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Window Based Method for Automatic Classification of Apple Fruit

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Abstract

This paper introduces a classification system of one variety of apple fruit with nearest neighbor classifier. The system encompasses preprocessing, dividing the image into windows, features collection, window elimination and classification or decision making step. It discriminates stem end / calyx from defected skin which are natural parts of the apple fruit. Statistical features are extracted from each window and then the fruit is classified by supervised nearest neighbor classifier. Stem end and calyx part of the apple is considered as defect in initial processing. After that this class apple features are fed to the classifier to classify whether apple is defected or whether it contains stem end / calyx. The experimental results show that the proposed technique is effective and efficient than the existing technique.

Keywords:Classification, Segmentation, Threshold, Nearest neighbor, Window system

1. INTRODUCTION

Automatic classification of apple fruit is necessary in marketing to increase the speed and minimize the miss-classification. Apple is one of the valuable export quality product. Manual grading of apple fruits is a hard work. To make the work faster and to reduce the human error, it is necessary to grade the fruits by automated process. Many researchers have made considerable efforts in the field of machine vision based classification of apples. Dervrim Unay et al. [6] introduced a threshold based segmentation to detect the defects in apple and grade the apple by machine vision. They applied three threshold techniques like Ostu, Entropy and Isodata within a neighborhood of each pixel for defect segmentation. Then they used different classifiers to classify the
apples. Apple defect detection and quality classification with MLP- neural networks is also done by them [2]. Here texture, color and wavelet features are extracted and principal components analysis is applied to select the features. Performance test were done with single and multi layer perceptrons.
Ismail KAVDIR et al. [5] applied a fuzzy logic to grade the apple fruits.
Moustafa Fattal et al. [22] introduced automatic apple sorting and grading using machine vision. In this paper the intensity plane is converted to binary image and calculated average intensity value, then morphological filling is done to that image to convert all the black pixels to white pixels assuming that black pixels are defects, again average intensity value is calculated. But not all the morphological filled pixels are defects. A.N. Lorestani et al. [1] introduced a fuzzy logic based decision support system for grading of golden delicious apples by the features such as color and size.
In the proposed method we have designed an algorithm to automate the process for grading of one variety of apple fruit, which is fast and efficient.
The paper is organized as follows: section 2 describes image acquisition and database collection, and preprocessing, Which separates foreground and background of the image. Section 3 discusses image division, window elimination, feature extraction and defect detection. Section 4 is about stem end and calyx recognition which are natural parts of the apple. In section 5 nearest neighbor classifier is explained with Euclidean distance. Results are discussed and output images are given in section 6.

2. METHODOLOGY

We propose a novel and more effective method to classify one variety of apples using nearest neighbor classifier. In which Euclidean distance is used to find the distance between features. Our method is based on windows features. The experimental results show that the proposed method is more efficient.

2.1 Image Acquisition And Database

Image acquisition device used for this paper is composed of a high resolution (456 x 391 pixels) digital camera, with 6 mega pixels. It has a focal length of 5.4 -16.2mm. The camera is capable of acquiring only one side-view images of apple fruits. Database contains all possible side views of the fruit. The images are taken with fixed distance. All the apples are of one variety. Then each image sample is resized to 150 x150 pixels.
The database contains 210 sample images of one variety of apple fruit. It includes defected, non-defected and stem end/calyx. The defects are of type fungi attack, bruise, and punch. Stem end/ calyx which are natural parts of apple fruits, are mis-

classified as defects in initial classification later in next classification, the same are classified as non-defect apple

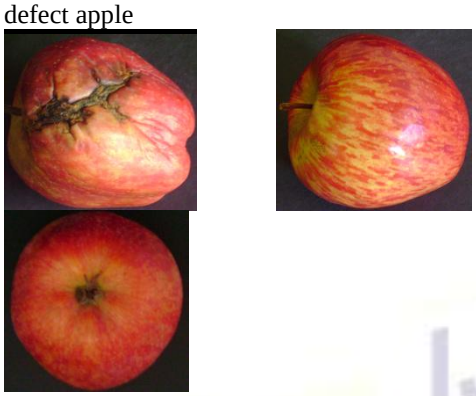
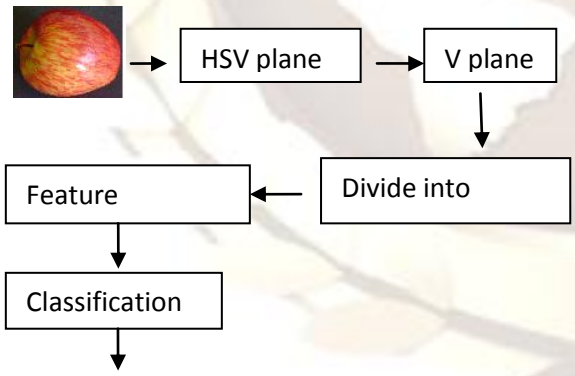


Figure 1 : sample images of fruit. Left to right good apple, defected apple and stem end/ calyx apple.

3. Preprocessing

Preprocessing is a technique in which foreground of the image is separated with its background. Here we have used threshold method to separate apple image from its background. The sample images are taken on a dark, uniform colored black background; the intensity of the background pixels is lower than that of the foreground pixels of the fruit image. Therefore, fruit area can be separated easily from background. For this the original images are converted to HSV (Hue, Saturation and Value) plane images [4] and threshold method is used on the value plane image with a fixed threshold value, which will end up with the foreground background separated image.

4. WINDOW APPROACH



Output (defect or non-defect)

5. 3.1 Window

Statistical features on whole image may give good results for defect and non defect images but it will not give correct classification between for non defect image and stem-end and calyx image. That is why the image is divided into small parts, called windows. It is easy to detect defects as the part of the image is very small, easy to identify the area of the defect, easy for computation.

The foreground and background separated image (threshold image) is converted to HSV plane images. The value plane image of the HSV images is divided into 25, 5x5 non overlapping equal parts. Each part is considered as one window.

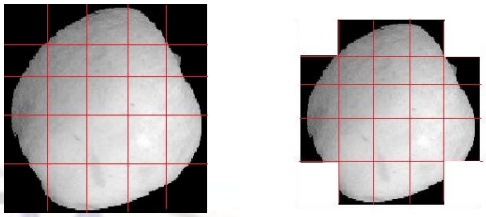


Figure 2: image windows, eliminated windows

6. 3.2 Feature Extraction

On each sub image that is on each window, features are extracted. Each window is processed individually. Statistical features like mean and Standard deviation of the window is calculated separately.

Mean of the window is calculated by,

$$m = \frac{1}{n} \sum_{i=1,j=1}^{n} xij$$

Where m is the mean and x is the gray level

Standard deviation is given by

$$sd = \sqrt{(xij - m)}$$

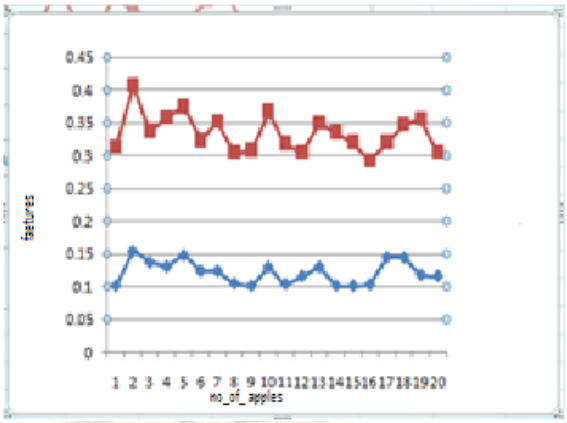


Figure 3: feature graph

7. 3.3 Defect detection

Using some threshold for mean and standard deviation, the window which contains only background and small part of an apple is eliminated (fig 2). The statistical features like Mean and Standard deviation of the remaining windows value will decide whether the apple is defected or non-defected.

Algorithm:

Input: Foreground and background separated image (threshold image).

Output: Classified apple [defected or non defected].

Method:

Convert the threshold image (foreground background separated image) to HSV plane.
Consider only value plane. Divide value image into several equal parts.
Each part is one window. Calculate mean and standard deviation for each window.

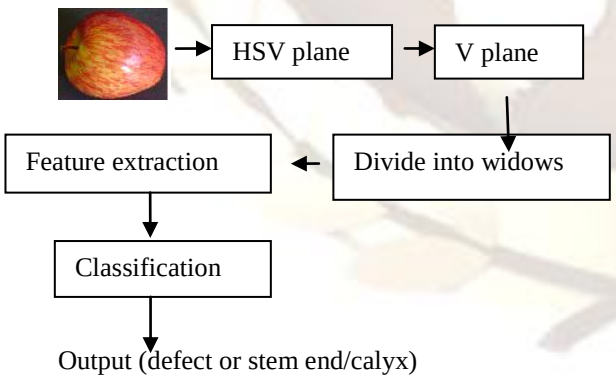
Mean $m = \frac{1}{n}\sum_{i=1,j=1}^{n} xij$

Standard deviation $sd = \sqrt{(xij - m)}$

Fix threshold to eliminate the windows which contains only background.
Arrange remaining windows mean and standard deviation in ascending order. Using first value of the list, classify whether the apple is defected or non defected apple.

8. STEM END /CALYX RECOGNITION

In the initial classification the window which contains stem-end and calyx is mis-classified as defects which are natural parts of the apple fruits. This can lead to error in classifying apples. Later in the next classification these mis-classified images are the input images to the system, with regular defect images. Using supervised nearest neighbor classifier these images are classified as defect images and stem-end and calyx images. The procedure is:
Divide the image into several parts called windows.
Calculate statistical features like mean and standard deviation of each window.
Eliminate background.
Feed these features to NN classifier.
The result is binary classification. That is stem end / calyx or defected.



9. CLASSIFICATION

Nearest neighbor classifier

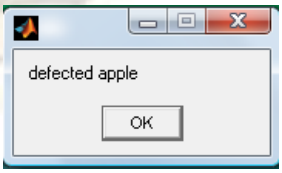
The main goal of a classifier is to assign an object to a predefined class using the given features. NN is one of the most popular classifiers used for classification. Nearest samples are found by Euclidean distance measure. Nearest Neighbor (k-NN) classifier puts a sample to the class that is most represented among nearest neighbors of that sample.

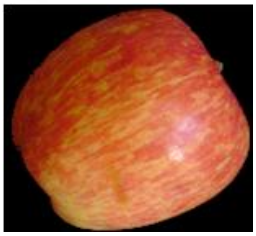
10. RESULTS AND DISCUSSION

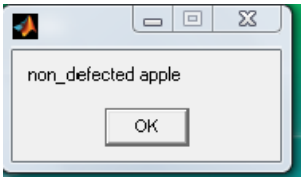
Defect detection of an apple using windows method on value plane image gives the best result. Where as in hue plane image and saturation plane image the contrast between healthy skin and defected skin is very low. Hence we got poorer result or false result with these images. Our visual examination on the results of all images of the database confirm that window based method should be applied on value plane image to get the best output.
Using nearest neighbor (NN) classifier the classification performs around 92% recognition. Total trained apples are 60 (20 defected, 20 stem end / calyx and 20 non- defected) and testing is done with 150 apples.
The method introduced in this paper will be a part of an automated fruit classification system, so computation time is another constraint to be checked in future work. The proposed method is implemented under Matlab 7.2 R2006a environment.

Apple	Train	Test	Correct class	Incorrect class	%
Good	20	70	70	Nil	100
Defected	20	30	29	01	96
Stem/calyx	20	60	48	12	80

11. OUTPUT IMAGES







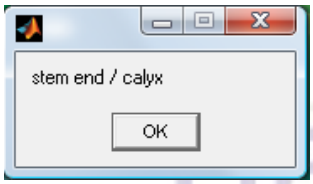


Figure 4 :top to bottom defected apple, good apple and stem end/ calyx apple.

12. CONCLUSION:

In this paper a computer vision based automatic classification system for apple fruit is introduced. The fruit area that is foreground of the image is separated from its background by threshold method, by putting some threshold to the value plane image from HSV plane images. Then the value plane image is divided into several equal parts which are called as windows. The statistical features like mean and standard deviation are calculated. The window which contains only black part that is only background and very small part of foreground is removed from the window list. Then these features are fed to the nearest neighbor (NN) supervised classifier for fruit classification, which is simple but effective in certain tasks. The resultant will be binary classification (defected apple or non-defected apple). The apples which contain stem end / calyx are classified as defects in initial classification. Then these defect class apples are again considered as inputs and procedure is repeated for next classification. These defected apples are again classified as defected apple or stem end / calyx apple which is a natural part of the apple. The experimental results show that the proposed technique is more effective and efficient.

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