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Study on an Automatic Sorting System for Citrus Fruits

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ABSTRACT: In the present study, a machine vision based, online sorting system was developed, the aim being to sort citric fruits based at different stages of maturity, namely Colour, size and amount of juice 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 fruit samples. Basically, two inspection stages of the system can be identified: external fruit inspection and internal fruit inspection. Citric 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 fruit was determined. When the fruit 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 Size and color and juice was satisfactory.

KEYWORDS: Citrus fruit sorter, Image Processing, .

I.INTRODUCTION

Color and size are the most important facial appearance for accurate classification and sorting of citrus fruits. Because of the ever-growing need to supply high quality food products within a short time, automated grading of agricultural products is getting special priority among many farmer associations. The momentum for these trends can be attributed to increased awareness by consumers about their better health well-being and a response by producers on the need to provide quality guaranteed products with consistency. It is in this context that the field of automatic inspection and machine vision comes in to play the important role of quality control for agricultural products. Fruit size estimation is also helpful in planning packaging, transportation and marketing operations. Among the physical attributes of agricultural materials, volume, mass and projected areas are the most important ones in sizing systems (Tabatabaeefar and Rajabipour, 2005; Wright et al., 1986; Safwat and Moustafa, 1971).
In the present article, a new color space for grading citrus fruit is proposed based on maturity stages. The Objectives of this work were:

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

II. METHODOLOGY

i. Selection of illumination and capturing system

Computer vision has been used for quality inspection of fruits. Quality inspections of fruits have two different objectives: quality evaluation and defect finding. In recent years, computer machine vision and image processing techniques have been found increasingly useful in the fruit industry, especially for applications in quality inspection and shape sorting. Researches in this area indicate the feasibility of using machine vision systems to improve product quality while freeing people from the traditional hand sorting of agricultural materials. Raji and Alamutu (2005) reviiewed the recent development and application of image analysis and computer machine vision in sorting of agricultural materials and products in the food industries.

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To select an appropriate combination of illumination and cap- turing 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. 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.

ii. Detection algorithm

A comprehensive study of the physical properties of Citrus fruits is necessary to develop appropriate sorting technologies.

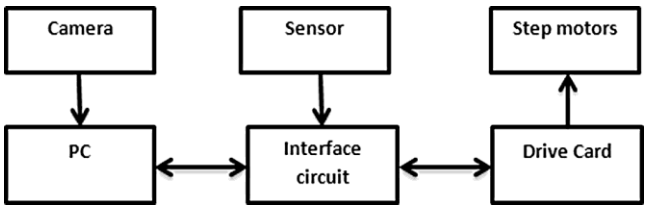

Figure.1 Schematic of sorting producer of Date fruit.

All the samples sorted by machine vision were re-sorted by 3 experts visually. The results from experts and machine vision were compared by the t-test.

III. RESULTS AND DISCUSSION

There were 4 combinations of light sources i.e. 12 V DC power LED and Fluorescent and cameras i.e. Telecam and Proline with 883 \ 556 resolutions. Since the pixel values of standard white card were 255, 255, 255 for red, green and blue components respectively, to obtain a good quality image, the best combination of light source and camera should have the ultimate pixel value of 255.

Color evalutation RGB color space is the most popular color model. Some algorithms of fruit vision are based on this color model (Steinmetz et al., 1996; Leemans et al., 1998; Paulus et al., 1997). When color is presented with R, G and B, the amount of information is tripled. Thus more algorithms could be developed to comprehensively utilize the color information in an image. However, RGB system is sensitive to lighting or other conditions. Another color model is HSI (Hue, Saturation and Intensity). Here we prefer using HSI, as in this system Hue value is comparatively stable. The color of fruit is determined by calculating average Hue (H) value for the fruit. In order to evaluate the color of captured images of fruit, the acquired RGB color information was transformed to HSI color by:

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Grade 1

Grade 2

Grade 3

Figure 2 Selected lemons of various sizes and grades according to human export judgments

A total of 50 randomly selected lemons of various sizes and colors were purchased from a local market for evaluation (Figure 2). Initially the fruits are graded by human expert into 3 classes; 22 into class One, 13 into class Two, and 15 into class Three. The relevant information for these fruits (Averaged Hue value and volume information) were extracted from the above mentioned algorithms as implemented by VB program (Figure 3). The actual volume of lemons was measured using the water displacement method (WDM). In this method, the object is completely submerged in water and the weight of the displaced water measured (Mohsenin, 1970). Even though this method is quite accurate, it is not ideal for objects that absorb water and for some products, this approach might be considered intrusive or destructive. Statistical measures including, maximum, minimum and average values were also calculated

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for three grades (Figure 3). Finally operator selected two threshold for volume and color with obtained data by calibration stage of machine vision system. These two thresholds were minimum volume and hue of grade one. Figure 4 shows the designed interface in calibration.

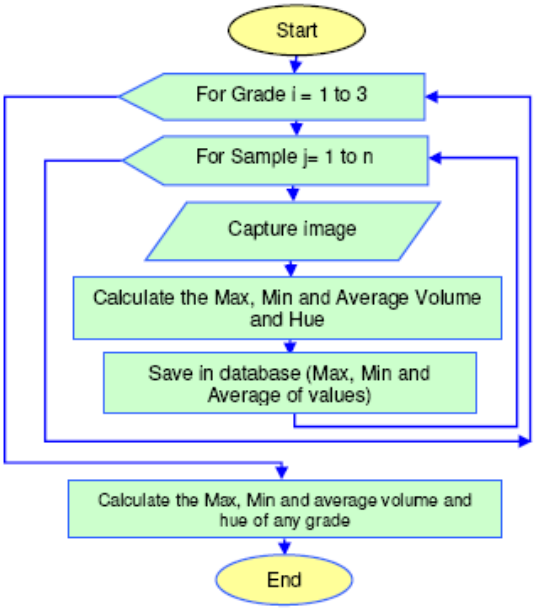

Figure 3. The algorithm of calibration stage.

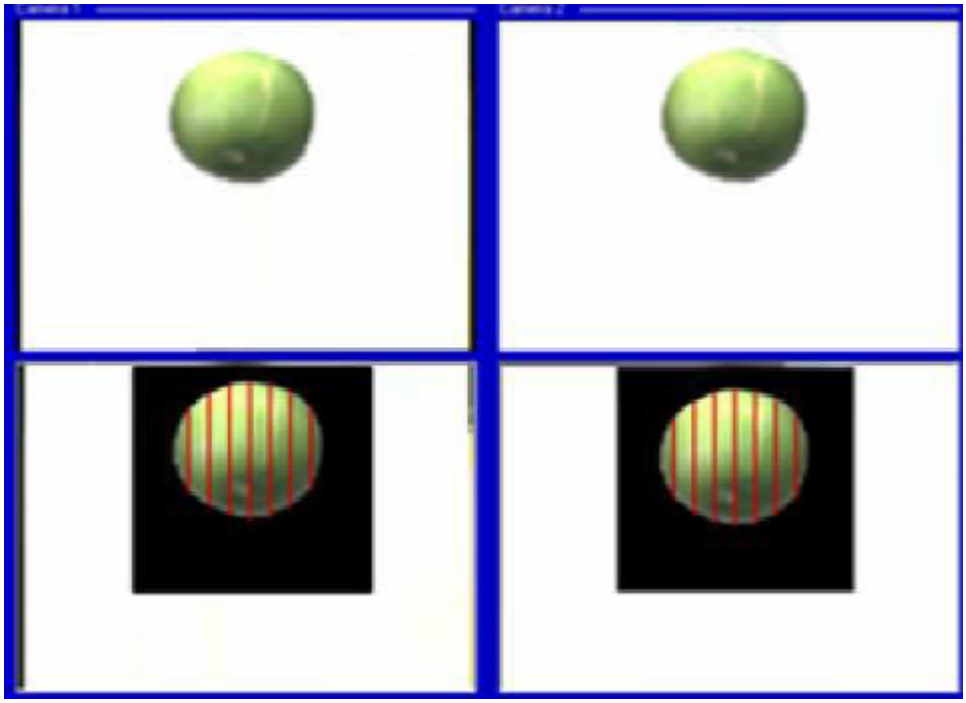

Figure 4. Designed interface in MATLAB programming language.

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	Human Expert
Grade 1	24
Grade 2	16
Grade 3	10

Table 1 Confusion matrix showing the number of correctly classified fruits with the developed machine vision system.

IV. CONCLUTION

In this paper, it is presented a novel approach for development of a sorting system for grading lemon based on color and size. The calibration of system is done by samples of different grades of fruit. The volume and color of fruit determined and saved in database during calibration stage. During sorting stage, the calculated color and volume compared with saved information in database. The final grade of fruit was determined and its center of gravity calculated to be later used for automatic sorting through phenematic mechanism. This algorithm can be easily adapted for grading/sorting different agricultural products such as apple, orange, cucumber etc.,

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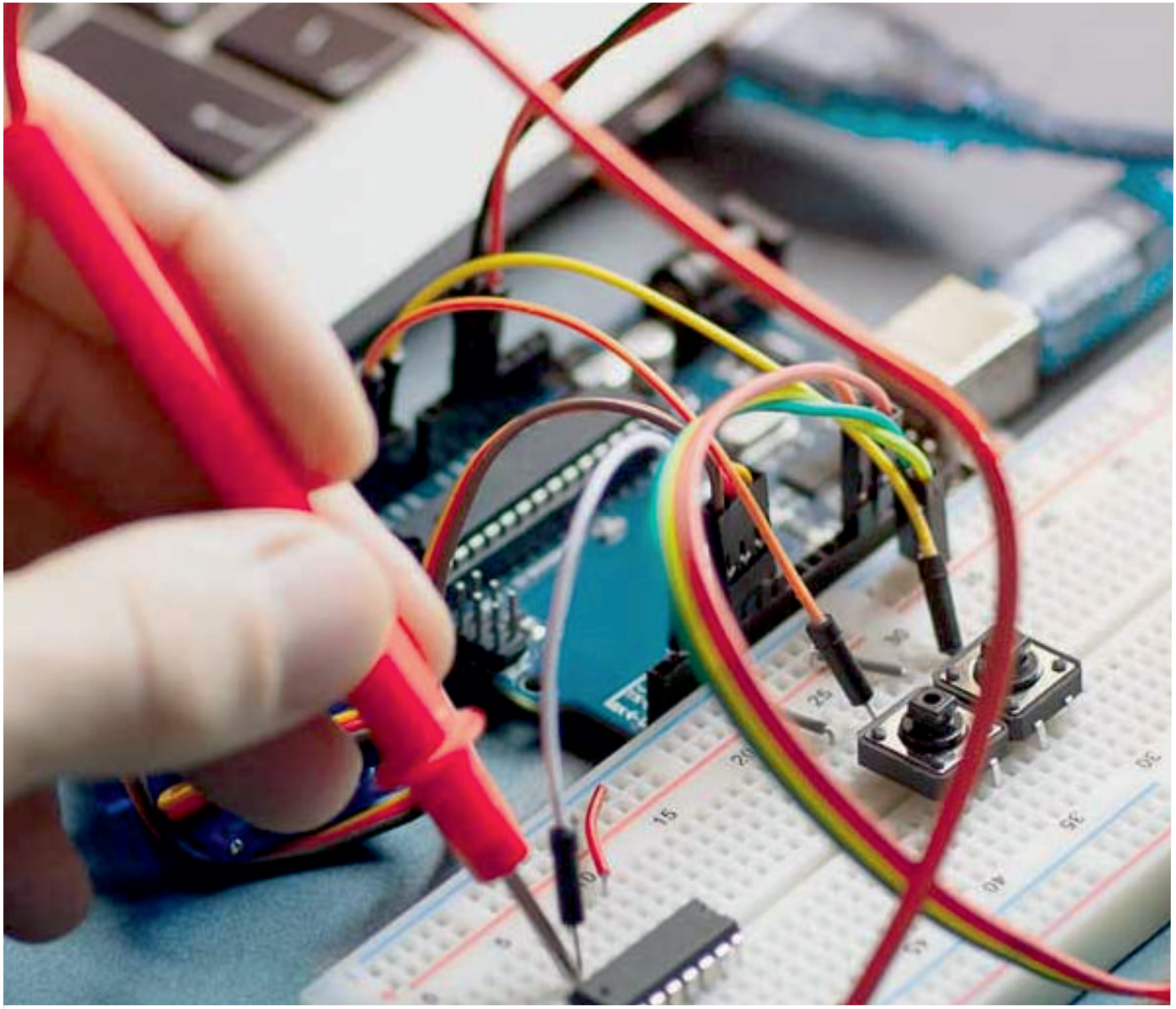

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