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Evaluation of the Efficiency Image Processing Technique in Detecting and Measuring the Volume of Tomatoes

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ABSTRACT

Today, consumers tend to eat high-quality food. Quality uniformity in terms of size, color, weight, volume, and density is one of the reasons for the selection of these materials, especially fruits and vegetables. In addition, the price of these products often depends on their size. In our country, most agricultural products supplied to the market are generally not separated and categorized. As a result, these products are being imported into the market with their waste, which also makes consumers unhappy with their purchases. Therefore, in this study, it has been tried to find a method for estimating the volume of these products. In this study, the method of combining mathematical equations and image processing has been used to measure tomato volume. In recent years, the use of new technologies, such as machine vision and image processing, has been increasing in various fields of the agricultural industry. Machine vision systems in the field of post-harvest agricultural technology play an important role in precise and uniform food control by eliminating the manual inspection of products. A machine vision system consists of two hardware and software components. The specific characteristics of a product (color, size, shape, texture, pests) can be measured for volume determination and categorizing by providing images of the product under investigation and using image processing techniques with specialized software as well as providing the appropriate detection algorithm. In this research, 20 tomatoes were used to examine the efficiency of using the image processing method in the volumetric data of this product to be able to compare the volume of the measured product with two methods of water displacement and image processing after digitizing the images. The data of the product volume were transferred to the Excel software using the image processing method and the data measured by the method of displacement of the water and statistically analyzed. The statistical results were R^2= 0.94 (Explanation coefficient) and the value of SEE = 125.5312 and RMSE = 2.3362 (lowest standard error), which indicates the high utilization of the image processing method in measuring tomato product volume.

Keyword: Tomato, volumetric modeling, image processing, sorting, volume measurement.

INTRODUCTION

Volume is one of the characteristics of agricultural products, which is very important given the willingness of consumers to buy and consume the same size and uniform products because changes in volumetric mass are negligible in most agricultural products product mass can be counted and used for sorting products measuring the volume of the product [3]. Sorting is a term meaning product grading and categorization. Indeed, sorting of agricultural products refers to the grading of all kinds of fruits and other agricultural products based on size, color, appearance, and other factors, and the separation of impurities, fruits, and products that are corrupted. In most cases, sorting is an introduction to packaging agricultural products. In addition, in the markets of fruits and vegetables in modern societies, almost all fruits and vegetables are put up for sale and labeled, which makes it easier to identify the quality of the product by the customer, which will result in more regular distribution and supply. It is certain that all the fruits of a tree are not the same size and little apples or small tomatoes should not be sold as much as a standard sized tomato or apple. Such a situation has several negative aspects. First, the consumer refuses to buy such a product, in which the product will remain unsold and the works of the manufacturer will be wasted. Second, if the buyer is compelled to buy such a product, he will be abusive, and thirdly, usually such products will be eliminated from the consumption cycle as waste, either at the beginning or at the end of the consumption line. However, sorting provides a consumer-demanded product by separating and grading the product, as well as pricing appropriately on each one. At the end of the grading process, that part of the product that cannot be marketable can be sent to processing plants and conversion industries. Today, sorting and equipment science and technology related to the grading and categorization of agricultural products have progressed in

advanced societies to such an extent that, in most agricultural units or in the vicinity of them, there are a variety of sourcing equipment, which facilitates the initial packaging and transporting the product gives more value added to farmers in these countries [9].

Unfortunately, sorting and packaging of fruits, vegetables, nuts, etc. are still considered as a fantasy, luxury and luxurious talk in our country that will increase the price of product supply, and especially the traditional society continues to use bulk and unloaded products. Grading and packaging of agricultural products have contributed to the maintenance, protection and standardization of products. Supply of the same size, sorted, and packed products is finding new foreign markets and increasing the exports and entry of the currency to the country. The use of frozen and packed agricultural products has led to the development of modern chain stores and the gradual elimination of the traditional supply of industrial products, one of which is the decline in the growth of small and traditional commercial space in residential space and the uniformity of supply prices as well as a more modern system of supply and control. Selling a variety of agricultural products, such as fruits, vegetables, meat, chicken, dried fruits, etc. graded and packaged in the same and standard parts and sizes, will boost e-commerce in the future. Many buyers can purchase standard and packaged products through online ordering or online shopping. This in the future will eliminate some of the ineffectual trips within the city that are currently seeking to purchase a variety of agricultural products [6].

The most basic method for grading agricultural products has been based on the use of visual capabilities of human resource. In this way, human resources are initially trained to be able to identify and distinguish healthy products from damage by using a predetermined pattern. In many cases, other indicators, including the size and mass of the product, are also added to the product separation characteristics. The use of this method involves problems such as the inability of the user to detect subcutaneous and internal damage to the product, user fatigue, visual error, low speed of work, and a lot of time and money wasting, which has led to the abolition of the manual method in today's large-scale production lines [4]. Currently, visualization of a machine is one of the most widely used non-destructive methods, because a major part of the automatic quality control system in these methods is the visual sensor [8]. Prakash et al. discussed on image processing using the MATLAB software to identify weed areas in a land-captured image to enhance the productivity of fertilizer on the ground by reviewing the photo [11].

The machine vision method is rapidly replaced by manual methods because of its advantages such as non-destructive, lower labor costs, higher accuracy, constant results in different conditions, and the ability to examine bodies in visible and invisible light [5]. Size is one of the parameters that determine the quality of external products in some products that are determined in the machine vision using surface, volume, environment, or diameter [2]. The large variety of shapes and sizes of products such as tomatoes and their vulnerability make it difficult to isolate these products through mechanical methods. Thus, using electronic methods to determine shape and size can be useful [7]. Carlos et al. also examined some of the product performance evaluation criteria to help researchers when selecting and developing new computer applications that are used to process fruit images [10].

Performance evaluation and recognition of fruit maturity have been evaluated using image processing systems by Aydin and Polati and in particular, factors such as the size, shape, and color of the fruit have been performed for quantitative and qualitative evaluation using image processing [1]. Sorting products such as tomatoes has an effect on reducing the waste caused by bulk transportation of tomatoes and other soft fruits, because the primary sorting in the fruit carrier boxes causes a balanced distribution of the pressure caused by the weight of the fruits in the boxes and too much pressure, cracking and crushing of the underlying fruit will be reduced by transport. For this reason, this research was carried out in order to find a way of sorting tomato products.

MATERIALS AND METHODS

Twenty tomatoes were randomly selected as samples, and then, the specimens were thoroughly washed and placed in a suitable place to evaporate their surface water. The specimens were captured in a machine vision system, comprised of an imaging chamber, a camera, and lighting. A SMD light-emitting diode was used for illumination, and a CCD camera was used to shoot the test. Tomato images were taken at a resolution of 768 x 576 pixels and transferred to the computer. The method used was to transfer images to MATLAB software for processing and binary processing. Then, the image binary processing performed using the appropriate algorithm, by the codes for image processing. The area of the tomato and the border of the image were separated and tomatoes appeared in the form of black pixels. Subsequently, the number of pixels on the tomato surface was counted by the software using the black pixel counting code (Figure 1).

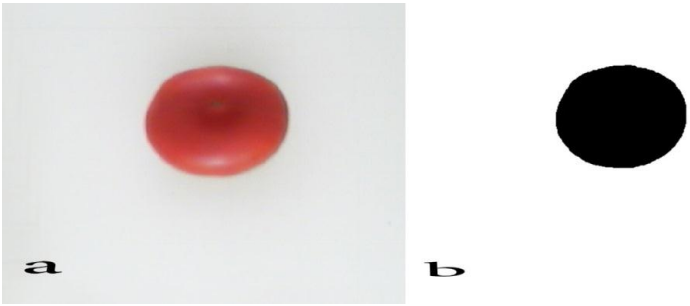

Figure 1. Images from left to right: a. a picture taken by camera b. Separation and binary processing of tomato

Then, the number of these pixels was converted to the area per square millimeter using the pixel-to-area conversion scale. The method of scaling is to conduct the image processing on a square of 100 mm in size, each of which is 10 mm in size. Then, the number of pixels in the same area of the image is counted by the camera by MATLAB software. It is determined that each millimeter of tomato area contains a few pixels of the photo, and this measure will be a measure of the number of pixels to the area in millimeters. Thus, the radius of tomato can be calculated and then its volume is calculated by the image processing method and using Equation (1).

$$v = \frac{4}{3}\pi r^3 \quad (1)$$

In which,

v= Tomato volume in cm^3

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r= Tomato radius in cm

π = is equivalent to 3.14159

Another method that is used to measure volume and is considered as a precise method is to calculate the volume by using the water displacement method. In this method, a 500-cc beaker and a scale were used. Twenty tomatoes were numbered and put into the full of water beaker so that tomatoes are suspended in the beaker and have no contact with the body of the beaker. In this case, the amount of water mass was read from the scale with the beaker and the number was reduced from the water mass of the beaker. This work was done for 20 tomatoes and then, the values were divided by the water density to get the volume of each tomato. In this method, equation (2) was used to obtain the volume. Then, the calculated volumes were recorded with image processing methods and water displacement method in Excel software. Finally, the values of RMSE, R^2 and SSE were calculated and reported using MATLAB software.

$$V=\frac{M_{dw}}{P_w} \quad (2)$$

In which,

M_{dw}= Tomato mass in gr

P_w=water density in gr/cm^3

DISCUSSION AND CONCLUSION

As was mentioned, in this research, the image was first captured by the camera and the color images were processed using MATLAB software, and tomato volume was calculated using the image processing method. Then, the real volume of the tomato was also measured using the water displacement method, in centimeter cubic meters. According to the data extracted from the statistical analysis of the comparison of the volume of measured tomato product with the method of water displacement and comparison of this method with the method of estimating the volume of the product using the image processing method, the results indicate the appropriate accuracy of this method in measuring the volume of tomato product. Therefore, this research can be the basis for designing and manufacturing a device that can perform the grading of tomato product in the shortest time based on the volume of the product using the taken images and processing them. In this method, the data of the product volume were transferred to the Excel software using the image processing method and the data measured by the method of displacement of the water and statistically analyzed. The statistical results were R^2= 0.94 (Explanation coefficient) and the value of SEE = 125.5312 and RMSE = 2.3362 (lowest standard error), which indicates the high utilization of the image processing method in measuring tomato product volume.

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