Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 3, Issue. 7, July 2014, pg.615 – 621

REVIEW ARTICLE

A Review on Fruit Grading Systems for Quality Inspection

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Abstract: India produces 44.04 million tons of fruit annually. A tremendous scope thus arises for grading the fruits for quality inspection tests from dispatch from farm to the consumer. Fruits must be graded for quality aspects like size, volume and hydration contents. A number of sensors primarily based on the optical characteristics at near Infra Red levels are used along with spectroscopic methods for grading the fruits. Fruits kept in piles and stock houses need more sophisticated robotic manipulators for in-house inspection. The readings obtained from the sensors or the inline cameras are feed for image processing methods and algorithms for grading. A few to name them are classifiers like neural network and fuzzy based classifiers.This review deals with the methods and practices used for the grading of the fruits.

Keywords- Imaging spectroscopy, Fruit grading, Fuzzy Inference system, Neural Networks

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Introduction

Fruits and vegetables, which are essential commodities in today'sworld, must be checked for the ripeness, firmness, texture and size. Different fruits or vegetables when shipped across one place to another must be checked for quality controls. The manual method of handpicking the best fruit or vegetables among the stock is a time consuming process.

Imaging spectroscopy [1] was used to determine the water concentration in a berry fruit type called as "Murtilla"to check for the level of dehydration. The basic principle of such a spectroscopy is based on the interaction of light with the material due to the atom or molecular composition of the material under interaction. A light wavelength of 1450 mm was used. The basic principle work involved the detection of humidity of a sample using absorption of bad component of H_2O. The overtone appearance of the light suggests the ample presence of H_2O molecules in the fruit. Homogeneity index was found, where a lower homogeneity index suggests that ununiformed hydration is present. The read out reflected radiation was found to be more for the microwave dried type of Murtilla fruit. For wavelength range of input between 1437 mm to 1458 mm it was found that the homogeneity index was 0.048.

Another method based on the non destructive quality inspection of fruits based on multispectral imaging [2] was done and it was found that the multispectral images had the highest recognition rate when spectral bands of multi spectral fusion images are red spectral band, blue spectral band and green spectral band. The accuracy of the fruit quality inspection achieved in experimental case was found to be 90.25%.

Orchard fruit was segmented using a multi class segmentation approach using unsupervised feature learning to automatically capture more relevant features from our data. Global accuracy achieved was 88%. A fisher linear discriminant analysis [4] was performed as a part of machine vision to implement pick and place operation on the ripened fruits. In this method the component of the visible image is selected and as the dominating component based on the spectral contrast between ripened colored citrus fruit from the background. The classification using the above method gave better classification results on sampling image data with small errors.

Various Methodologies for fruits quality

An algorithm similar to the Forgys algorithm [5] based on the data input to the algorithm and forming k group of clusters .The process was further followed by the k clusters means for one of the first k samples. For remaining samples the nearest centroid is identified. The ROI regions are selected for checking the fruit quality.

Fig 1: Effected mango fruits affected by anthracnose.

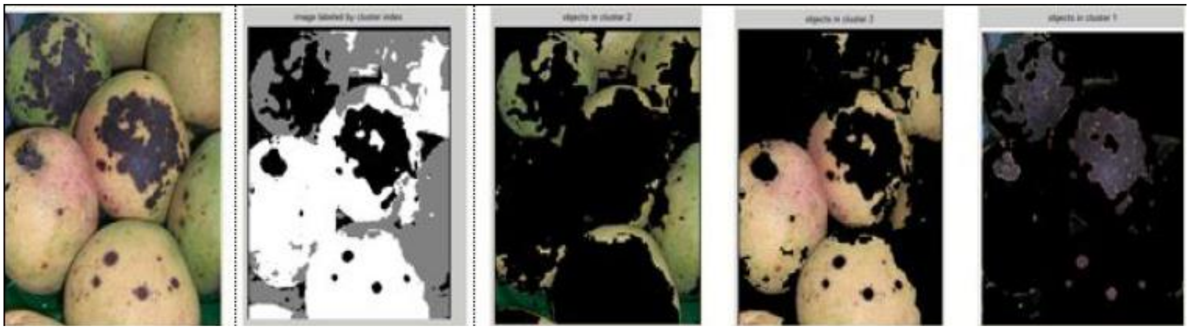


Fig 2. The image shows the less severe infection in mango. The process shows the area affected with anthracnose obtained after the Forgys algorithm.

Another method based on the CMOS based camera [6] and fruits on a conveyor belt for faster classification of the fruits was proposed using the ARM 7 microcontroller. The basic steps involved were Edge detection, Fruit size detection, Size grading and output.

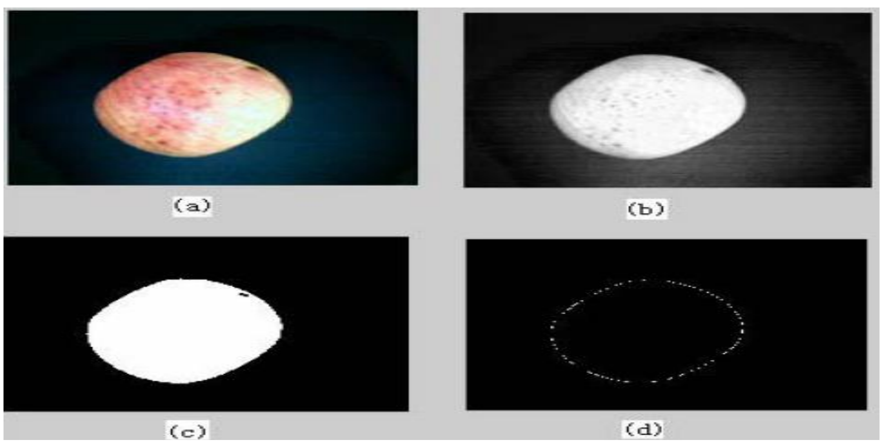


Fig 3: Processing the fruit image (a) original image, (b) gray scale image (c) diversion image (d) tracking edge

For detecting the fruit size, it was assumed that the fruits have symmetry and an axis separates them.

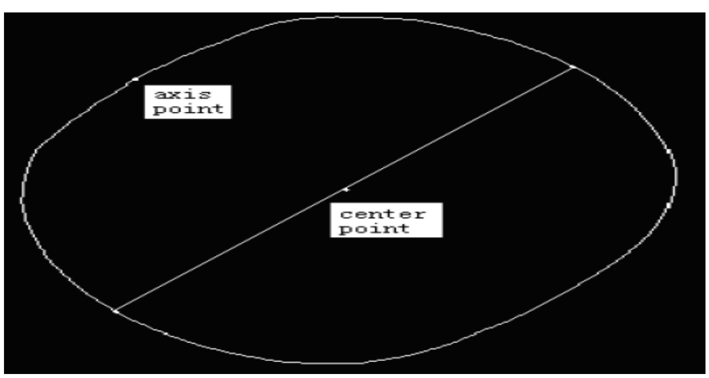


Fig 4: Detection of fruit axis point and centre point of location.

The algorithm was able to classify the fruit images based on two categories of the sizes.

(i) Big >= 60 mm diameter

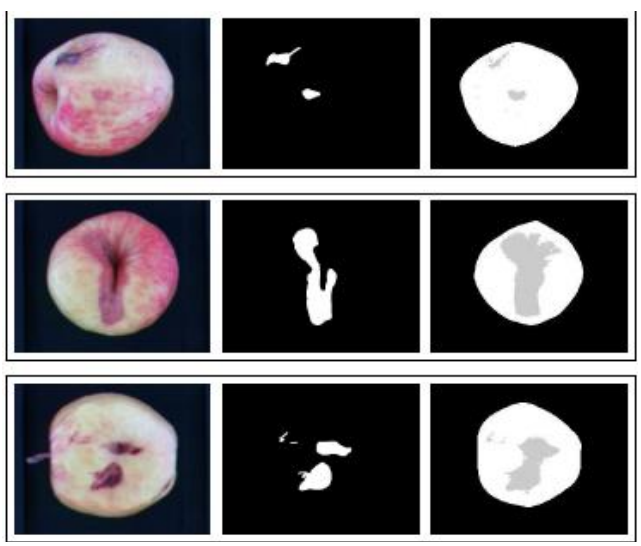
(ii) Small <= 50 mm diameter

The inner contents of the fruit could also be analyzed for exotic class fruits using x rays [7]. In exotic fruits like peach the split ends of the peach could be detected using transmission images in real time to evaluate the water content distribution and internal structure of fruit.

Fruits side view was captured and grading was realized using embedded grading system with lower costs [8]. Also the system had advanced high speed and minimal costs.

Significant works were done by Saudi Researchers on categorizing the date fruits for the quality. During the harvesting season of the dates it becomes impervious to categorize them for quality and separate them out of 400 varieties available. A back propagation neural network based classifier was applied in [9] for the grading of the dates. The system was trained on 1200 (400 samples / grade). The system shows the test results can sort the dates in varieties with 80% accuracy. Barberry product quality estimation was done using the fuzzy system in [10]. The different quality of test data was collected and image was enhanced using the split blocks and converted to a KxK format. Average rate of making was thus calculated for each block and final quality of the fruit was determined. Mamdani Fuzzy inference system was discussed in [11] and was applied for the decision making to classify the Mozafati dates based on the quality. Grading results showed 91% general conformity with experimental results. Similar Grading system was implemented in [12] by using the Near Infra Red Imaging Technique.

To grade a large number of fruit objects on a conveyor system a high speed camera was used and inspection path was formed for the image analysis [13]. A high speed camera was used for a fast conveyor belt system in [14]. The camera took images at 900 fps in bi angle views for inspecting the lateral side images for fruit grading system. In another high speed grading method using the high speed camera the statistical features [15] were extracted from the defected regions of the apple and it was graded using a supervised classifier. The experiment showed 90 % recognition rate in grading the fruits. For the similar system Fuzzy based classifier showed 87% recognition rate.



(a) (b) (c)

Fig: 5 (a) Input apple images with skin color perforation, central split and flesh bruise. (b) Manual segmentation result of the three image (c) Extracted region of damage.

Fast testing to increase the speed of the recognition was performed on pear fruit using a transport unit, control module, image acquisition mode, image processing mode and recognition module. The system was based on the automatic feature extraction. The features captured were color, features and defect. A dynamic thresholding method based on V component dynamic threshold [16] is put forward. The dynamic recognition rate for 630 tests was found to be 90.3%. In yet another method the fruits were graded based on the characteristics matrix of shape of the object from the centroid [17]. The fruits with misallocated centroid along the designated axis were graded separated.

Similar principle was used by the fruit graders in eye lens headsets wear on the head, which could detect the bad fruit quality. A wearable mobile sensor platform to assist fruit grading was experimented in [18]. The novel method was flexible and reconfigurable instrumentation method in it in the form of a glove which was used for the analysis and measurement of attributes.

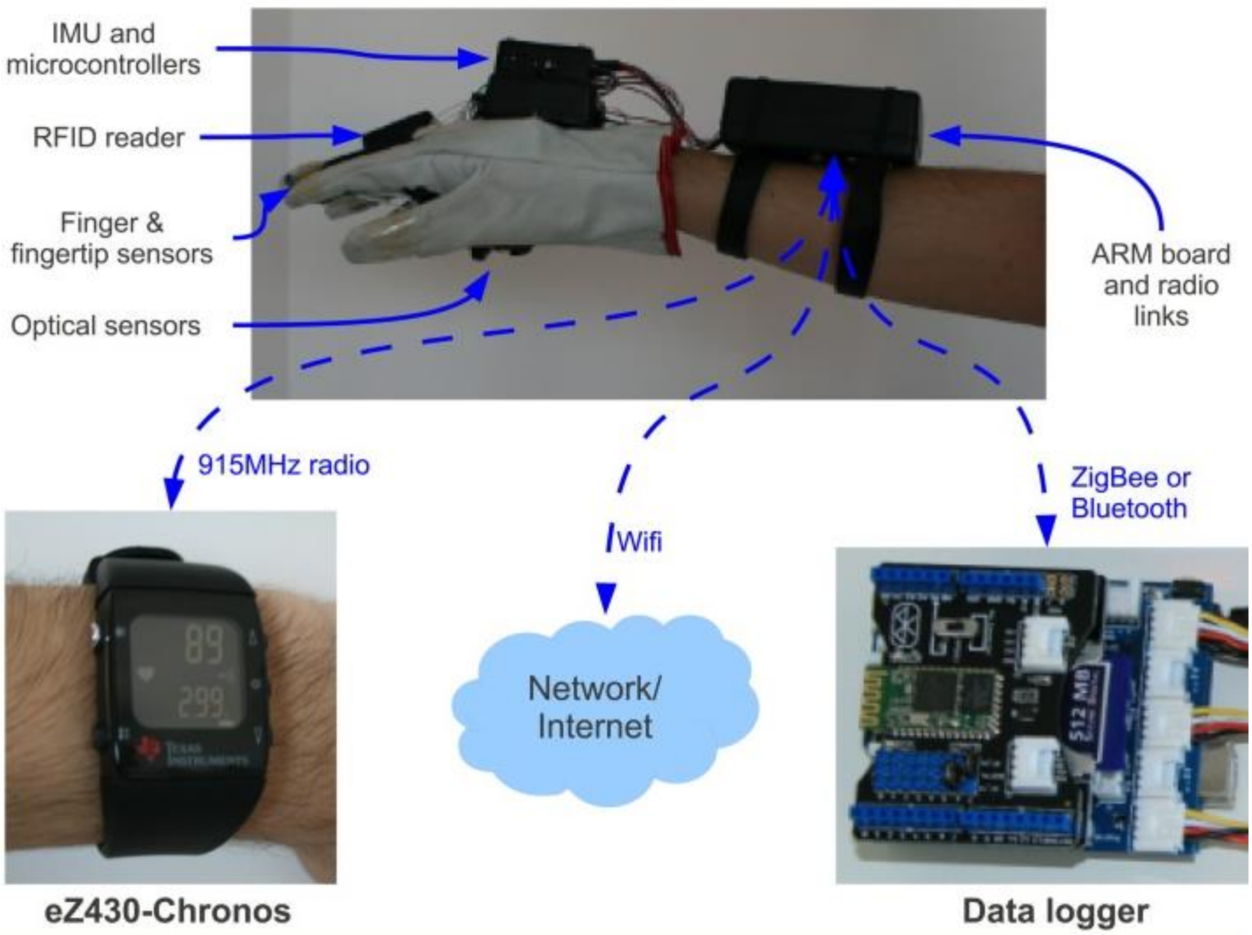


Fig 6: Hand held fruit grading system with fingertip sensors, optical sensors and RFID reader for the grading of the fruits.

The system had IMU and microcontroller, RFID reader , finger and finger trip sensors , optical sensors and a Zigbee based data logger connected to an internet connection for sending data. Volume measurement was done using a Fast fuzzy segmentation algorithm to extract the fruits image from the rest of the scene. After segmentation the system calulates the number of pixels covered over the segmented region to calculate the area of the fruit followed by the height estimation for the volume estimation

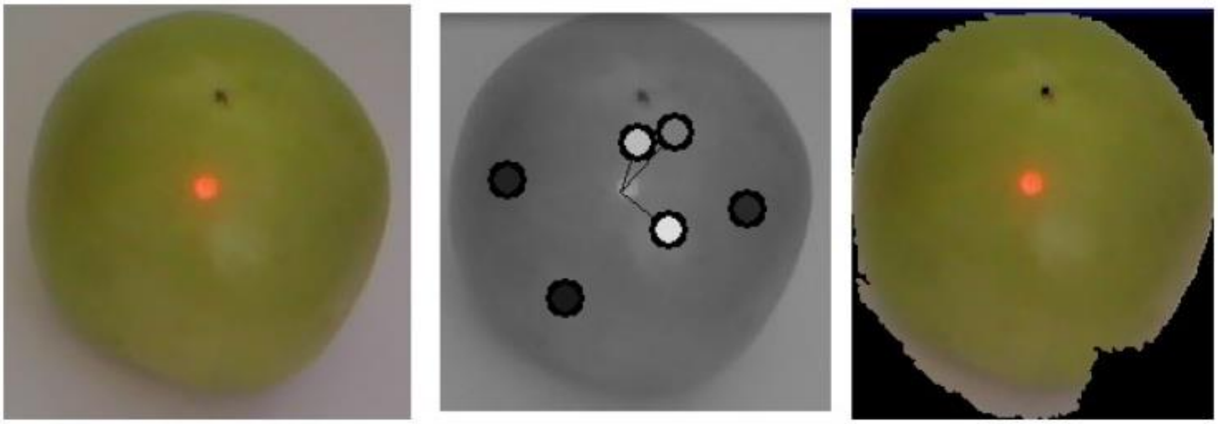


Fig 7: The tomato seeds detected by the hand held unit and the resulting segmentation results.

The above figure shows the detected seed components obtained from the optical detector. The deeper tissues of fruits and vegetables were studied using the Time resolved reflactance spectroscopy[19] for non invasive tissue inspection. Development of movable robots was done in [20] for grading the fruits in pile. A tray based sorting was done by the robot where each fruits 4 images were taken by rotating the suction pads for 270 degrees. The manipulator had length of 1.2m and took about 4.3 seconds to move back and forth and three seconds to grade the fruit.

Conclusion

Methods and methodologies of the fruit grading system are studied. The fruit grading system based on the spectroscopy and narrow beams showed the inner seeds. The non invasive techniques discussed are capable of studying the tissues of the inner skin of the fruits like tomato. The parameters like hydration and volume can be measured by using the biaxial cameras. Classification methods like fuzzy and neural network based classifiers proved better in segmenting and quality determination. To keep an online record of the fruits graded the internet and zigbee interface could be provided. The method could be made faster and accurate by using the IR sensors in triple axis directions and applying classifiers on multiple numbers of fruits at once.

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