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A Review On Various Steps In Apple Fruit Grading

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***Abstract*—**Image processing is used to transform images into digital form and carry out some process on it, and get an improved image or obtain some useful details from it . Image processing has a lot of applications especially in agricultural, food industries, quality control and classification of products. Quality control in apple-based industries and marketing plays an important role in producing high quality products. Traditionally, apple quality inspection is performed by human experts. But the accuracy of them is low. To solve this there are different apple grading techniques and each techniques follow the same steps. Apple graded in three or more quality grades .These grades are AAA, AA and A; A, B, C. This review deals with compare different methods used in each step of apple grading and identify the best methods.

***Keywords*—** Image processing, Apple grading, Digital images.

I. INTRODUCTION

Image processing is used to carry out some process on an image, in order to get a better image. The result of image processing is set of characteristics related to the image. Image processing involves mainly three steps: Firstly, images are imported using optical devices like a scanner or a camera or directly using digital processing. Secondly, analyze the images in some way. This step includes image progress and data summary. At last final result is obtained , The resulting images varied by some way . Image processing normally deals with digital image processing, but optical and analog image processing are also involved and it has various applications in Remote Sensing, Non-destructive Evaluation Forensic Studies, computer vision, classification of food quality products especially in apple grading .

Apple fruit is classified into quality depending on their color, size ,presence of defect and shape. To determine there price apples fruits transported to the packing plant and test their various quality attributes. One of the important elements in pricing of the apple is their external appearance. Surface defects are of great issue to farmers and vendors to grade the apples. The apple defects are because of the various factors. Previously apple grading is done by human but the problem is that it is not accurate. To solve this various apple grading methods are used.

A. Various apple grading methods

1)Computer vision

In 2013 Vilas D. Sadegaonkar, Kiran H. Wagh done a work to grade apple using Computer vision .The computer vision system provide an accurate sorting and grading of apple. Computer vision deals with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. Computer vision uses basic Image Processing algorithms. Accessibility of computer vision infrastructures lead to increase the use of computer vision based sorting in agricultural felids. Most of the fruits are graded by using machine vision. The machine-vision technology is the technology that consist a color camera equipped with an image grab device, a bi-cone roller device controlled by a stepping motor, and a lighting source to grade fruit based on the characteristic such as color, size, shape and defection. In fruit grading system, shape, color and size is used to classify the fruits grade. Color gives necessary information in estimating the maturity and examining the freshness of fruits. Color is one of the most important criteria related to fruit recognition and fruit quality and it is a good indicator for ripeness. In this paper prove that Computer vision provide 95% accuracy in apple grading[1].

2)Near-infrared spectroscopy (NIRS)

Uses the near-infrared region of the electromagnetic spectrum (ranges in between 780 nm -2500 nm) with clear lights and it utilize in apple grading to identify the stem-calyx region of apple. In analytical techniques near infrared spectroscopy (NIRS) has attracted much attention. In 2015 Xiaohong Wu,Bin Wu, Jun Sun, Min Li, and Hui Du introduced a NIR based prediction model. In this study consider the potential of NIRS to identify harvest time points, storage times, and to build up prediction models for individual sugars as well as other quality parameters for “Cripps Pink” and “Braeburn” apples. Both cultivars have a firm fruit flesh with different fruit flesh softening behavior during storage. Moreover, no comprehensive data have been

reported on the chemical combination of the two cultivars as well as on the spectral evaluation of the quality parameters including different harvest time-points and storage periods. One of the drawback in this method is that poor penetration depth[2].

3)Artificial neural networks (ANN)
ANN is a computational model which is based on the structure and functions of biological neural networks. In ANN basically three layers are present : input layer, hidden layer, and output layer.ANN provide better classification of apple fruit.

In 2005 Devrim Unay, Bernard Gosselin proposed a ANN based segmentation of apple fruits. In this An artificial neural network Separate the defected regions on fruit by pixel-wise processing. Statistical features are extracted from the defected regions and then fruit is graded by a supervised classifier Linear discriminant, nearest neighbor, fuzzy nearest neighbor, t and support vector machines classifiers are tested for fruit grading, This proposed system provide 90 % recognition accuracy[3].

4)Hyper spectral imaging
Hyper spectral imaging connect both the digital imaging and spectroscopy. In image each pixel, using a hyper spectral camera manage the light intensity for a big number of closer spectral bands. Each pixel in an image include closer spectrum and which is used to show the objects in the scene.

In 2018 Wenyi Tan1,Laijun Sun, Fei Yang,Wenkai Che, Dandan Ye,Dan Zhang and Borui Zou introduced detection and grading of apple bruises using hyper spectral imaging. In this study, segmented principal component analysis for hyper spectral images in the spectral range of 401 to 1037 nm was carried out, and seven characteristic wavelengths were selected based on the weight coefficients of the principal component images. By using the principal component analysis operations with the selected wavelengths and image processing methods, an accurate recognition algorithm for apple bruises was proposed. For 40 intact samples and 160 bruised samples, the average correct recognition rate was 99.1%. Moreover, this paper obtained the average spectra of 157 segmented bruised regions by applying a binary mask. A characteristic wavelength selection method that combines competitive adaptive reweighted sampling with correlation coefficient methods and supports vector machine modeling methods based on grid parameter optimization was put forward for the classification and identification of the bruising degrees of apples. The results showed that the classification accuracy was as high as 97.5% for the test set[4].

Overall, this study demonstrated that hyper spectral imaging technology can be used to accurately and effectively identify early bruises and determine the bruising degree of apples, it provides a new method for on-line, nondestructive detection, and grading of early bruises in apples.

In all of the above methods used for apple grading , mainly three steps are used . They are : images acquisition , segmentation, and the fruit classification(fig1:). A detailed study of these steps are discussed below.

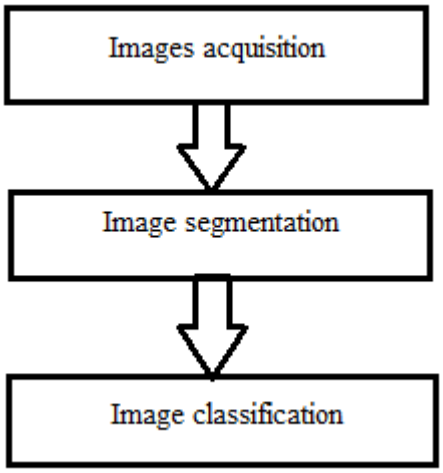

Fig1:Apple grading steps

II. COMPARISON OF VARIOUS METHODS USED IN EACH STEPS OF APPLE FRUIT GRADING

A. Images acquisition
The first step consists of acquiring images from the surface of the apple , while it goes through the grading machine. In order to grade apples, two requirements have to be meet: the images should cover the whole surface of the fruit; a high contrast has to be created between the defects and the healthy tissue, while maintaining a low variability for the healthy tissue.

One method for the image acquisition is using 3 charge coupled devices (CCD)cameras. In this method at the inner side of lighting box Four lighting tubes were placed and three 3CCD camera two inclined at about 60 and one above observed the grading line in the box . The standard image treatments based on the Matrox libraries and the other algorithms were implemented in C++. The fruits placed on rollers are rotating while they are moving. The moving speed in the range zero to fifteen apples per second and it could be adjusted by the stepping motor .The rotational speed of rollers was settled in such a way that a spherical object having a diameter of 80 mm made a rotation in exactly three images(fig2:). Using this method the correct classification rate of apples was of 89%. One drawback of this method is that it could not distinguish different defects types. Defects of apples, such as bruising, scab, fungal growth, and disease, are treated as the same[5].

Another similar system for image acquisition is the fruits placed on rollers are rotating while moving On the common systems for the image acquisition is the apple placed vertically in the stem- calyx direction and then they rotating while moving. Images were acquired using only one CCD camera (Model RGB Sony ,SSC-DC58AP) equipped with 25 mm lens, using the camera with spatial resolution (10241024 pixels, 256 grey levels) and high sensitivity .Here the diffuse light from two halogen lamps ,and computer with MultiScan program image analysis were used. The camera mounted 400 mm to the side of the sample. Eight images of each apple taken. The captured Images were digitized using a frame grabber, and it displayed on the monitor(fig3:).In this system different threshold segmentation methods were used . 96% was the average classification accuracy of this method[6].

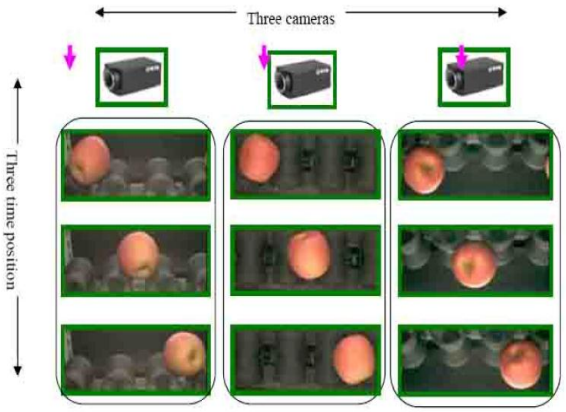

Fig2:Three camera placed at three positions

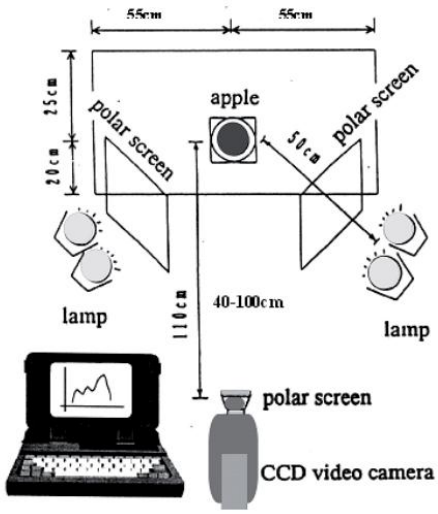

Fig 3:Machine vision

In Another system the fruit rolling on rubber bicones, and the image is captured by using a 12S-200 solid-state camera. This camera is prepare with a Thomson-CSF silicon chip with a 208 x 144 rectangular matrix of pixels. The software for processing is CYCLOPE, it require a particular interface board between the camera and a BFM 186, a 16-bit color microcomputer equipped with an 8086 processor and an 8 MHz clock. In this method take four images per fruit. The average fruit with a diameter of 75 mm rotated 90% between two images, in the direction of travel because of the rotation system was adjusted .this method shows that the 69% of the fruit were correctly graded[7].

B. Image segmentation

The images resulting from the previous step is the input to this step . This step is the separation of the defects from the healthy tissue. It is also necessary to distinguish the calyx and stem ends.

One method is by using An artificial neural network segments the defected regions on fruit by pixel-wise processing. Here using artificial neural network for the segmentation is two layer back-propagated network of perceptron neurons (BPNN) . It has thirteen neurons in the input layer and two neurons in the output layers. Different number of hidden neurons are tested, but there segmentation performance found to be independent(fig4:). Using this the apple image segmentation are found to be quite successful. One drawback of this method is that the stem/calyx region of the apple treat us defect[8].

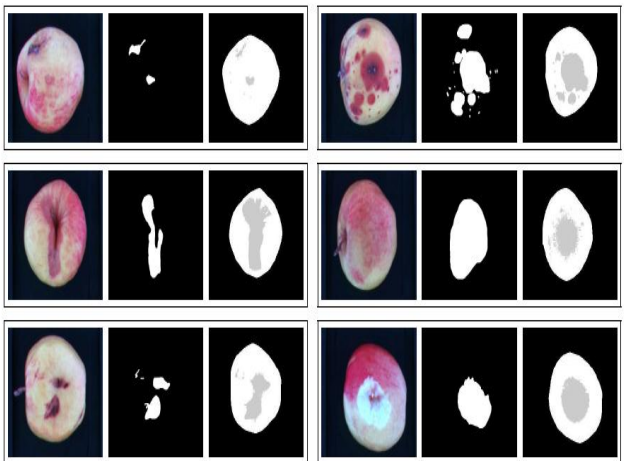

Fig4: Results of segmentation by artificial neural network.

A system that solve the stem/calyx recognition problem by using apple shape descriptors. The major steps in this system is segmentation of apple using grow cut method ,the stem/calyx region and small defects are detected using Random descriptor and Multifractal Fourier, finally supervised classification algorithms such as Support Vector Machine (SVM) is used to recognize and differentiated true defects from stem/calyx regions. This system provides 90% accuracy[9].

In Another method to identify stem/calyx region using visual inspection .In this the apples were illuminated by blue linear light sources and a standard color video camera was employed to detect the reflection patterns. Blue lights were employed because they outside the spectrum of interest for blemish detection. This enables the technique to be used simultaneously with blemish detection. The reflection patterns were in the form of light stripes, with a shape dependent on the shape and orientation of each apple. Analysis of these patterns made it possible to identify the location of stem and calyx regions, But this technique can only approximately identify the region where the stem/calyx lies[10] .

C. Image classification

It is the third step in apple grading the segmented apple image is the input of this step and apples were classified based on their surface quality conditions .

One system that use k-mean clustering for the image classification. The first step is apple image captures by using CCD cameras during the motion of fruit. These images were then segmented and the features of the defects were extracted. Then using the k-mean clustering the objects were classified into clusters. The classification probabilities of the objects were summarized and on this basis the fruits were graded . The fruits were correctly classified with a rate of 73 %[11].

Another method is classification of apple quality was simulated by tree-based modeling using objective measurements of the external properties. In tree-based modeling generates decision trees as a succession of binary decision rules. A binary rule is calculated at each node of tree using single objective measured variable .Then the classified group split into smaller parts. 10 trees were iteratively calculated and cross-validated by CART(classification and regression tree) in order to get an averaged model. In each tree 10% data chosen us a test set remaining used to calculate tree. Result of the classification used us training set. It measure the inconsistency of the human quality classification by comparison done with table that contain apples that already classified by human experts and the classification done using tree-based modeling[12].

Apple classification is done with Artificial Neural Networks and Statistical classifiers based on the Textural Features. Apples were classified based on their surface quality conditions using back propagation neural networks (BPNN) and statistical classifiers such as decision tree (DT), K nearest neighbour(K-NN) and Bayesian with textural features obtain using all the pixels in an entire apple image. Mainly two classification is done: one is into apple group and good apple group. Other is 5 subsets they are defective (leaf roller, bruise and puncture on Empire, and bruise bitter pit and russet on Golden Delicious) and good apple groups (good tissue and stem/calyx views).With two subsets, classification accuracy using textural features ranged between 72-2 and 100% for Empire apples while it ranged between 76-5 and 100% for Golden Delicious apples. Results obtained using histogram features were significantly lower than the other classification applications. With five subsets, slightly lower recognition accuracies were obtained; the BPNN using textural features performed 93-8% success rate in recognizing Empire apples. However, for Golden Delicious apples, all the classifiers produced similar accuracy rates ranging between 85-9 and 89-7%. Results obtained from the BPNN using histogram features were significantly lower than the classification applications using textural features[13].

III. CONCLUSION

This paper reviewed various methods used in each step of apple fruit grading. Different computer vision and image processing methods are used in apple fruit grading .Most of the work in apple fruit grading is done by following three main steps (1) image acquisition,(2)Image segmentation,(3)Image classification. Each technique have its own advantages and limitations . In image acquisition using the CCD camera is the best method. In image segmentation using pixel-wise processing is best one. Using BPPN classification is best for image classification. There are a lot of existing methods available for stem/calyx detection ,but most of this methods are not efficient so there is a need for further research in this area.

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