



FULL LENGTH ARTICLE

Study on an automatic sorting system for Date fruits



Razieh Pourdarbani ^{a,*}, Hamid Reza Ghassemzadeh ^a, Hadi Seyedarabi ^b,
Fariborz Zaare Nahandi ^c, Mohammad Moghaddam Vahed ^c

^a Department of Agricultural Machinery Engineering, Faculty of Agriculture, University of Tabriz, Iran

^b Department of Electronical Engineering, Faculty of Electrical and Computer Engineering, University of Tabriz, Iran

^c Department of Plant Breeding and Biotechnology, Faculty of Agriculture, University of Tabriz, Iran

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Abstract In the present study, a machine vision based, online sorting system was developed, the aim being to sort Date fruits (Berhee CV.) based at different stages of maturity, namely Khalal, Rotab and Tamar to meet consumers' demands. The system comprises a conveying unit, illumination and capturing unit, and sorting unit. Physical and mechanical features were extracted from the samples provided, and the detection algorithm was designed accordingly. An index based on color features was defined to detect Date samples. Date fruits were fed on a conveyor belt in a row. When they were at the center of the camera's field of view, a snapshot was taken, the image was processed immediately and the maturity stage of the Date was determined. When the Date passed the sensor, positioned at the end of the conveyor belt, a signal was sent to the interface circuit and an appropriate actuator, driven by a step motor, was actuated, leading the Date toward an appropriate port. For validation of proposed system performance, entire samples were again sorted by experts visually. Detection rate of the system for Tamar and Khalal was satisfactory. Although the detection rate was insufficient for the Rotab stage, there was no a significant difference between system accuracy and that obtained by the experts. The speed of image processing system was 0.34 s. System capacity was 15.45 kg/h.

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1. Introduction

Date is one of the non-oil export products of Iran that can play an important role in the country's economy. Every component

* Corresponding author. Tel.: +98 9143162785.

E-mail address: r_pourdarbani60@yahoo.com (R. Pourdarbani).

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of Date, such as flesh, stone, leaf, etc. can benefit the food supply chain if processed properly (Rohani, 1988).

Ripening process of the Date includes four principle stages, namely; Kimri (immature), Khalal (changing color, not mature), Rotab (mature) and Tamar (ripe) stages. In general, fruits at the Khalal stage are ready to market as "fresh" fruit but this is true only for those cultivars that are sweet, with a low amount of tannin and low astringency (Barreveld, 1993). Some of Date cultivars are suitable for marketing at the Khalal stage including "Barhee", "Bereim", "Hayany" and "Khalas" among which, Barhee is the most popular cultivar worldwide

(Mortazavi et al., 2007). The Khalal fruits that usually harvested at the end of July are highly perishable and must be transported to the market as soon as possible (Glasner et al., 2002). Any transport delay or improper storage conditions may result in quick appearance of Rotab spots and surface wrinkling, accompanied by a loss of flavor and taste. Since, a Date fruit in the Khalal stage is physiologically mature, it would be very perishable if it contains moisture over 50% and undergoes fermentation (alcoholic) resulting from the microbiological activity. This is considered a limiting factor in terms of product marketing and storage (Mortazavi et al., 2007). Packing Dates at different stages of maturity, i.e. Khalal and Rotab, in a same package is not recommended because of adverse mutual effects; Paying attention to the consumer's life style is a prerequisite of the good marketing. For example, Khalal in the Barhee cultivar is more desirable in the south of Iran, whereas Rotab is more desirable in the north of Iran. Manual sorting method of Date fruits, currently practiced in Iran, is time consuming and costly. Also it relies on labor skills and its accuracy is affected by numerous factors, such as labor fatigue. To overcome these shortcomings, increase in the sorting efficiency, improving product quality and conserving energy, automatic sorting systems have been employed by a number of researchers. Hobani et al. (2003) developed a neural network classifier for Date fruit varieties using some physical attributes. Ismail and Al-Gaadi (2009) developed an electronic sensor for Date fruit sorting based on moisture content. Al-Janobi (1998) used the Co-occurrence matrix method to grade the Date. Fedal (2008) identified the Date varieties and did sugar content estimation by color analysis. Also he studied Probabilistic Neural Network (PNN) techniques and succeeded in developing an object classifier (Fedal, 2007). Picus and Kalman (2000) proposed an adaptive grading approach for Date fruits by "prototype populations". Lee et al. (2010) evaluated Date fruit quality using color mapping. Calpe et al. (1996) presented low cost machine vision system for fruit grading. Abdulrahman and Al-Janobi (2000) developed a color computer vision system consisting of a microcomputer together with an image frame grabber and a CCD color camera for sorting and grading Saudi Dates (Sifri variety).

In the present article, a new color space for grading Date fruit is proposed based on maturity stages. The Objectives of this work were:

- i. Grading Dates according to consumer desire,
- ii. separating Khalal from other Date fruits to avoid its deterioration due to the enzymatic activity of Khalal, and
- iii. Performing the sorting task objectively by machine vision instead of a manually subjective sorting system.

2. Material and method

2.1. Selection of illumination and capturing system

To select an appropriate combination of illumination and capturing devices, two types of illumination sources were used, namely Power LED 12 V DC and fluorescent lamp examined in combination with two models of camera namely Proline and Telecam (No. Nck 41CV). A dome shaped lighting box

was developed. Six Power LEDs were powered by a 12 V DC source, and a circular 40 cm diameter Fluorescent lamp was powered by 220 V AC source. The images were captured according to standard RAL white card, 10 replications per combination of camera/light source. The RGB values of images were extracted by Image processing toolbox of Matlab software. These values were then compared with standard card value i.e. 255 by SPSS software.

2.2. Design of feeder system

To convey fruits into a paddle wheel feeder, a 300 cm long and 45 cm wide belt conveyor was made and installed at 70 cm height off the floor. An inverter driven half a horsepower electro-gearbox was used for driving the conveyor. Inverter was set to 15 Hz so that the belt speed of 22.6 m per minute was achieved.

2.3. Design of electronic interface and actuators

Fig. 1 depicts the diagram of the sorting system. The images captured by camera were recalled immediately to the workspace of Matlab. The detection algorithm identified a stage of maturity for individual Date fruits within 0.67 s in average. Then the results from the detection algorithm were sent to the interface circuit. An optical sensor (Autonics, model BEN5M-MFR) was placed 2–3 cm away from the paddle wheel feeder, in such a way that it was able to sense the presence of passing fruit. A signal from the sensor was then sent to the actuator to activate a paddle wheel feeder in an appropriate time to move a fruit toward the right exit port. If detected fruit was raw (Khalal), then step motor 1 opened the normally closed port and the fruit dropped out of port (Fig. 2). If detected fruit was semi ripe (Rotab), step motor 2 rotated the paddle wheel by 90°CW (Fig. 2). If the fruit was completely ripe (Tamar), step motor 2 rotated the paddle wheel 90°CCW. Fig. 3 illustrates the prototype sorting system of Date fruits.

2.4. Detection algorithm

A comprehensive study of the physical properties of Date is necessary to develop appropriate sorting technologies. In this study, the Date fruit samples were selected randomly from the Barhee cultivar from the Date Research Institute in Ahvaz (located in the south of Iran). The samples were at 3 stages of maturity namely Khalal, Rotab and Tamar. The fruits were taken to a Laboratory. Both, offline and online experiments were carried out. During offline experiments for every stage, 50 samples were selected at random for feature extraction. The images of samples were captured by Telecam No.Nck 41CV and saved in a personal computer for processing. To simplify the algorithm, the size of the images were reduced

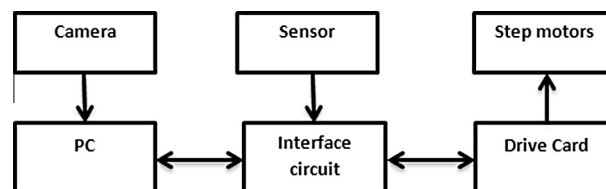


Figure 1 Schematic of sorting producer of Date fruit.

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