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Improvement of an Apple Sorting Machine Using PSNR Criterion

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***Abstract*—This paper deals with development of an apple sorting machine. The fabricated machine employed apple weights as a classification factor to sort the fruits in 6 categories. A load cell with rated capacity equal to 2 kg and 1 mv/v sensitivity is employed in measuring system. The pre-filtered load cell output signal is amplified before being applied to the control unit in order to be easily detected by microcontroller. Peak signal to noise ratio (PSNR) criterion is employed to analyze the machine performance which aids its improvement. The PSNR results as well as experimental results specify that vibration could significantly affect machine performance. To overcome this issue, the fabricated machine divided into two parts of measuring and transferring units with separate chassis.**

***Keywords*— sorting, peak signal to noise ratio (PSNR), load cell, amplification**

I. Introduction

The increasing consumer demand for quality produces, the consistent behavior of machines in compare with humans, the scarceness of labor and attempt to reduce labor costs are the main motivations of automated packing and sorting in the past decades [1]. The definitions for quality used in the literatures, however, are not consistent. Different qualitative evaluation of agricultural productions give rises to various mechanized and automated sorting machines. However, certain basic factors such as size, shape, color, taste, and freedom from defects are the commonly used ones in machines development [2].

Several researchers reviewed the main advances of recent introduces automated machines in the past few years. Studman [3] emphasizes on the major impact of computer and electronic technologies in the postharvest industry. Brosnan et al. [4] deals with comparison of different computer vision systems to sort the fruits. García-Ramos et al. [5] employs firmness sensors to achieve a mechanized sorter. Butz et al. [6] reviewed the papers which introduces internal quality as a criterion for sorting. Most of the published researches in the state-of-the-art employ the non-size factors to develop mechanized machines while size-based sorting is missed. However, fruit size determination is important in the context of postharvest operations for several reasons as follows [1].

1- It allows the sorting of fresh market fruits into size groups. In other words, this takes into account the consumer preferences.

2- Size determination is mandatory for successful drying of fruits.

3- Size determination studies are largely used by microbial scientist to evaluate microbial population on the surface of a foodstuff.

4- Fruit size could provide meaningful information to employ internal quality sensors.

5- The shape of fruits could be estimated by means of fruit size.

In other word, the fruit sorting based on its size could cover the advantages of other sorting methods. Therefore the developed machines based on size could provide a flexible platform which could easily implement other sorting factors with a little architecture changes. It is noteworthy that, fruit size can be expressed in terms of volume, weight, and diameter.

This paper develops a grading/sorting machine for apple fruits based on their weights. Although, the designed machine could be widely employed for several fruit applications, this paper focuses on apple sorting. Apple is one the important fruits on which grading could influence their markets. The United States packs over 170 million cartons of apples each year [7].

The rest of this paper organized as follows. Section 2 describes the design methodology. Section3 explains simulation and experimental results in detail, and finally section 4 concludes the paper.

II. Design Methodology

A model is designed for the proposed machine in SolidWorks 2009 as depicted in Fig. 1. According to the suggested model, the experimental machine is fabricated as shown in Fig. 2. A weight sensing system measures the fruit weight and a duct with a 20-cm working width transfer the fruits to the chutes. Their gates are manipulated by pneumatic cylinders and magnetic valves which controlled by the weight control system. A load cell with rated capacity equal to 2 kg and 1 mv/v sensitivity is employed for measuring unit. The load cell output signal pre-filtered before being amplified in order to eliminate noises.

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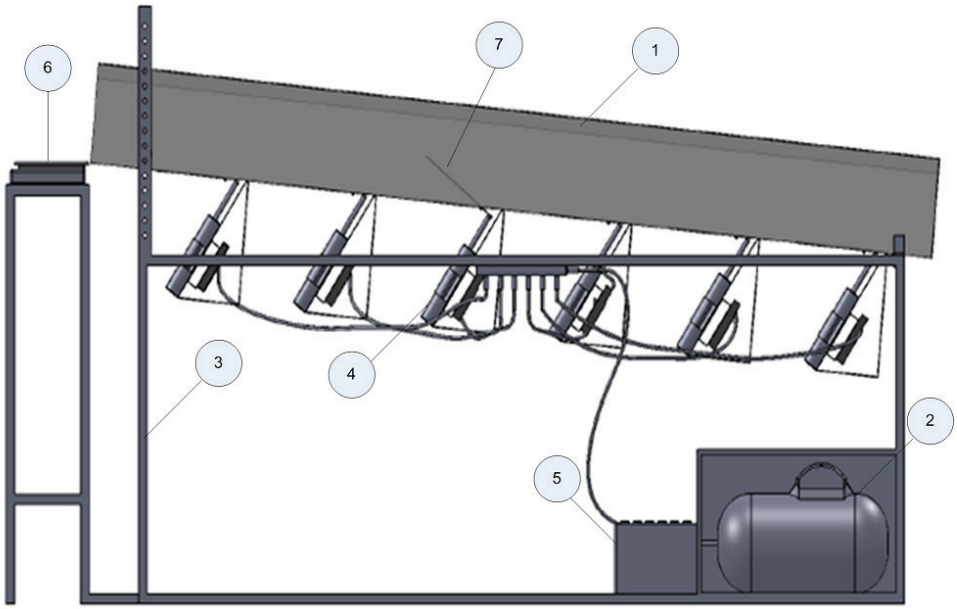

Fig. 1. The grading machine model; 1) duct; 2) pneumatic pump; 3) frame 4 Pneumatic cylinder; 5) electrical motor; 6) weight sensing unit; 7) chute

Fig. 2. The experimental machine for apple grading

Microcontroller ATMEGA 32 is employed as decision making unit which produces command signal to the magnetic valves. It should be noted that to drive the magnetic valves by means of microcontroller ports, its output current should be amplified before applying to the valves. For this proposes integrated circuit (IC) BDX 53 in common collector form is employed to amplifies the output port current. The implemented control diagram is shown (Fig. 3). The control diagram is successfully simulated by the Proteus software.

III. Machine Evaluation

Reduction of fruit damage is an important issue and could be explained as the bottle neck of a grading machine. Bruising occurs as a result of machinery roughness and the susceptibility inherent of fruit during fruit transferring. Therefore, several considerations should be made to design a transfer duct as it significantly affects the fruit damage.

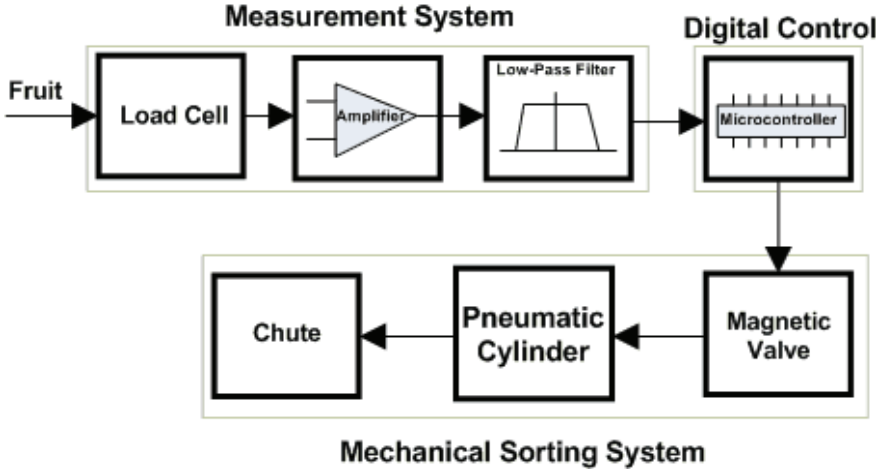

Fig. 3. Control unit diagram of the grading machine

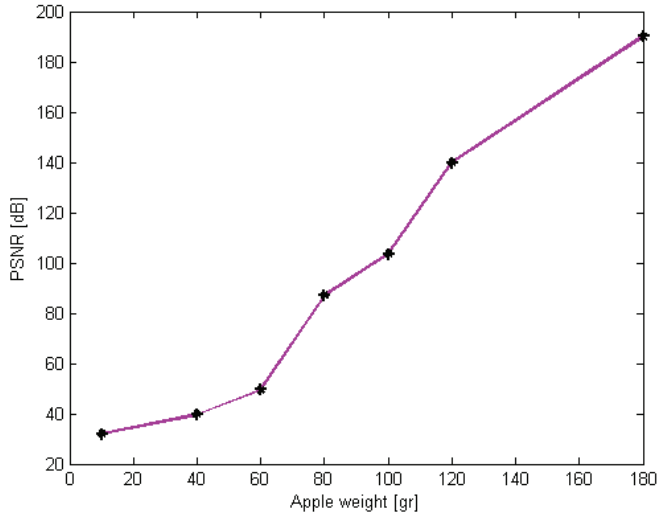

Fig. 4. PSNR results for the various weights

After weighting and data processing, fruit is delivered through conveying duct to one of the six inserted gates for sorting. The apple bruising critical height of drop is statistically determined on steel plate. This critical height is 6 cm for a local variety of apple called Golab. To avoid mechanical damage, the fruit velocity fixed at 1 m/s. Theoretical impact force analyzing on fruit in the duct reveals that the machine has no harmful effect on fruit in sorting process. It was approved by actual results of machine evaluation.

IV. Simulation And Experimental Results

The proposed control and measuring system examined by Proteus is implemented in experimental machine. Note that, the details about the mechanical features of the machine are completely explained in [8-10]. It is assumed that the apples should be sorted in 6 categories based on their sizes.

The excitation voltage of load cell is considered to be 10 [Volt]. Therefore the maximum achievable voltage at the load cell terminal is 10 [mv]. The maximum probable weight for the examined apples considers as 500 [gr] which produces 2.5 [mv] at the output port. This voltage level is so low to be processed by microcontroller on which drives the valves correctly. Amplifying the output signal of load cell is done by using ultra-low-noise amplifier (OP155). As the load cell output signal is a dc one with constant value for each fruit, the added noise to the desired signal could be easily removed. Therefore, a low pass filter is implemented in order to eliminate the unwanted environmental noises as well as machine vibration. At the first step the controlling and measuring systems are implemented in the same chassis as transferring system. The experimental results show that the control system only drives the 3 latest pneumatic cylinders. In other words, the apples with weights in range of 0-80 [gr] pass through the duct and fall in the end of it. The only parameter which could affect the performance of the machine seems to be noises. To evaluate impact of this unwanted parameter on the machine performance, peak signal to noise ratio (PSNR) criterion is implemented. Fig. 4 demonstrates the PSNR results for the load cell output signals related to the various apple weights. It is noteworthy that the PSNR is calculated between the real amplified signal and the desired one which is a load cell output signal multiplied at the amplification gain. It could be clearly seen that there is a significant decrease in the PSNR for the low output signals. This means that in the low level of voltages related to the lower weights, the noise signal becomes dominant in compare with the load cell desired signals.

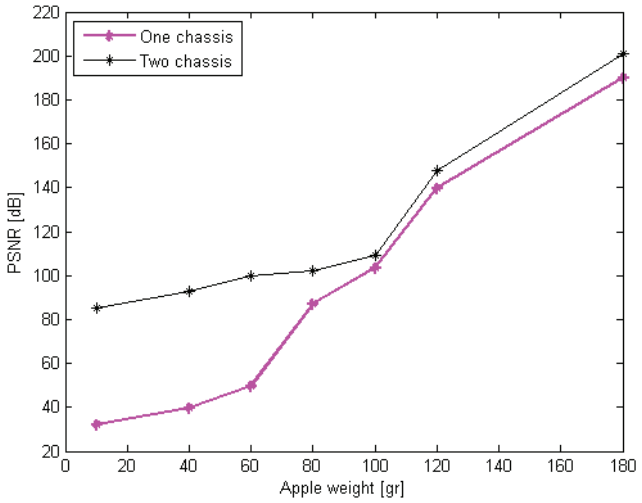

Fig. 5. PSNR comparison for the combined and separated chassis

In the amplifying stage the employed equipments are the accurate and ultra low noise ones on which introduce negligible noises in the system. Therefore, it seems that the vibration give rises from pneumatic cylinders reaction affect the system performance. Therefore, the chassis divided into two parts, one as controlling and measuring system and the other as transferring duct. Fig. 5 demonstrates the comparison between PSNRs for the system with one and two chassis. It could be clearly seen that PSNR significantly improved in the lower weights range. Experimental results also prove the PSNR results. In other words, after dividing the chassis to two parts, all the apples are sorted based on their sizes without any concerns.

V. Conclusion

The objective of this study is the design, development and evaluation of weight sorting automatic machine for apple. A weight-based sorting machine is designed for apple fruit. The designed machine employs load cell to sort the fruits in 6 categories. Using load cell in fabrication of a machine requires several considerations regarding its amplification. PSNR criterion is employed to overcome the challenges associated with load cell signal amplification. Modification

of the primary machine based on PSNR results give rises to a machine with acceptable performance. The grading machine capacity is 130 kg/h for the machine width of 20 cm.

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