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ARM Based Fruit Grading and Management System Using Image Processing

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Abstract —traditionally, classification and grading is performed based on observations and through experience. This paper presents an integrating system for grading by considering different attributes. A fruit color, size detecting, and grading system based on image processing. Weight of fruit is used as a design metric to find out grading in food processing. For grading using color and size after capturing the fruit side view image, some fruit characters is extracted by using detecting algorithms. According to these characters, grading is realized. And for grading using weight as a parameter the load cell arrangement can be used. Also by using GSM module the consumer or head office can get the idea about the grading process easily. Results show that this embedded system has the advantage of high accuracy of grading, high speed and low cost. This proposed system will have a good prospect of application in fruit quality detecting and grading areas.

Keywords: Grading; Sorting; Image Processing; ARM Embedded system; GSM module.

I. Introduction

Agriculture sector plays an important role in economic development of India. As compared with development in electronic and automobile sector, development in agriculture sector is very slow. Hence, there is need to come up with some novel techniques so as to fore front the agriculture sector again. As fruits plays vital role in day to day life, grading of fruits is necessary in evaluating agricultural produce, meeting quality standards and increasing market value. It is also helpful in planning, packaging. If the classification and grading is done through manual techniques, the process will be too slow and sometimes it will be error prone.

Fruit quality attributes such as size, freedom from defects, color, and firmness, can be measured by a number of different methods. The absolute reference point is the way a consumer perceives and interprets the quality of fruit. Fruits are delicate materials, so they should be tested via non-destructive techniques. Classification is vital for the evaluation of agricultural produce. Fruit size is the most important physical property while color resembles visual property.

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The labors classify based on color, size, weight etc. if these quality measures are mapped into automated system by using suitable programming language then the work will be faster and error free.

Here two choices are provided for grading either by color and size or by weight. In first case we are going to sort circular shaped fruits according color and grading is done according to size. The proposed automated classification and grading system is designed to combine three processes such as feature extraction, sorting according to color and grading according to size. Software development is highly important in this color classification system and for finding size of a fruit. The entire system is designed over Matlab software to inspect the color and size of the fruit. Here grading can be categories into four ways Red small, Red big, Green small, Green big. Similarly here we can grade fruits according to weight also by considering some reference point for weight measurement, and accordingly it can be graded as a small or big weight fruit. For the same purpose load cell arrangement is required. Here grading can be categories into two ways small weight, big weight fruit by considering one reference point for weight measurement.

Work in this paper considered two different fruits apple or tomato and guava having different features like apple or tomato is red and guava is green and system can sort and grade the fruits according to different attributes such as color and size or weight.

This paper is organized as follows. Section I gives the introduction. Section II reviews some previous work of food processing. Section III introduces the hardware system used for food grading. Section IV gives results of proposed system. Section V concludes this paper.

II. Literature Survey

Hongshe Dang, Jinguo Song, Qin Guo [1] have proposed fruit size detecting and grading system based on image processing. The system takes ARM9 as main processor and develops the fruits size detecting program using image processing algorithms on the QT/Embedded platform. Authors in [2] have proposed system which finds size of different fruits and accordingly different fruits can be sorted using fuzzy logic, here author proposed matlab for the features extraction and for making GUI.

John B. Njoroge. Kazunori Ninomiya. Naoshi Kondo and Hideki Toita [3] have developed an automated grading system using image processing where the focus is on the fruit's internal and external defects. The system consists of six CCD cameras. Two cameras are mounted on the top, two on the right and another two cameras mounted on the left of the fruit. X-ray imaging is used for inspecting the biological defects. Image processing is used to analyze the fruit's features; size, color, shape and the grade is determined based on the features. The developed system is built from a combination of advanced designs, expert fabrications and automatic mechanical control.

J. V. Frances, J. Calpe, E. Soria, M. Martinez, A. Rosado, A.J. Serrano, J. Calleja, M. Diaz [4] presented a procedure to improve the performance, whether increasing speed or accuracy, of the load-cell-based weighting subsystem in a fruit sorting and grading machine to achieve an accuracy of ± l gram.

Wong Bing Yit, Nur Badariah Ahmad Mustafa, Zaipatimah Ali, Syed Khaleel Ahmed, Zainul Abidin Md Sharrif [5] proposed new MMS-based system design and developed with signal processing for fruit grading for consumers. The prototype network architecture, integration of wireless messaging system with signal processing between mobile consumers for development purposes was studied, proposed and designed.

Here in all above work the grading is done by considering each attributes separately. This paper suggest an integrating system which provides different options for grading fruits i.e. either according to color and size or weight and finally by using GSM module system can send message automatically to consumer or to head office to know about the grading process progress.

III. System Overview

This automated system is designed to overcome the problems of manual techniques. Here the hardware model is designed which contains conveyor system, grading assembly which contains three plates in which one main plate and two lower plates to which dc motor is connected for moving in clockwise or anticlockwise direction, digital camera, IR sensor, LPC2148 Processor, Load cell for weight measurement, LCD display on field, GSM module and grading assembly, The image could be captured using a regular digital camera. Here we have used for capturing image the iball twist cam which is CMOS based camera. The system works on 12V dc power supply, and for the weight measurement purpose 5V dc power supply is used.

The system arrangement is done as shown below the basic aim is to obtaining the fruit's features. The system consists of several steps like feature extraction, sorting and grading. The block diagram of a system is shown in figure 1. Here, conveyor system, grading assembly is designed as shown in figure 2.and the prototype for grading assembly is as shown in figure 3. As proposed in [1], to avoid shadow, two annular lights are used to supply well- distributed light. The black background color in image is easier to extract the fruit edge characters later. So the background is set black in whole process of image capture. The light and camera location is as shown in Figure 4.

Firstly grading is decided either by color and size (considered as choice 1 in further discussion) or by weight (considered as choice 2 in further discussions), for the same purpose one switch is used**.**

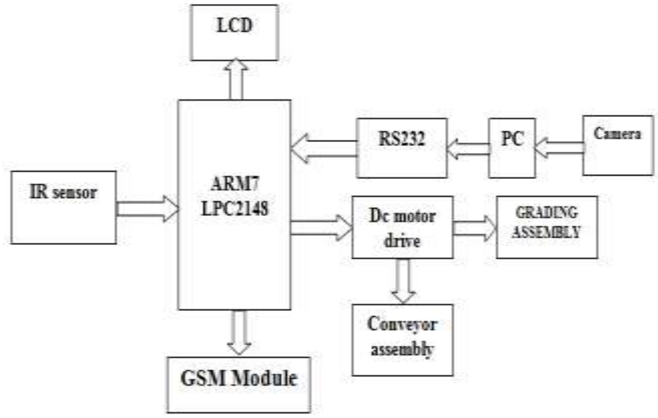

Figure 1: System block diagram

Figure 2: Hardware prototype

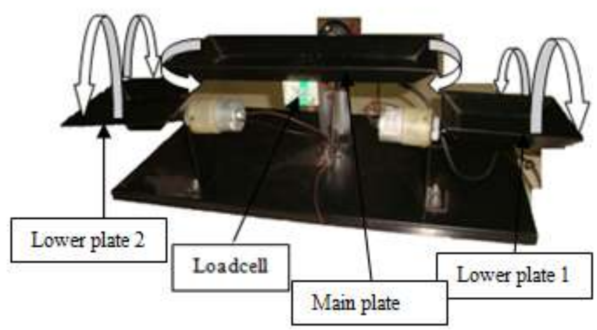

Figure 3: Grading Assembly

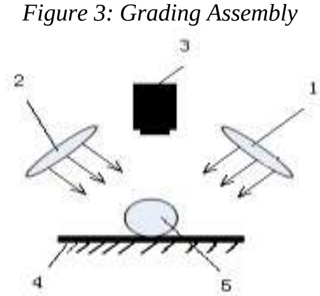

Figure 4: Fruit system light and camera location.1-light; 2-light; 3-cmoscamera; 4-conveyor belt; 5-fruit

For grading using first choice camera position is adjusted in such a way that For capturing live image of a fruit the camera is continuously scanning the conveyor belt in video mode, when conveyor stops as fruit is detected by IR system camera can capture top view image of fruit. The

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black background color in image is easier to extract the fruit edge characters later [1] so black color is used for the conveyor system. The captured image is given as an input to the Matlab software which extracts (detects) color and size of a fruit, this data is transferred to ARM based system by using RS232 and com port and accordingly control action is taken place, later conveyor starts and Then fruit is collected in main plate of grading assembly.

If fruit is red color (as detected by Matlab) then the main plate is moving anticlockwise and accordingly the fruit is collected in lower plate 1, now depending on the size of fruit(as detected by Matlab) it can be graded as a small or big fruit. If fruit is of big size the lower plate 1 will be moving anticlockwise and if fruit is of small size the lower plate 1 will be moving clockwise,

Similarly, if fruit is of green color (as detected by Matlab) then the main plate is moving clockwise and accordingly the fruit is collected in lower plate 2, now depending on the size of fruit (as detected by Matlab) it can be graded as a small or big fruit. If fruit is of big size the lower plate 2 will be moving anticlockwise and if fruit is of big size the lower plate 2 will be moving clockwise.

Later fruits can be collected in different boxes which can be packed depending as per the count decided number of fruits per box, finally once grading is done then the massage can be send to consumer or head office by using GSM module as shown in figure 5. For the same purpose AT commands can be used.

Here for First choice i.e. grading using color and size, grading can be categories into four ways Red small: A, Red big: B, Green small: C, Green big: D and for second choice i.e. for weight measurement grading can be categories into two ways which is small weight: SW and big weight: LW.

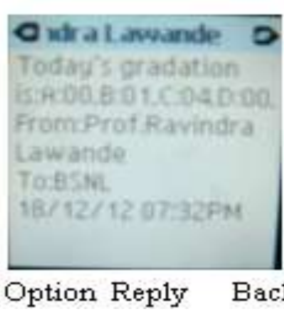

Figure 5: GSM message send for choice 1

Choice 1: Fruit color and size detecting

A. Processing flow

Take apple as the processing example, according to [1], the apple size is its diameter, which is the longest distance in the apple's cross section. So the detecting program is focused on how to calculate the diameter in an apple side-view image. The fruit image size detecting and grading processing flow is shown in Fig. 6.

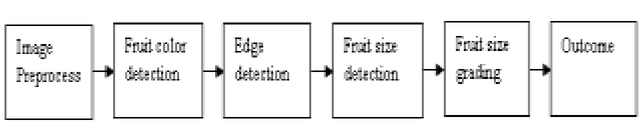

Figure 6: processing flow for choice 1

B. Color Detection

In the process of fruit color is detected according to RGB values, here fruits are sorted according to color and size. So for e.g. two fruits are considered say tomato having red color and guava having green color, so in this step work is going to find out color of a fruit by using RGB values of an image taken from the camera, this image can be processed by using Matlab software and accordingly color can be detected i.e. green or red.

Color detection algorithm:

1) Start
2) Read the input color image using imread fuction.
3) Read the input pixel of color image in three different planes (RGB) and store it into three variable r, g, b.
4) Read the small region of fruit to detect color of fruit.
5) Store in different variable r1, g1, b1.
6) Calculate the mean of r1, g1, b1 and store into variable r2, g2, b2.
7) Compare the value with threshold.
8) If g2>threshold, Color detected is green.
9) If r2>threshold, Color detected is Red.
10) End.

C. *Edge Detection*

Once color is detected, there is a need to find out size of a fruit. The size of circular shaped fruit is its diameter [1]. The edge extraction is key factor for size detecting. After gray image, the most powerful edge-detection method that finds edge is the canny method. The Canny method differs from the other edge-detection methods in that it uses two different thresholds (to detect strong and weak edges), and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges.

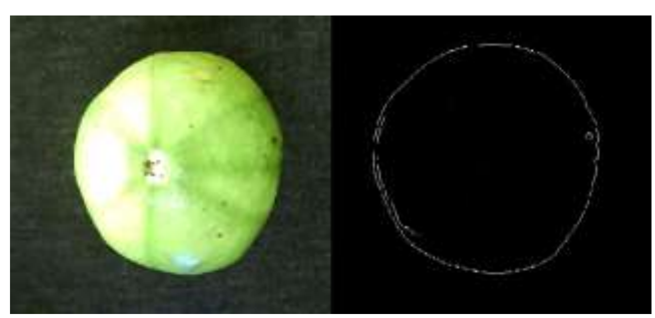

Figure 7: Edge detection

Fruit Size detecting algorithm:

In order to calculate this diameter, the fruit's natural symmetry is considered, so the fruit size detecting algorithm based on its symmetry mainly contains two parts: finding the center coordinate of fruit's shape in image and finding fruit's axis in image. The algorithm is described as follows:

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1) Finding the center coordinate of fruit's shape in image:

The center coordinate can be easily calculated once finding the edge sequence points. Suppose the finding edge sequence points is q (x_i, y_i), i=1,…,n. the center coordinate of fruit's shape is (c_x, c_y), it can be calculated by (1) and (2) as in [1]:

$$c_x = \frac{\sum_{k=1}^{n}[y_k(x_k^2-x_{k-1}^2)-x_k^2(y_k-y_{k-1})]}{2\sum_{k=1}^{n}[y_k(x_k-x_{k-1})-(y_k-y_{k-1})]} \quad (1)$$

$$c_y = \frac{\sum_{k=1}^{n}[y_k^2(x_k-x_{k-1})-x_k(y_k^2-y_{k-1}^2)]}{2\sum_{k=1}^{n}[y_k(x_k-x_{k-1})-x_k(y_k-y_{k-1})]} \quad (2)$$

2) Finding the fruit's axis in image:

After get the center coordinates of fruit's shape in image, the diameter sequence from the edge point to the center can be also acquired, that is $p(j)$. j=1,…, n. and then it's even points selected from $p(j)$, called $r(j)$,j=1,…,m. suppose $h = 1,\ldots,m/2$. So the $r(j)$ can be divided in two parts by h, and then calculating the g, which is described by (3).

$$g = \sum_{l=1}^{\frac{m}{2}} |r(h+1) - r(h-1)| \; (h = 1,2,\ldots\ldots,m/2)$$

If|h-1|≤ 1, r (h-1) =r (m+l-h-1) (3)

The direction of $r(h)$ is the fruit's axis in image while the g getting its minimum. Following the below method, the fruit's axis point and center point is found in image as shown in Figure. 6. Once known the axis point and the center point, a line through the center point which is vertical to the line from axis point to center point will be crossed with the edge sequences, two edge points that on the line will be searched.

Suppose the two points is (x_1, y_1) and (x_2, y_2) in order to improving the system's speed, the diameter is calculated by (4) directly, this diameter value can approximately indicates the fruit's real maximal diameter in image. From the detecting result in Figure 8, this method can find the axis point accurately in a fruit image. And also, it still can find the two points while the fruit's location changed. So this method can satisfy the fruit size detecting on line which its location changed often.

$$d = [(x_1 - x_2)^2 + (y_1 - y_2)^2]^{1/2} \quad (4)$$

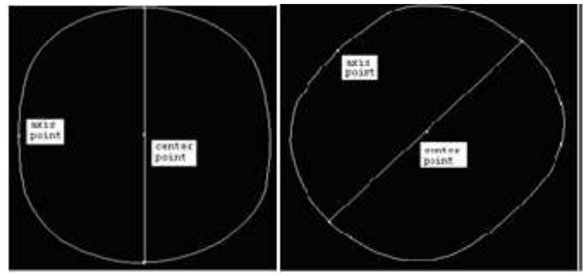

Figure 8: the fruit's axis point and the center point

Choice 2: Weight measurement and grading

For grading using choice 2, weight as a parameter is decided by using switch provided. The load cell is used for the same purpose [4], as the voltage generated by load cell is of the order of mill volts it needs to be amplified before sending to ARM microcontroller. The load cell is attached to main plate so that when plate receives a fruit from conveyor then by using load cell weight of a fruit can be measured and displayed on the LCD display. By considering one reference point the fruits can be graded as a small or big weight fruits.

Figure 9 shows a circuit used for the load cell. The output of this load cell is of the order of millivolts so it is amplified using OP07 op amp chip and then sends to ARM processor which does further grading using grading assembly. The gain of the following circuit is approximately 10. Figure 10 shows the gain amplifier arrangement having gain approximately 11.

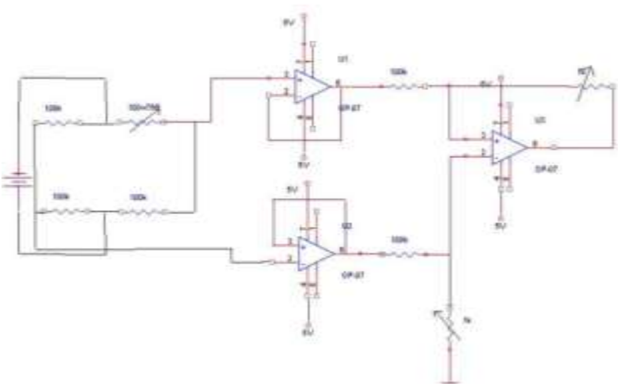

Figure 9: Load cell circuit arrangement

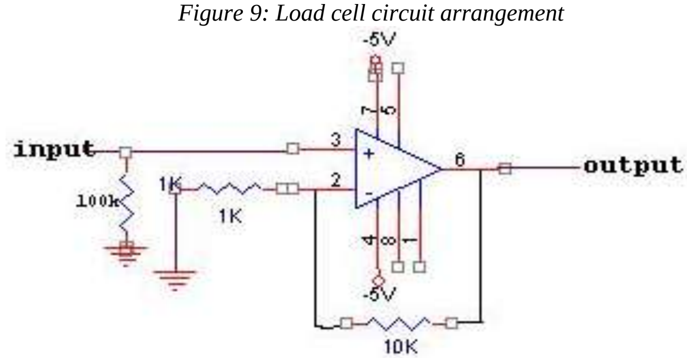

Figure 10: Gain Amplifier

IV. Discussion and results

The results and analysis step is the final step in which outcome of the project is being displayed. Here the size of fruit image is converted form pixels to millimeter as mentioned in [2]. For choice 1, the fruit image is captured from a fixed distance and accordingly camera is calibrated so the error is size detection becomes less than 1%. The GUI is created for choice 1 i.e. grading using color and size detection, the user with proper buttons to use them on the query image and features of the object are displayed directly on to the screen. The comments regarding the query image are displayed on the text box. The query image is displayed in the axis box.

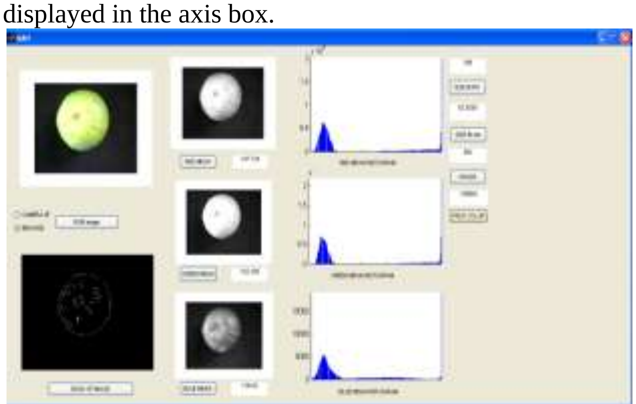

Figure 11: Graphical User Interface

Here, two options are provided for the users i.e. to capture live image from the camera or browse the existing stored image. In both cases the image size is converted into 640x480 pixels. Figure 11 shows the GUI on which the RGB image, gray scale image ,red mean , green mean, blue mean, size in pixel, size in millimeter, color of a fruit and Grade of a fruit is displayed in the text box and for displaying these attributes different buttons are provided. Here for converting size of image from pixel to millimeter the system scale is equal to 4.0683 is used. This is decided by taking image from a fixed distance of 17 centimeters (170mm). For capturing image CMOS based iball twist camera is used.

For choice 1, after capturing 10 tomatoes and 10 guava top view image and measuring its size separately, 5 apples and 5 guava measuring result among those and its real size measured by Vernier Caliper are shown in Table 1. For deciding grade using choice 1, for size 60mm reference value is considered. For choice 2, i.e. grading using weight measurement reference value as 60gm is used; real value of a fruit is measured separately by using standard weighing machine. If fruit is having weight below 60gm it can be considered as low weight fruit and if fruit is having weight greater than or equal to 60gm then it can be graded as big weight fruit. Table 1 and Table 2 shows the corresponding experiment results.

V. Conclusion and Future work

The proposed system is a demo version, so for a large scale production the number of cameras and length of conveyor system can be modified. This work presents new integrated techniques for sorting and grading of different fruits. Generally image capture is a big challenge as there is a chance of high uncertainty due to the external lighting conditions, so we are taking the advantage of gray scale image which are less effected to the external environment changes as well as beneficial for finding size of a fruit. Same way while collecting fruit from conveyor system by a main plate there is variation in the weight measurement of a fruit so further design can be modified so fruits can be collected stably. Speed and efficiency of a system can be further improved by using ARM9 or ARM11 processor for the same purpose.

Table 1: Results for grading using color and size measurement (dimensions in millimeters)

Result Table	Real value	Measured Value	Absolute error	Relative error	Red Mean	Green Mean	Blue Mean	Color	Grade
Tomato1	37.80	37.85	+0.05	+0.132%	125.701	137.725	107.916	Red	Small
Tomato2	49.10	49.16	+0.06	+0.122%	138.653	146.122	121.096	Red	Small
Tomato3	52.20	52.11	-0.09	-0.172%	138.229	143.568	123.72	Red	Small
Tomato4	54.50	54.56	+0.06	+0.110%	137.295	144.78	118.547	Red	Small
Tomato5	65.70	65.87	+0.17	+0.258%	139.235	145.462	120.235	Red	Big
Gauva1	63.00	62.97	-0.03	-0.047%	147.724	152.305	136.83	Green	Big
Gauva2	64.40	64.89	+0.49	+0.760%	160.978	166.128	151.084	Green	Big
Gauva3	53.50	53.09	-0.41	-0.766%	146.581	152.243	138.961	Green	small
Gauva4	60.80	60.71	-0.09	-0.148%	149.314	157.797	135.216	Green	Big
Gauva5	47.60	47.19	-0.41	-0.861%	140.609	145.697	135.426	Green	Small

Table 2: Results for grading using weight measurement (weight in gm)

Result Table	Real value	Measured Value1	Measured Value2	Measured Value3	Measured Value4	Measured Value5	Measured Value mean	Absolute error	Relative error %	Grade
Tomato1	52	52	53	54	50	52	52.2	+0.2	+0.38%	Small
Tomato2	95	92	91	96	95	90	92.8	-2.2	-2.31%	Big
Tomato3	58	56	59	55	57	56	56.6	-1.4	-2.41%	Small
Tomato4	50	48	49	49	50	50	49.2	-0.8	-1.60%	Small
Tomato5	56	54	55	56	56	55	55.2	-0.8	-1.42%	Small
Gauva1	80	76	81	82	80	79	79.6	-0.4	-0.50%	Big
Gauva2	76	76	78	77	77	76	76.8	+0.8	+1.05%	Big
Gauva3	53	51	53	52	53	54	53.8	+0.8	+1.50%	Small
Gauva4	107	109	103	105	102	106	105	-2.0	-1.90%	Big
Gauva5	120	114	124	122	120	118	119.6	-0.4	-0.33%	Big

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