CORN FRUIT GRADING BASED ON SIZE USING IMAGE ANALYSIS

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ABSTRACT

Image processing analysis and computer visions have shown a tremendous growth in its applications. In agricultural sector, one of the applications includes the automated agricultural products grading and sorting. An automated system is vital because the conventional grading method done by humans is deemed inefficient, time consuming, labour intensive, costly and prone to errors. To help maintain the uniformity and consistency of the corn quality, there is a need to develop an efficient corn grading system. The developed system consisted of an image acquisition unit, image analysis by MATLAB R2012b algorithm and a sorting mechanism controlled by Arduino UNO R3 microcontroller. The size of corn is calculated from the binary image of the corn and graded according to specification given by Federal Agricultural Marketing Authority (FAMA). The system also comes with a user friendly GUI. The evaluation results showed that the developed system is capable of grading the corn into different size categories with 86% accuracy.

Keywords: computer vision, image analysis, fruit sorting and grading

1.0 INTRODUCTION

Malaysia produces an estimated 60,000 Metric Tonnes of corn and gained RM 37.57 million from corn exports in 2013 (Statistik Utama Pemasaran FAMA 2014). However, before the corn can enter the local market or exported it must go through a stringent grading process. Grading is essential as people are becoming more quality conscious and a higher graded commodity fetches a higher price in market. Brennan (2006) defined commodity grading as sorting the commodity according to specific quality and can be accomplished by comparing its appearance (colour and absence of defects), texture, shape and size. Aleixos et al., (2002) stresses that size is one of the major parameters or attributes that the consumers associated with the quality of the fruits. According to MS 1229-1991 by Federal Agricultural Marketing Authority (FAMA), corn can be classified into large (L), medium (M) and small (S) sizes (Table 1). It can be concluded that the bigger the corn is, the better it is considered in term of quality.

Table 1: Specification of corn size by FAMA Standard

Size Class	Code	Dimensions	
		Length (cm)	Diameter (cm)
Large	L	> 17.1 cm	>5 cm
Medium	M	14.1-17 cm	4.5 cm
Small	S	10-14 cm	3.5-4 cm

(Standards Malaysia, 1991)

1.1 AUTOMATION AS THE WAY FORWARD

To date, the corn is still being graded manually by human. The conventional manually grading method is undoubtedly inefficient because it is time consuming, labour intensive and therefore costly especially in large scale farming. Manual grading by human is also prone to errors, lacks of uniformity and inconsistent thus affecting the quality and customer's satisfaction. To make matters worse, Sun et al. (2003) stated that the basis of quality assessment is also subjective to human. If one is serious about addressing these issues then automated computer vision sorting system is the answer. An automated system would not only increases productivity, but also lowers the overall operating cost and thus, enabling a more rapid return of investment (ROI) which is good for the corn industry. Given the corn short storage period of around 24 to 36 hours upon harvest in ambient temperature, a speedy grading and sorting process is also a must. This would greatly reduce the time needed for the corn to reach its consumer before the quality is degraded by time. The above mentioned issues are the main motivation towards developing a more efficient corn grading system.

1.2 THE PROPOSED CORN GRADING AND SORTING SYSTEM

As the name suggest, a typical computer mediated grading and sorting system is actually a combination of two subsystem namely a computer vision system and a fruit sorting mechanism. In this study, the authors focused on the external quality factors of the corn by analyzing its visual appearance. The system will acquire real time image data from Logitech HD C920 webcam and fed it to the computer for analyzing purposes. An algorithm that effectively analyze the length and diameter dimensions of the captured corn images had been developed by using MATLAB R2012b together with a user friendly Graphical User Interface (GUI) that displays the captured images, length, diameter and grade classification of the corn in real time according to FAMA MS 1229:1991. The authors have also developed a conveyor that comes with a built in corn sorting mechanism controlled by Arduino UNO R3 microcontroller. Large scale corn farmers and FAMA is the targeted end user for the product.

2.0 METHODOLOGY

The developed system (Figure 1) consisted of an image acquisition unit, image analysis by MATLAB R2012b algorithm and a sorting mechanism controlled by Arduino UNO R3 microcontroller. The system also comes with a belt conveyor that feeds the corn into the image acquisition unit and sorting out process.

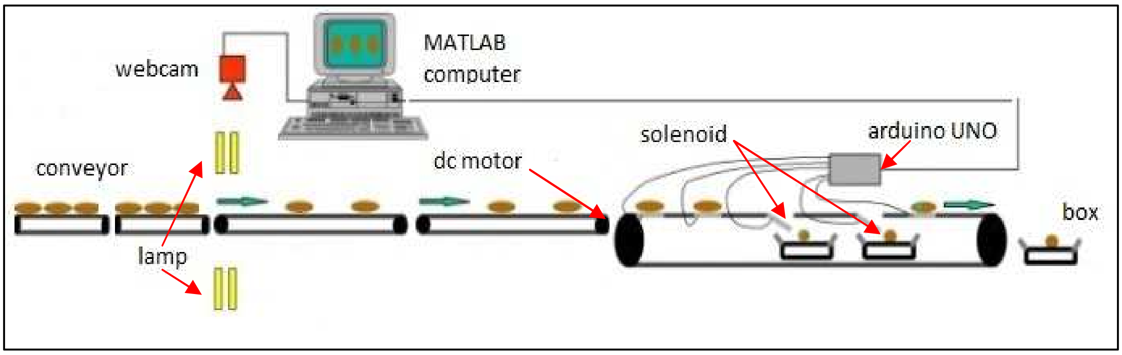

Figure 1: Shows the executive summary of the developed corn grading system.

2.1 IMAGE ACQUISITION

The image capturing process is not triggered by any sensors. Instead, an algorithm is written in MATLAB that will enable the system to continuously acquire real time image data from the webcam and then calculate its pixels by using Equation 1. Equation 1 can be best understood by referring to Figure 2.

$$1 = 2C\,[(\,R2 - R1\,) + (\,R4 - R3\,)] \qquad \text{Eq. (1)}$$

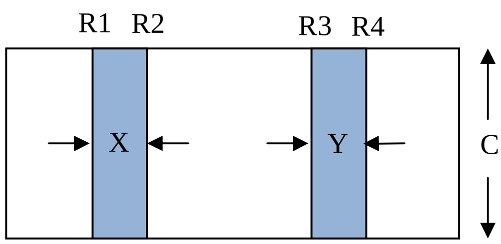

Figure 2: Shows the diagram of pixels calculation.

When the corn passes through two imaginary columns namely column X and Y, it would cause the pixels within the two columns to change. The changes in number of pixels is continuously monitored by the system and compared with a default value. The image is automatically captured if the pixels difference is greater than 50 pixels. Nothing will happen if the pixel value is recorded to be lower than 50. The captured image is then cropped and displayed on GUI as static image. The whole process of image acquisition is shown in Figure 3.

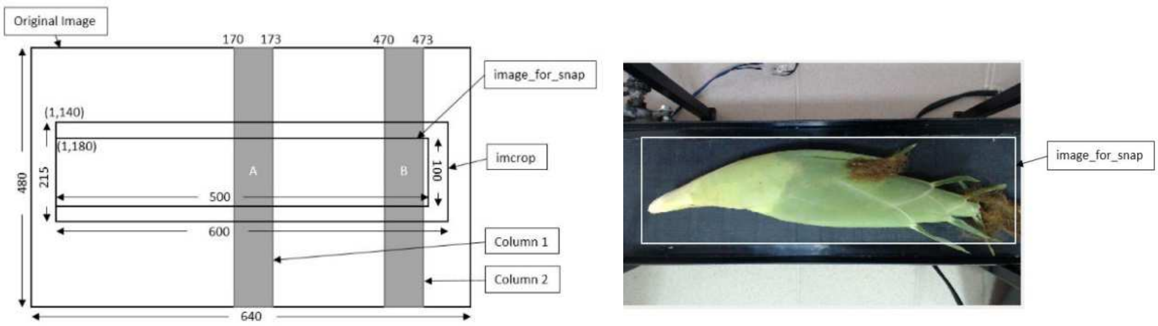

Figure 3: Shows the automatic image acquisition process.

2.2 IMAGE PROCESSING

The size is estimated by calculating the area covered by the corn image. However, before the area can be computed, the image must first be converted into binary image to separate the corn image from its background and the number of pixels that covers the area is calculated to estimate the corn size. The edge extraction using canny method is the key factor to detect size. Next, the BoundingBox Function is used to get the centroid point and determine the length and diameter of the corn. The step by step procedure is best described in Figure 4 and the flowchart in Figure 5.

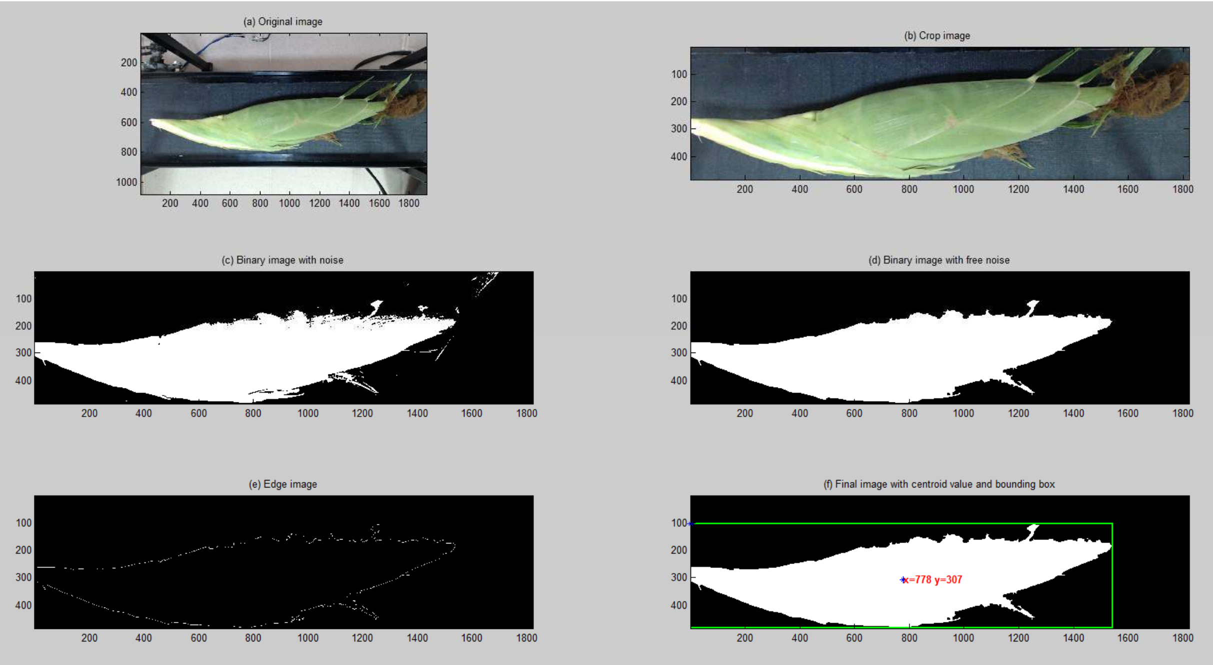

Figure 4: Processing the corn image. (a) Original image (b) Cropped image (c) Binary image with noise (d) Binary image without noise (e) Edge trimming (f) Final image with centroid value and bounding box.

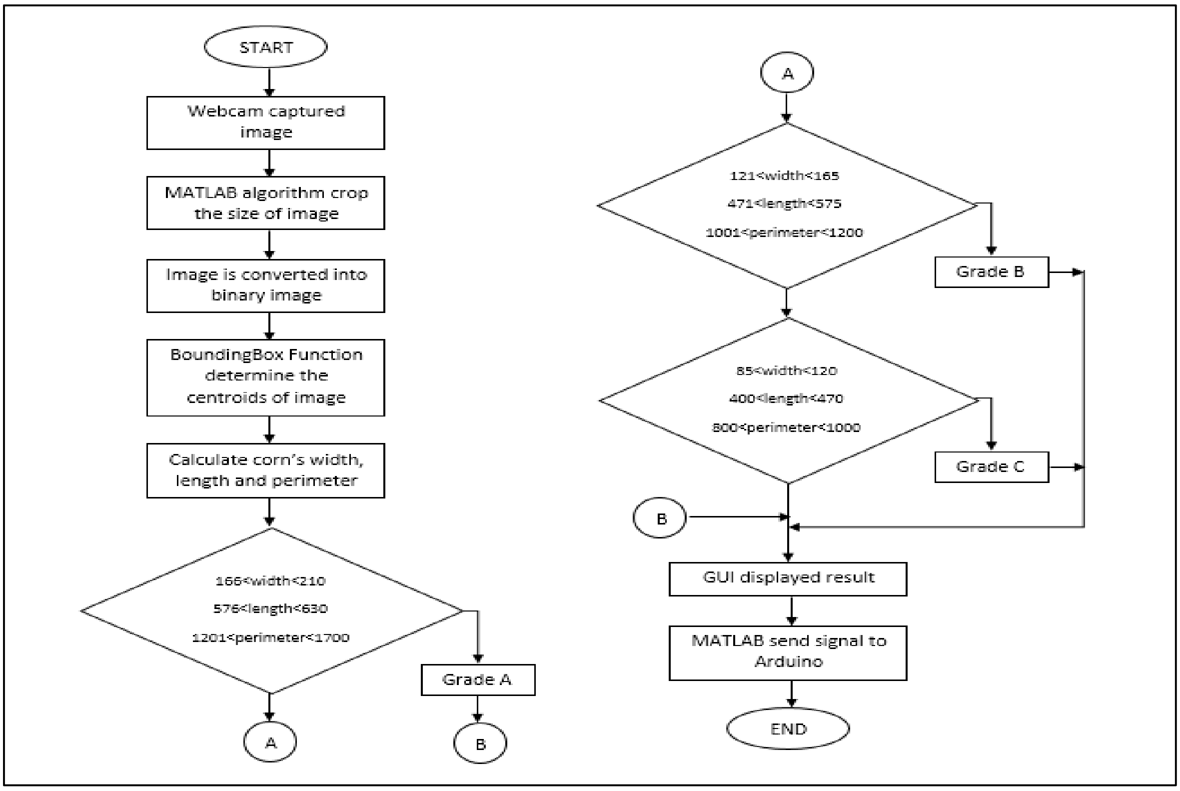

Figure 5: Shows the image processing flowchart.

2.3 CORN HANDLING AND SORTING

Once the grade had been determined, the MATLAB GUI will display the result and a signal will be sent to Arduino UNO R3 microcontroller via a USB. The Arduino UNO R3 microcontroller controls the sorter by switching the relay which in turn would power up the 12V DC solenoid and directs the corn into the appropriate bin. The conveyor is powered by a 12V DC electric motor. For consistent image capturing result, a controlled environment with the required amount of illumination is important. This is where the imaging chamber and a pair of 240V compact fluorescent lamp or CFL would be handy. The corn image is captured from a fixed height of 160mm.

Figure 6: Shows the working prototype of the corn grading and sorting system

3.0 FINDINGS AND DISCUSSION

The system managed to show a real time video of the conveyor which was fed directly from the Logitech HD C920 webcam. The GUI had also successfully display the captured RGB image given if the set condition is fulfilled together with the processed binary image. For concise information, the binary image will be displayed with centroid and bounding box. The developed system had also been able to display the required information of the corn diameter, length and perimeter in pixel together. It had also successful in giving the grade classification. The GUI will also let the user to switch from real time to offline control as expected. It means that the operator can let the system to capture live image from the camera or disengage the real time control and do it manually. Figure 7 shows the GUI with a tested Grade A corn.

Figure 7: Shows the GUI with grade ‘A’ test subject.

3.1 INITIAL EXPERIMENT

During the initial test of the grading process, a total of 45 corn samples were collected from a farm in Sekinchan, Selangor. The distribution of the corn is based on the size specification from FAMA, 15 corns were each of grade A, grade B and grade C respectively. The initial test is important in order to determine the value of threshold. The threshold value will be set as a predefined value for the system to distinguish the grade of corn. The testing was done off-line under controlled environment condition. Table 2 shows the corresponding experiment results.

Table 2: The minimum and maximum width, length and perimeter value for each size of corn

Grade	Width (pixel)		Length (pixel)		Perimeter (pixel)	
	Min	Max	Min	Max	Min	Max
A	272	442	1260	1590	3202	5999
B	235	378	1130	1348	2505	3526
C	227	322	1059	1144	2261	2750

3.2 FINAL EXPERIMENT

Further tests were done to evaluate the overall system's functionality and performance. The second test was to focus on the system's capability to feed the corn into the conveyor for the image acquisition, processing stages, classify the fruits correctly to their grades and sort the fruits accordingly. A total of 65 corn samples of were taken from a local farm with different grades. Before the test, the fruits were visually examined and manually graded according to MS 1229:1991 criterions. From the manual grading process, 24 of the corn are classified as grade A, 20 of the corn are classified as grade B and 21 of the corn are classified as grade C. The corn fruits are then continuously fed into the conveyor belt.

Table 3 compares the experimental result of the successful attempts by automatic grading with respect to manual grading method. During the experiment, it is learnt that a total of 7 corns were inaccurately classified or graded. This was probably due to the positioning of the fruit on the conveyor belt. Since the system only uses vision to capture the image and determine the required dimensions, the fruit must be in straight position and on the centre axis of the conveyor belt for the system to give accurate readings. Another issue that had been encountered during the test run has got to do with the corns silk and husk as they were still in the image after pre-processing. Due to the present of corn's silk and husk, the system had misinterpreted the actual size of corn image. Overall, the results show that this method is successful in classifying the corns. The result shows that the accuracy of this system is 86%.

Table 3: Experimental result

	Grade A	**Grade B**	**Grade C**
Manual grading	24	20	21
Automatic grading	21	17	18
Number of corns can't be classified using automatic grading	1	3	3

4.0 CONCLUSION

It can be concluded that the developed prototype for automatic corn grading and sorting machine that applies image processing as its quality evaluation method had been successful and met the intended designed objectives. However, image capture is a big challenge as there is a high chance of uncertainty due to the factor of external lighting conditions thus preparing a control environment for the image acquisition process is vital. The author is also suggesting a proper feeder that would straightly aligned the corn on the center of the conveyor. Besides, the capacity of the grading machine needed much further improvements, especially in speed and accuracy, before it can be implementation in the field.

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