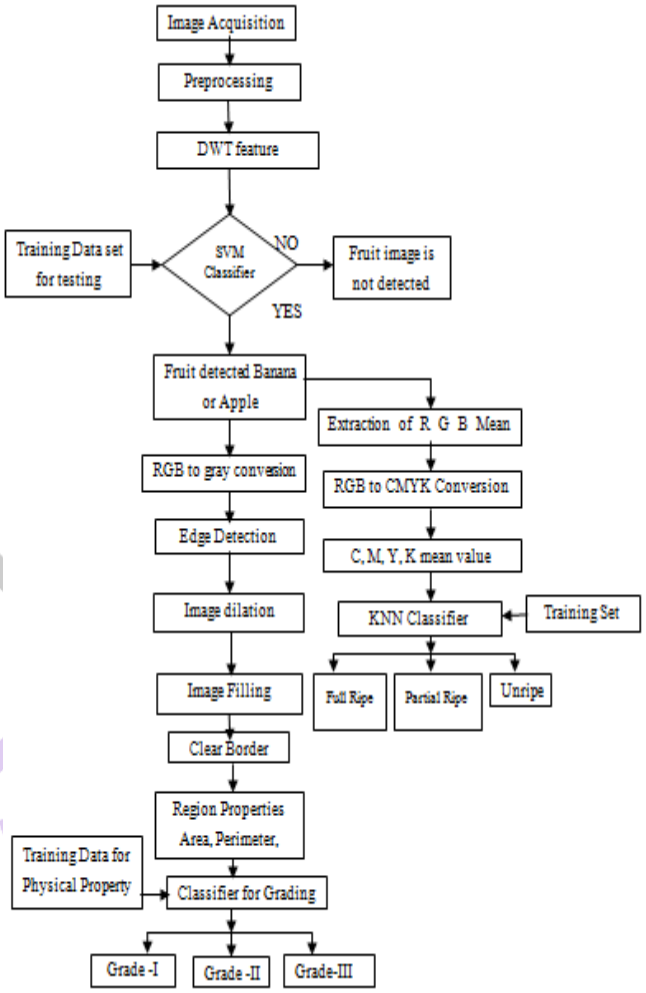

Figure 2: Algorithms

3.2 Fruit detection using DWT

Step1: Image Acquisition

Step 2: Image resizing in same direction

Step 3: 3 level wavelet decomposition with db1 wavelet for feature extraction

Step 4: Detection of fruit using SVM classifier**.**

For fruit detection, first step involves the image acquisition task. After that image is resize in to same dimension. For the feature extraction Single-level discrete 2-D wavelet transform used. We apply 3 level DWT on fruit images decomposes the image into sub-images, 3 details and 1 approximation .The value of these decomposed images (CA, CH, CV, CD)are stored as feature vector in feature library and is further used for detection and classification.

3.2.1 SVM Classifier

Support Vector Machine is supervised learning classifier which is used for classification.

A support vector machine creates a hyper plane or set of hyper planes, which can used for the purpose of classification or other tasks [3]. We have used SVM classifier for classification of Banana an apples. We have considered linear kernal function for the SVM classifier for Automatic detection fruit. SVM classifier was implemented in two steps: training and testing Phase.Feature vector is fed into the SVM classifier initially for training [9] from known samples and for predicting the labels of unknown samples once the training is complete

3.3 Fruit Grading by using Morphological feature

The proposed automated system is designed to overcome the problem of manual techniques .for this work. After the fruit image is detected it can be used to extract different shape, color features. Extracted features are stored in the data base for classification. Grading system based on the features extracted from the image. Therefore, feature extraction plays an important role in developing this grading system. The grading flow as explain below. An Algorithm is developed to extract 4 shape features,

Step 1: Read an RGB image

Step 2: Convert an RGB image into gray scale image

Step 3: Determine the thresholding to differentiate between object and background

Step 4: Convert a gray scale image into binary image.

Step 5: Calculate area, perimeter, and major axis length and Minor axis length.

Step 6: Classification of grading using feed forward neural network

The feature extraction process begins with the conversion of the original image to gray image and then to binary image. The boundary of fruit image is detected before the image features such as area, Perimeter, major-axis length, minor -axis length are determined. The major and minor axis length can represent the actual length and width of a fruit. The fruit area is measured by calculating the actual number of pixels in the fruit image. Perimeteris determined by calculating the distance between each adjoining pair of pixels around the border of the fruit. Extracting the size of the fruit is called grading. After extracting feature are is fed to Feed -forward neural network for classify fruit in to different grade. Fruits are graded in to three categories ie Grade –I, Grade-II and Grade III.

3.3.1 Feed-Forward neural network

For this work Feed –forward neural network. FNN is chosen as the classifier because it is widely used in pattern classification, and it does not need any information about the probability distribution and the a priori probabilities of different class's It is clearly perceived that there are three layers contained in FNN input layer, hidden layer, and output layer connections are present [10]. Training and Testing phase of Feed foreword neural network is shown in Fig.1.3. This model consists of input layer, hidden layer and output layer. In the input layer, (4) size features are calculated. Three hidden layer (50) consist of neurons which generate output. Output layer (3) represents the three different fruits grade that is classified.

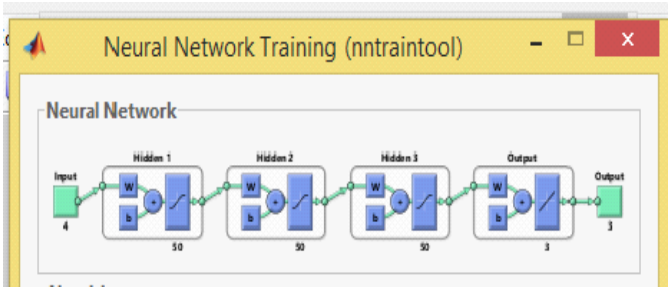

Figure 3: Training and Testing Model

3.4 Fruit ripening by using color feature

Image captured using digital camera is a colored image which consist of RGB (red, green and blue) component. For color feature extraction RGB is converted into CMYK color .For above color space mean calculated and these calculated mean values are used for classification

There are four Steps for the fruit ripeness detection in proposed methodology. These steps are as following.

Start

Step 1: Calculate Mean values RGB image.

Step 2: Convert a RGB image into CMYK

Step3: Calculate mean value for CMYK color space.

Step 4: Classify ripeness of fruit by using KNN

After the fruit detected SVM output is further used for finding ripeness of fruit .First R mean, G mean and B mean value are calculated .For the more feature extraction RGB is converted into CMYK color space after that C mean, M mean, Y mean and K mean value are calculated .Total seven color feature are extracted from fruit images . The fruit is graded into three classes; full ripe, partial ripe, Unripe, Ripe. The extracted color features are fed to the KNN classifier. The Fruit ripening System using the KNN algorithm as a classifier to classify fruit based on mean value.

3.4.1 KNN classifier

K-Nearest Neighbor is the most popular Classification algorithm in area of fruit Recognition and machine learning. Classification based on the proximity of the training samples in the feature space [11] A fruit is classified by majority vote of its neighbors measured by a Euclidean distance, used to find out the shortest distance between the feature values of test fruit Euclidean distance is calculated by using formula given below

$$D_E\,(M\,.S) = \sum_i^k (x_i - y_i)^2$$

Where M= [M1, M2 . . . MN] and S= [S1, S2 . . . SN] are the features vectors. In K-NN input feature vector is classified into class CJ, based on a voting mechanism

The fruit is assigned to a category on the basis of its closest k neighbors. For fruits ripening System, the value chosen for 'K' is '1' fruit is simply assigned to the class of its nearest neighbor. The K-NN classifier compares the features of the test image with the features of the different images already classified and stored in the data base. It calculates the Euclidian distance between the feature values and classifies the test image to one of the classes in the database based on the similarity.

4. Result and Discussion

In this work, we have used three important classifiers SVM, Feed –Forward Neural network and K-NN. Classification is a process of classifying an image based upon the extracted features. Typically, classification approach is implemented in two phases i.e. training phase and testing phase. In the training phase characteristics properties of images belongs to different category is separated into different classes for the generation of training set. In the further testing phase, an image is classified into a class on the basis of training set. This work is tested on self-generated database images of Apple and Banana. Overall 128 images are evaluated out of which 64 images are of Banana and another 64 images are of Apple. For training purpose 32 images of Banana and 32 images of Apple are used and total 128 images are tested.

Fruit detection using DWT

First step of fruit detection is image acquisition after the image acquisition image is resize in to same dimension .later 3lvel wavelet decomposition using db1 wavelet is perform to get various feature value .These features are fed to linear kernel base SVM classifier. SVM classifier was implemented in two steps: training and testing Later accuracy of this algorithm is calculated .The overall result of correctly classified images with accuracy is given table number I

Table 1: The Summery of Corrected Classified Banana and Apple Images

Class	No of image tested	No of image Classify correctly	No of image misclassified	% Accuracy
Banana	64	61	3	95.31
Apple	64	64	0	100
Overall percentage (%)Accuracy of Detection System				97.65

Grading by using Morphological feature

An algorithm for the grading the Banana and Apple was developed. Size were taken as the feature parameters for the grading these fruit into grade1, grade2, grade3.Feature extracted from fruit image such as Area, perimeter, Major Axis, Minor Axis was used for size feature .The grading of fruit is carried out by using Feed- forward neural network .The overall result of correctly classified images with accuracy is given in table number II.

Table 2: The Summery of Corrected Classified Grade of Banana and Apple Image

Fruit	Class	Correctly Classified Samples (Banana)	No of miss classified Sampled	Total Samples	Accuracy (%)
Banana	Grade I	39	1	40	97.5
	Grade II	13	2	15	86.67
	Grade III	8	1	9	88.89
Apple	Grade I	15	3	18	83.33
	Grade II	39	0	39	100
	Grade III	7	0	7	100

Ripening by using color feature

This work was conducted to determine the Ripeness of fruits on the basis of color properties. The grading system successfully detected the fruit class as full ripe, partial Ripe and unripe .The color features are extracted from the mean value of RGB and CMYK components. 7colour features were obtained for each fruit image which are used for classification using KNN classifier with Euclidian distance with k=1 the fruit is simply assigned to the class of its nearest neighbor. The overall result of correctly classified images with accuracy is given in table number III.

Table 3: The Summery of Corrected Ripped Banana and Apple Images

Fruit	Class	Correctly Classified Samples (Banana)	No of miss classified Sampled	Total Samples	Percentage Accuracy (%)
Banana	Full Ripe	38	2	40	95
	Partial Ripe	10	1	11	90.9
	Unripe	12	1	13	92.30
Apple	Full Ripe	14	1	15	93.33
	Partial Ripe	15	9	24	62.5
	Unripe	21	4	25	84

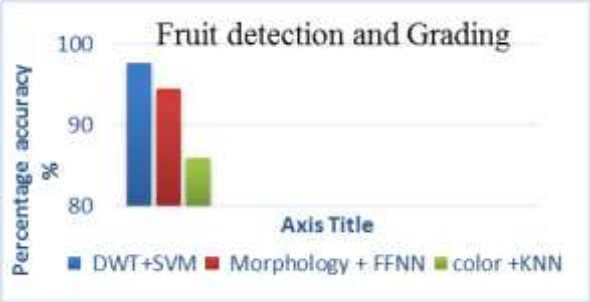

Figure 4: Overall Accuracy Fruit Detection and grading System

5. Conclusion

This work presents technique for Detecting and grading of fruits. This technique begins with capturing the fruits image using regular digital camera. The features are efficiently extracted from the test image. The summarized results of Fruit detection and grading system based on size and color of Banana and Apple which are used in this work are shown in figure 1.4. The graph reveals that the accuracy of Detection of fruit by using SVM classifier is 97.65% and grading according to size by using Feed Forward Neural Network is 94.53% and for color ripening with K-NN classifier gives 85.93 % Accuracy. The performance of SVM is better than other two classifier.

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