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Feasibility of Image Processing Techniques to Estimate the Volume of Tangerine

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ABSTRACT

Measuring the volume of agricultural products, especially fruits, is one of the mainstays of the agricultural sector and the conversion industry for various reasons, such as packaging, the process of transferring, food separation, pricing, product trade and sales, as well as product maintenance. The machine vision and image processing systems are new methods used in the agricultural sector. Due to the fact that these systems are used for grading different products, 20 tangerines were used in order to calculate the volume of tangerine volume using an image processing method in this research. This was done 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= 0.90 and the value of SEE = 56.5898 and RMSE = 1.5686, the ability to use the image processing method to measure the volume of tangerine.

Keywords: Image processing, real volume, volume measurement, tangerine, measurements (sizing, scaling).

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 [6]. 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, almost all fruits and vegetables in the markets of fruits and vegetables in modern societies 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. 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 [11]. 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 [7].

In recent years, the visual machine and image processing have been significantly effective in the agricultural industry, especially in qualitative inspection and grading in terms of shape. Researchers have examined the possibility of using systems to improve the quality of production without the need for human resources and without the manual assessment system for agricultural materials and products. The studies indicate that the visual machine is a useful system for measuring external properties such as color intensity, uniformity of color, surface banding, size, shape of fruits and vegetables, and identification of the stem. The system is also able to operate in a long time and continuously. On the other hand, the ability to define classification criteria in the automated way and software allows the possibility of changing the separation criteria for different varieties of a product. While training these criteria to human resources requires a great volume of time and money [4].

In general, the science of image processing is the set of operations and methods used to reduce defects and improve the quality of the image in various fields. This science is one of the most popular sciences in the world today, many studies have been conducted in this field for a long time, and many advances have been made in this regard. The pace of development of these advances has been so high that now and after a short time; the effect of this science can be clearly seen in many sciences and industries. This science, which is becoming more important in today's world, is almost in the middle pace in our country [14]. With increasing expansion of different methods for obtaining discrete information such as scanners and digital cameras, image processing have been used extensively in industrial, military, meteorological, medical, and robotic sectors, which are not excluded from the agricultural sector. The main role of image processing is to create a new image in such a way that the parts of the image that are desired in the new image are improved in terms of quality and the waste segments of the image are deleted. Most machine vision systems include general methods for initial image processing algorithms such as noise removing, image editing and image area correction. The pixel values of two different images may be combined based on image processing algorithms subtracted from each other, or multiplied by a coefficient to reveal changes occurring between different regions of the image.

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 [13]. 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 [12]. 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].

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 [8]. Determining the volume of the product plays a major role in packaging issues and its related parameters such as box dimensions, how to place the fruit, the packaging coefficient (the number of products in a given volume). The calculations related to the volume of cells and warehouses, the processes of transfer and grading and separation are possible through measuring the volume [15]. Various methods have been proposed to determine the volume of agricultural products, including water displacement, geometric shapes similarity[10], 3D model reconstruction using image processing[9], the use of The use of regular geometric shapes[2,3], the use of the average surface of the image [10] and the method of water displacement. In this method, the volume of the product is obtained through dividing the floating force (displaced mass) by water density [15]. What has been addressed in this study is the use of two-dimensional imaging of a tangerine product to estimate the volume of this product.

MATERIALS AND METHODS:

Twenty tangerines were used to compare the volume measurement with two methods of image processing and volume measurements using water displacement. In the first method, which is the method of estimating the volume using the image processing, the tangerines were first numbered and then each one was placed inside the lighting enclosure to obtain the images and then to be stored for subsequent processing. The lighting enclosure used in this study has a trapezoidal shape with a 45-degree angle. Investigations on the types of lighting enclosures have shown that the trapezoidal lighting system is preferable to lighting, bilaterality, deployment of lamps in comparison to other methods and lighting enclosures. Therefore, the design and construction of this type of enclosure was considered for the lighting unit of the device.

Due to the specific shape of the enclosure, the light could be uniformly distributed in all directions and reflected in the walls in the same way uniformly in all directions [5]. Since there was a more uniform playability on the tangerines, the color of the inner walls of the enclosure was chosen white because the white color also contributed to a better, more uniform reflection of the light. Given that the height of the camera should be adjusted so that at only the image of a single tangerine is taken by the camera at the time of shooting then the height of the enclosure is 40 cm, so that the height of the camera can be adjusted.

A SMD light-emitting diode was used for illumination, and an analog camera was used to shoot the test. Tangerine images were taken using an analog capture card at a resolution of 768 x 576 pixels and transferred to the computer. The images were then transferred to the MATLAB software for processing and binary processing. Then, the image binary processing performed using the appropriate algorithm, by the codes for image processing that differentiated between the tangerine and the margin of the image. While performing image processing, the images related to tangerine were black and the image border was white in color (Figure 1). Then, the number of pixels in the coaxial region was counted by the software using white pixel counting codes. Then, the area of these pixels was converted to area in millimeters using pixel conversion scale. In scaling method, the area of an area has been measured with the dimension of 1cm^2 using a square whose area is 100 mm^2. Then the number of pixels in the area is counted by the software from the image captured by the camera and it is determined that each millimeter of the area contains several pixels of tangerine from the photo, which is the measure of the size of the number of pixels to the area in millimeters. After the image scaling operation, the number of pixels was counted for each millimeter, and 861,2188 pixels per millimeter of image was obtained.

Then, the average radius of the tangerine can be calculate using the obtained area and its volume can be calculated using Equation 1.

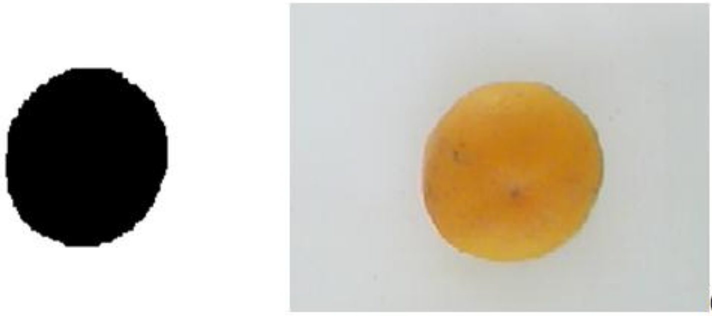
$v = \frac{4}{3}\pi r^3$ (1)

In which,

v= tangerine volume in cm^3

r= tangerine radius in cm

π = is equivalent to 3.14159



(b) (a)

Figure 1. Tangerine image before (a) and after binary processing (b)

The second method, which is used to measure volume and is considered as a precise method, calculates volumes using the water displacement method. In this method, a 500-cc beaker and a scale were used. Twenty tangerines were numbered and put into the full of water beaker so that tangerines 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 tangerines and then, the values were divided by the water density to get the volume of each tangerine. 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= $\frac{M_{dw}}{P_w}$ (2)

In which,

M_{dw}= tangerine mass in gr

P_w=water density in gr/cm^3

DISCUSSION AND CONCLUSION:

According to the data extracted from the statistical analysis related to comparison of the measured volume of tangerine product by 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 tangerine. Therefore, this research can be the basis for designing and manufacturing a device that can perform the grading of tangerine 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= 0.90 and the value of SEE = 56.5898 and RMSE = 1.5686, the ability to use the image processing method to measure the volume of tangerine.

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