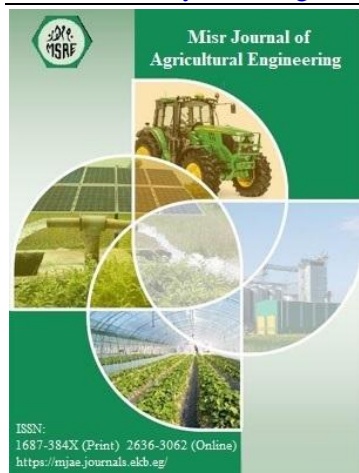# AUTOMATIC CLASSIFICATION USING IMAGE PROCESSING TECHNIQUE IN MATLAB FOR ORANGE FRUITS

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ABSTRACT

This research develops an automatic algorithm for orange fruits sorting image processing technique in MATLAB (7.8) program. The orange fruits were acquired using a digital camera in illumination chamber. A picture handling system was produced to quantify the volume and size of orange fruits. Surface images of every orange, caught with an advanced camera, were used in the picture preparing method. An effective calculation was structured and actualized in MATLAB (7.8) programming. The volumes figured demonstrated great concurrence with the real volumes dictated by water displacement technique. The coefficient of determination "R2" of orange was more than 98%, and the size code by the MATLAB Graphical User Interface (GUI) for orange fruits was concurrence and fast compared to the manual method for sizing. Image processing strategy palatably evaluated orange volume and size. In like manner, image processing gives a precise, straightforward, fast, and noninvasive technique to evaluate orange fruits volume and size and can be effortlessly executed in arranging of orange fruits amid postharvest processing.

1. INTRODUCTION

For the most part, the regularly expanding populace, misfortunes engaged with preparing and the expanding demand of products of high caliber with great appearance, there is a requirement for the advancement of exact, quick, and centered quality assurance of sustenance and horticultural items like fruits and vegetables.

Since, evaluating basically done by experiencing specialists who work along the transport frameworks, certain work – related issues, including rising work costs, generation squander on account of conflicting arranging and grading and human mistakes, are tormenting the potato-bundling industry **(Zhou *et al.* 1998)**. Other than the inconsistency and subjectivity, the manual procedure is extremely repetitive, difficult, exorbitant, and is effectively influenced by encompassing conditions **(Razmjooy *et al.* 2012)**.

Arranging of rural items is proficient dependent on appearance (shading and nonattendance defects), surface, shape, and sizes. Manual arranging depends on conventional visual quality inspection performed by human administrators, which is dull, tedious, moderate, and non-consistent. It has turned out to be progressively hard to contract ability that is satisfactorily prepared and willing to embrace the monotonous assignment of examination. These reasons make the product quality not adjusting to particulars and quality guidelines set for the

agricultural items per the prerequisites of the global market on account of export. A savvy, reliable, predominant speed, meeting quality models and precise sorting can be accomplished with machine vision and picture handling strategy in arranging and grading tasks of horticultural items. Picture preparing is the utilization of a PC to analyze an image with the end goal to extricate significant data good and gone. Utilizing this powerful device, precise data, for example, the pictures shape, volume, size, or appearance, can be gotten from a question that could not be effortlessly acquired by human perception.

The most important parameter in adjustment, transportation, delivering, and packaging systems is physical properties of farming items. Among these physical properties, volumes, mass, surface area and center of gravity are their most critical in valuing systems. The major physical properties of citrus natural products are shape, size, density, porosity, volume, and mass of foods grown from the ground against different surfaces (**Akar and Aydin, 2005**). These properties have been considered for different horticultural items, for example, breadfruit, natural products, onion, almond, escapade, myrtle, orange and pomegranate (**Omobuwajo *et al.* 1999**; **Aydin and Ozcan, 2002**; **Abhayawick *et al.* 2002**; **Aydin, 2003**; **Sessiz *et al.* 2007**; **Aydine and Ozcan, 2007**; **Hassan, 2002** and **Khoshnam *et al.* 2007**). The span of foods grown from the ground is essential physiological property that can be portrayed by various parameters, for example, volume, weight, length, and distance across (**Moreda *et al.* 2009**).

In the rural division, the effectiveness and the precise evaluating process is exceptionally basic to expand the efficiency of create. Ordinary brilliant natural products are traded to different nations and create a decent salary. That is the reason for evaluating procedure of the natural product is critical to enhance the nature of fruits (**Ge, *et al.* 2007**; and **Sadegaonkar and Wagh, 2015**).

The goal of this examination is to build up a picture handling strategy for determination of orange size and volume using MATLAB Graphical User Interface (GUI) that are essential for planning an extraordinary machine or analyzing the subsequent conduct in transporting items.

2. MATERIALS AND METHODS

Image acquisition

The picture catch chamber utilized in this investigation appeared in **Figure 1** was based on that exhibited by **Kang *et al.* (2008)**. The internal size of the light box is 70×70×50 cm. Two fluorescence lights (TL-D Select, 18W/965, Philips) were attached at the top corner of the light box, in parallel, at an edge of 45◦ to the item area **Papadakis *el.al.* (2000)**. The two lights were secured with diffuse secures. This light box is intended to enlighten an A3 measure area. With the end goal to enlighten this vast surface as equally as would be prudent, within walls and roof were painted white, while the floor (background for the photographs) was painted dark to anticipate reflection. A digital camera (Samsung ST65) capture pictures through a gap on the top surface. The camera settings for this test were: manual mode ISO200; without using zoom and flash; resolution 14 MP; format JPEG.

Approach including assurance of orange fruits volume and size by picture handling method incorporates picture securing errand according to (**Eissa**, *et. al*.,**2012**), assurance of relationship recipe, picture processing undertaking. These means are additionally explained in the accompanying sub-segments. **Figure 2** summarizes the methodology involved.
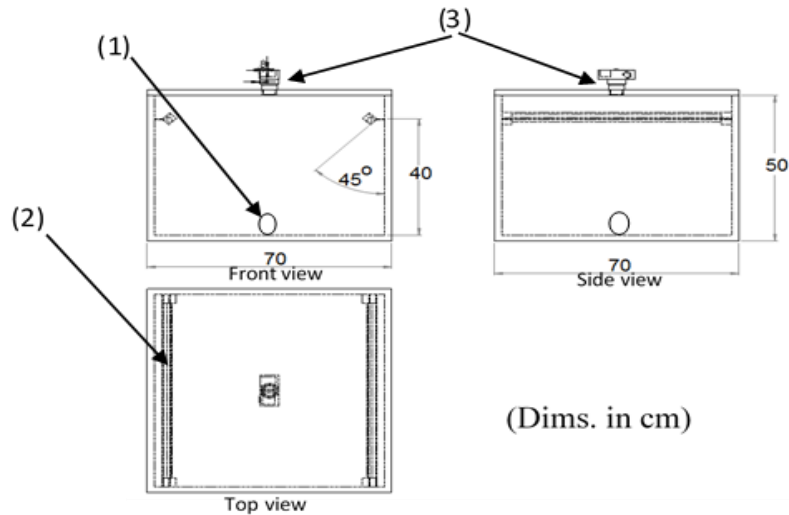
Figure 1: Capturing champer views. Where 1) Orange fruit sample, 2) Philips, TL-D Delux, 18W/965 Fluorescent lamp, 3) Digital camera.
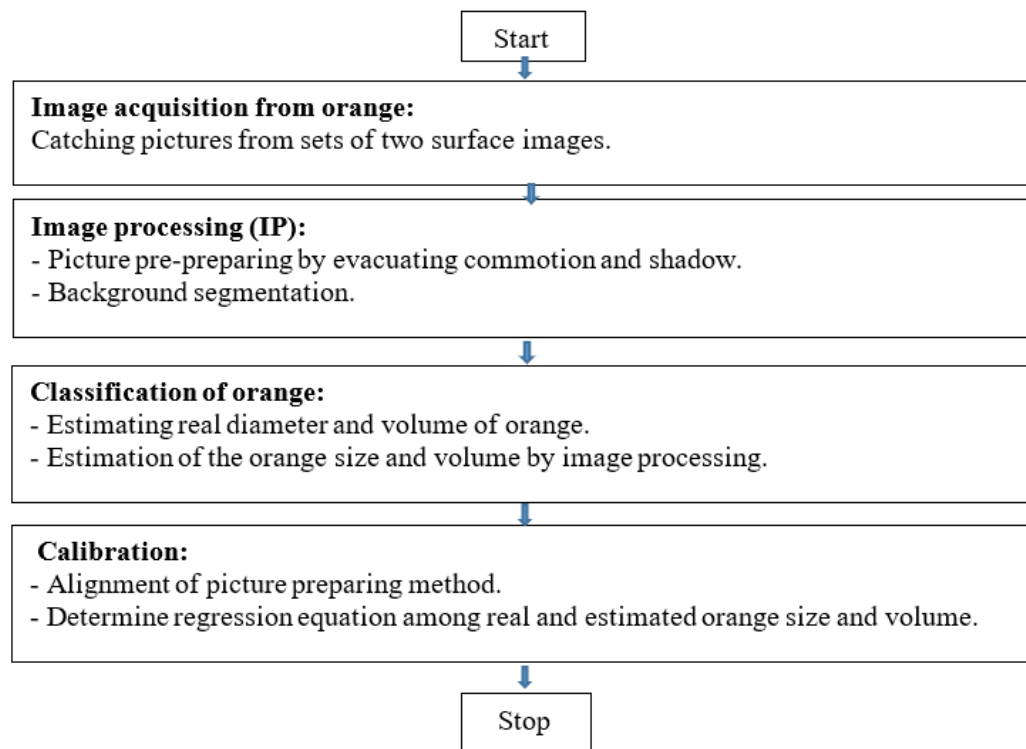

Figure 2: Methodology adapted in this research

Image processing

A PC program, written in MATLAB 7.8, was created for handling, and investigating the caught pictures. The program naturally records the surface pictures of the example fruits.

Image pre-processing:

In this progression the shading picture is changed over to a grayscale picture, called the power image. To lessen the computational time of handling the pictures were sub-sampled to 818*527 pixels.

Segmentation

The division procedure included the accompanying advances: (1) change of shading picture to grey-scale esteems; (2) utilization of an edge and foundation subtraction to acquire the binary

picture; (3) shutting the little loud openings inside the object; and (4) covering the shape of the twofold picture to the first shading image, as follow recommended by **Naik and Patel 2017**.

Classification of orange fruit:

Fruits samples: 39 oranges samples were utilization of Washington navel orange assortment amid test periods. Tests were given in various sizes. Organic products were chosen for opportunity from defects via watchful visual investigation, exchanged to the research facility to utilize. the example of orange was chosen haphazardly from the field of Daltex Organization situated at El-Beheira Governorate - Egypt for evaluation.

Measuring actual diameter and volume of fruit

The real diameter for orange samples was determined by caliber (0.01 mm accuracy). And the genuine volume of natural products can be estimated by water displacement method (WDM). The WDM is a standout amongst the most well-known and straightforward methods for estimating the volume of expansive objects, for example, fruit and vegetables (**Mohsenin, 1986**)

$$volume(cm^3) = \frac{Weight\ of\ displaced\ water\ (kg)}{Water\ density\ \left(\frac{kg}{cm^3}\right)} \qquad (1)$$

Estimation and calibrating orange volume

To obtain an index of measuring image processing method (IPM), two images were chosen and after doing pre-processing section, the binary image was obtained. Then, the area of section that was separated had obtained by pixel from this image. Regards that the superficial shape of orange was like spherical body, samples were regarded as sphere. As clear, the volume of sphere is given by (**V=4/3 πr^3**), by obtaining the area of **Figure 3 (Part c)** and that two-dimensional image of sphere is the biggest of its Circumferential circle and its radius is the same as radius of sphere. Therefore, by using obtained area of Circle from image processing method, the radius (r) by pixel from relation (A= πr^2). As Indicated, to calibrate, it was used of two images of orange samples obtained from mean samples chosen randomly. Calibrating was that the ratio of the real volume from water displacement method, and the volume by pixel from image processing method was calculated. This ratio was used to convert the volume by pixel of other samples of orange and their volume was obtained by cm3, according to **Fellegari and Navid (2011)**.
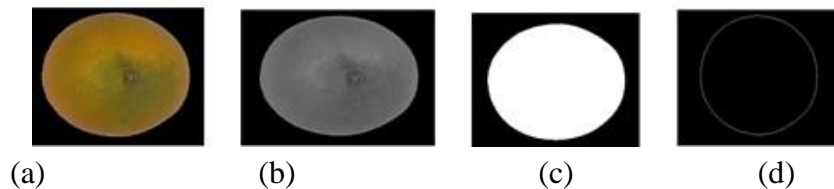

| (a) | (b) | (c) | (d) |

Figure 3: (a) Original RGB color, (b) grayscale, (c) black-and-white and (d) outline images of orange.

The images were converted to gray scale images then the binary images were obtained using a random threshold and the holes of oranges in images were constructed. Then images were labeled. Finally, determination of the orange fruit size and volume of the imaging were performed at **G**raphical **U**ser **I**nterface (GUI) that created in MATLAB 7.8 using image processing toolbox (**MATLAB 2009**) as shown in **Figure 4.**
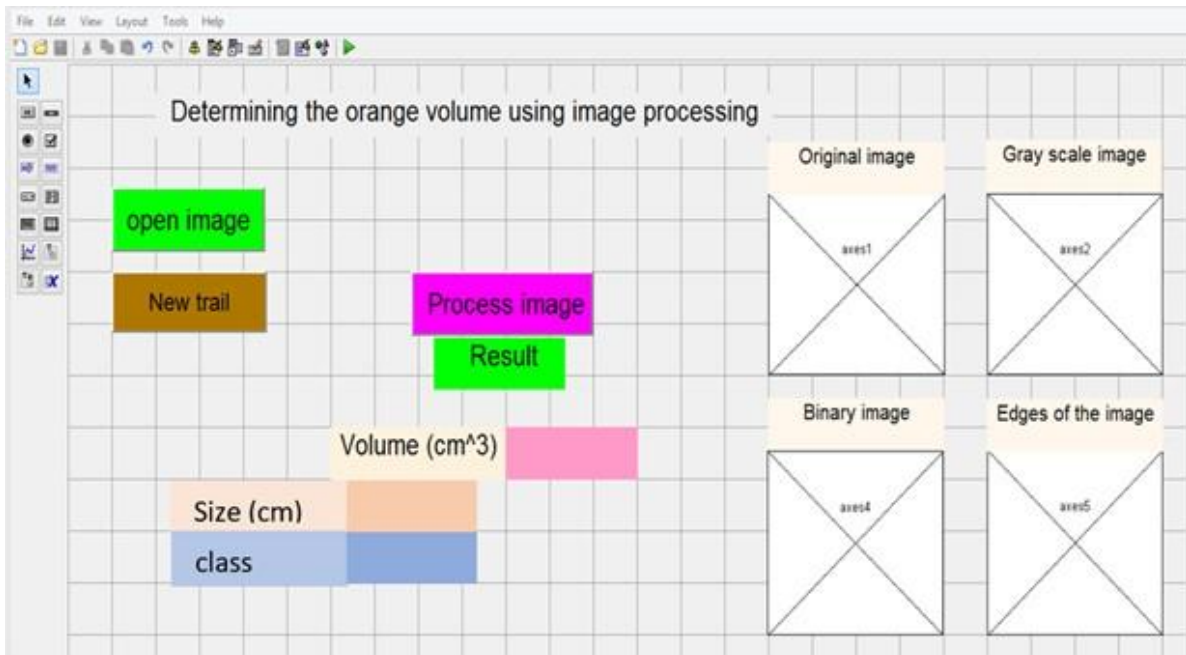
Figure 4: Graphical **U**ser **I**nterface (GUI) layout

Approximation of the orange size by IP.

Size is determined maximum diameter of fruit equatorial section, in accordance as in **Table (1)**.

Table (1): The size code by diameter according to (**European Commission, 2011** and **Codex Alimentarius, 2005**).

Size Code	Diameter (mm)
0	92 – 110
1	87 – 100
2	84 – 96
3	81 – 92
4	77 – 88
5	73 – 84
6	70 – 80
7	67 – 76
8	64 – 73
9	62 – 70
10	60 – 68
11	58 – 66
12	56 – 63
13	53 – 60

3. RESULTS AND DISCUSSION

Estimation of orange volume image processing

In this research a demo was developed by using MATLAB (7.8) software to extract the final orange images and processing and then the volume and size code were determined.

The figure (5) represents the volume and size of orange under clicked the process image button. From the observation based on figure, the surface of captured image is converting to gray image then convert to binary image to determine the orange fruit volume and size.
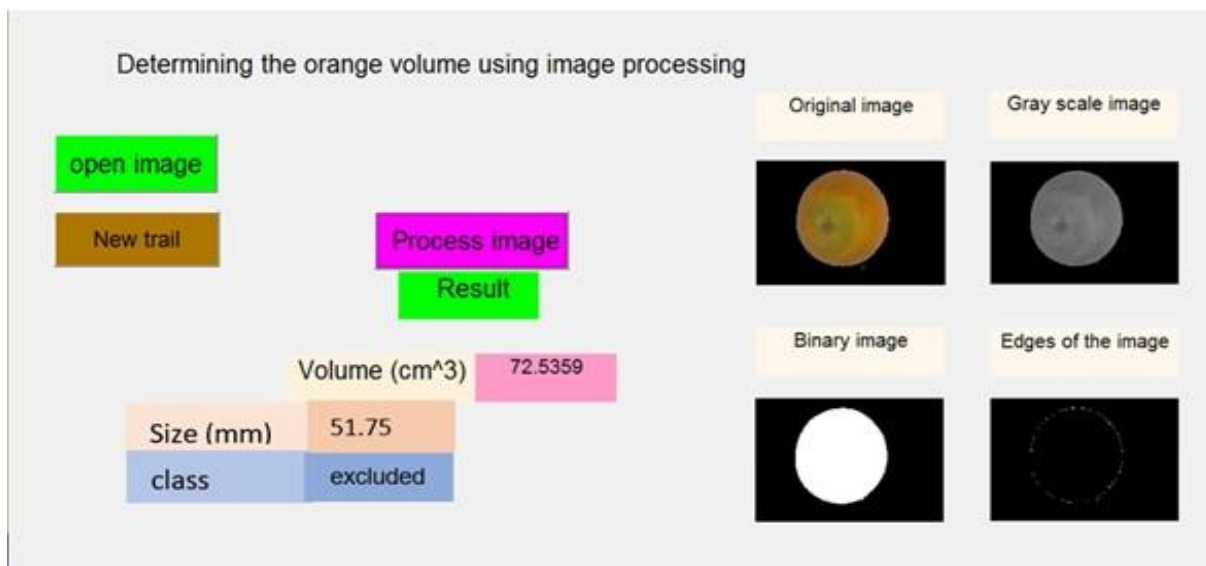

Figure (5): Determining the orange volume and size using image processing (GUI)

Orange calibration results

The volume of twelve being used samples were calculated by WDM and everyone were obtained by relation sphere volume (r). Also, (r) was calculated in image processing method (IPM) using area. Finally, ratio (r) calculated from WDM volume to (r) calculated from IPM was cleared for every sample. Then mean of both ratios was considered for all samples as calibration ratio. This ratio was equal to 0.261. Results from image processing method that converted to sample volumes using ratio in calibration, it has obtained along volume data calculated from base WMD in **Table (2).**

Comparison of image processing method with actual method

The results of comparison between predicted (IP) and actual (WDM) volumes of orange fruits are shown in **Figure (6).** The correlation coefficient (R^2) for orange was more than 0.98. The R^2 values can be interpreted as the proportion of the variance in the IP estimates attributable to the variance in the actual measurements. The higher value of R^2, it means the IP results are closer to the actual (WDM) results. The proposed IP method yielded above 98% accuracy in estimating orange fruit volume, So IP method can be used in estimating orange fruit volume.

The results of comparison between predicted (IP) and actual diameter of orange fruits are shown in **Figure (7).** The correlation coefficient (R^2) for orange was 0.99. The R^2 values can be interpreted as the proportion of the variance in the IP estimates attributable to the variance in the actual measurements. The higher value of R^2, it means the IP results are closer to the actual results. **Figure (8)** illustrate the determining the size of orange fruits by measuring the diameter by image processing (IP) and caliper methods, this groups from size by marketing standards (**European Commission, 2011** and **Codex Alimentarius, 2005**), the results showed that the size categories were closely via using the two methods.

Table (2): Volumes and size obtained from both methods for all samples studied.

	Size (diameter) (mm)			Volumes (cm³)	
	Average dia. (pixel)	Dia. (mm) IP	Dia. (mm) caliper	WDM	IPM
1	136.42	35.57	36.22	22.10	23.54
2	139.42	36.35	36.89	25.47	25.13
3	142.26	37.09	38.88	21.80	26.69
4	147.39	38.42	38.00	39.42	29.69
5	152.46	39.75	38.77	42.17	32.86
6	153.65	40.06	38.65	36.84	33.63
7	153.74	40.08	41.68	40.89	33.69
8	172.49	44.97	45.54	57.92	47.59
9	182.45	47.56	46.15	66.48	56.31
10	182.45	47.56	46.85	58.48	56.31
11	187.89	48.98	50.49	62.97	61.50
12	197.75	51.55	52.24	71.81	71.70
13	209.05	54.50	56.61	95.07	84.71
14	210.94	54.99	55.67	97.08	87.03
15	212.90	55.50	54.67	87.20	89.48
16	219.34	57.18	57.85	87.45	97.85
17	223.83	58.35	59.46	105.76	103.98
18	225.12	58.69	58.83	95.33	105.79
19	228.55	59.58	57.95	100.57	110.69
20	230.36	60.06	61.32	100.88	113.36
21	230.95	60.21	61.44	107.63	114.23
22	235.35	61.36	62.43	114.40	120.88
23	239.78	62.51	61.85	140.41	127.83
24	240.56	62.71	62.30	145.50	129.08
25	247.07	64.41	65.72	148.82	139.85
26	257.41	67.11	66.21	150.68	158.16
27	260.72	67.97	68.75	154.03	164.34
28	262.32	68.39	66.93	152.66	167.38
29	264.20	68.88	69.48	184.80	171.00
30	268.37	69.97	71.11	174.93	179.24
31	287.20	74.87	73.36	237.94	219.66
32	287.20	74.87	75.44	210.94	219.66
33	289.49	75.47	74.67	235.52	224.96
34	289.83	75.56	75.70	250.21	225.74
35	301.00	78.47	77.84	225.71	252.88
36	317.04	82.65	81.32	270.60	295.48
37	318.99	83.16	82.11	288.35	300.97
38	321.94	83.93	82.55	325.67	309.42
39	354.11	92.32	91.22	420.28	411.74
Mean	**230.31**	**60.04**	**60.08**	**134.74**	**133.95**

Anyway, in addition IPM to calculate size and volume of orange fruit is not only fast, no harmful, and care ness way, but can obtain the size and volume and size code of many samples simultaneous. Also, this way can be employed in systems after harvesting such as ones which make grouping by sizing and can add separating by diameter and volume to this system to be economic. Other than this, image processing method to identify size and volume, can be even useful pre-harvest processes.
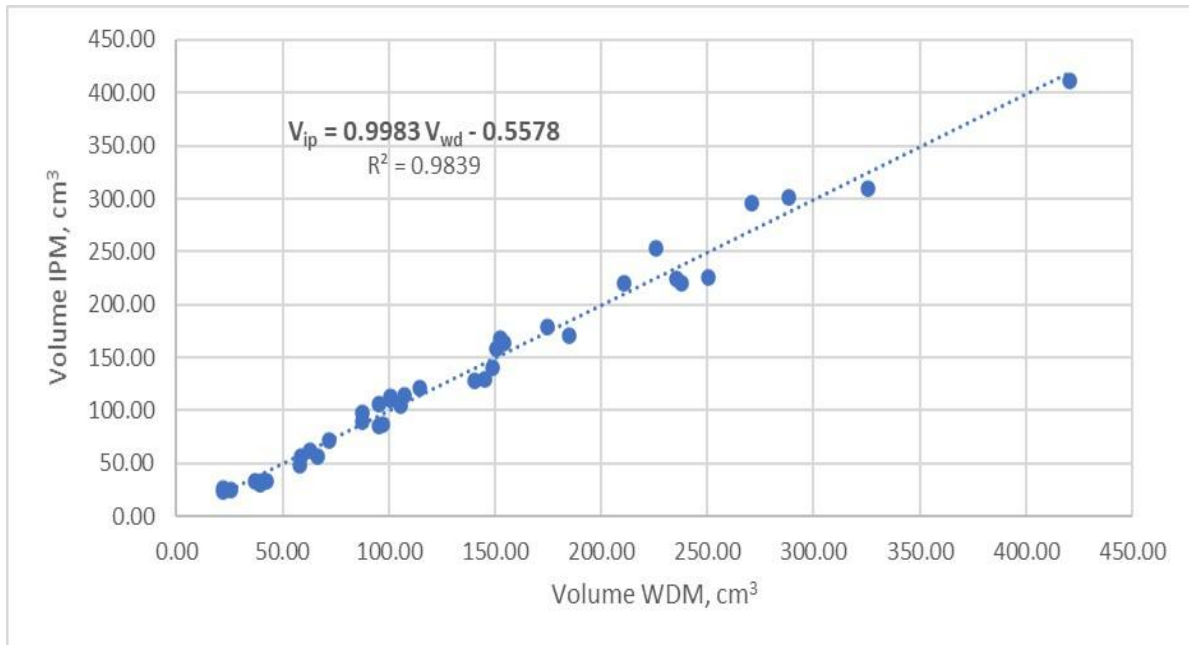

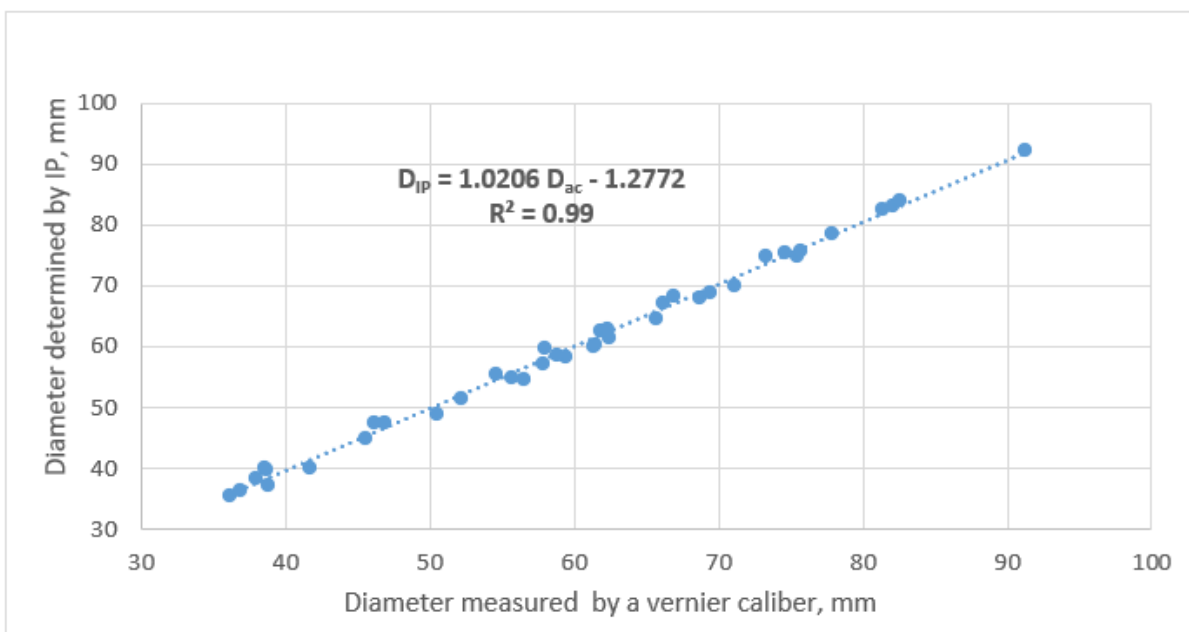**Figure 6:** Calibration of volume of orange fruit with image processing (IP) method.

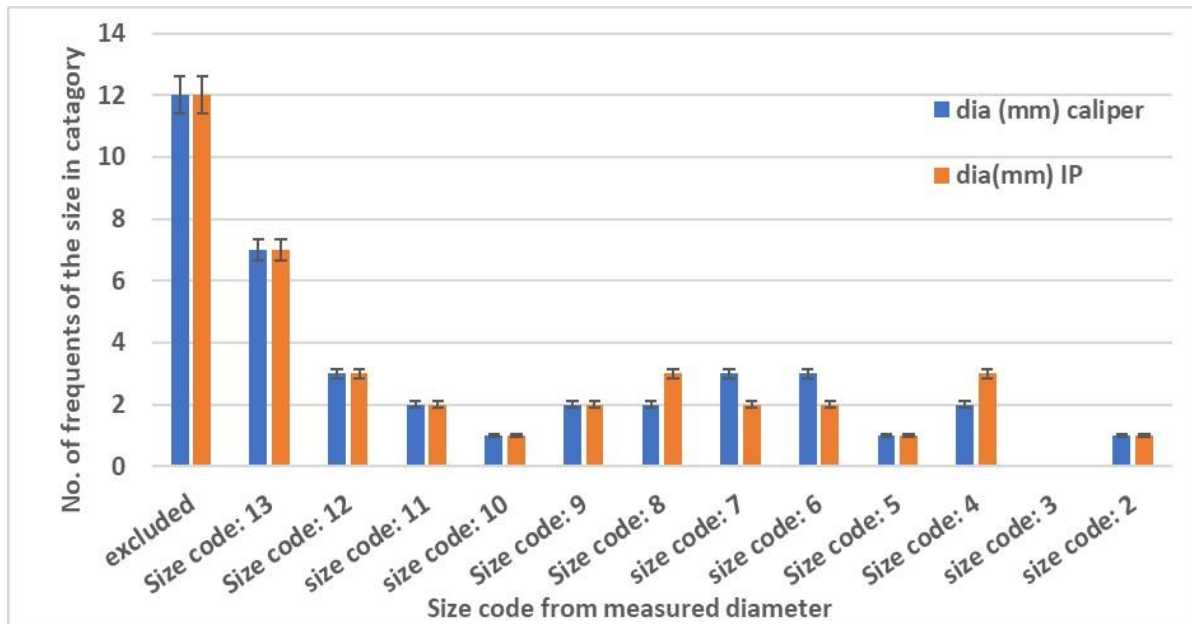**Figure 7:** Calibration of diameter of orange fruit with image processing (IP) method

Figure 8: Evaluation of size category for fruits by caliper and IP methods.

4. CONCLUSION

The image processing method satisfactorily estimated orange volume and size. Accordingly, image processing provides an accurate, simple, rapid, and noninvasive method to determine orange volume and size, and can be easily implemented in monitoring growth development under various management practices and sorting of orange during post-harvest processing.

5. REFERENCES

Abhayawick, L.; J. C. Laguerre; V. Tauzin and A. Duquenoy (2002). Physical properties of Three onion varieties as affected by the moisture content. J. Food Eng. 55(3), 253–262.

Akar, R. and C. Aydin (2005). Some physical properties of gumbo fruit varieties. J. Food Eng. 66, 387–393.

Arakeri, M.P. and Lakshmana (2016). Computer vision-based fruit grading system for quality evaluation of tomato in agriculture industry. Procedia Comput. Sci. 79, 426–433.

Aydin, C. and M. Ozcan (2002). some physico-mechanic properties of terebinth (PictaciaterebinthusL.) Fruits. J. Food Eng. 53, 97–101.

Aydin, C. (2003). Physical properties of almond nut and kernel. J. Food Eng. 60, 315–320.

Aydine, C. and M. Ozcan (2007). Determination of nutritional and physical properties of Myrtle (MyrtuscommunisL.) fruit growing wild in Turkey. J. Food Eng. 79, 453–458.

Codex Alimentarius (2005). Standard for oranges: Codex Stan 245-2004. 1º Amendment. Rome: FAO e WHO, 6 p.

Eissa, A. A.; A. A. Khalik; and A. A. Abdel (2012). Understanding color image processing by machine vision for biological materials. *Structure and Function of Food Engineering*, pp. 227-274.

European Commission (2011b). European Commission Regulation (EU) No 543/2011 of 7 June 2011 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 in respect of the fruit and vegetables and processed fruit and vegetables sectors Regulation No 1121/2008 of 13 November 2008 establishing the standard import values for determining the entry price of certain fruit and vegetables.

Fellegari, R. and H. Navid (2011) Determining the orange volume using image processing. International Conference on Food Engineering and Biotechnology IPCBEE vol.9IACSIT Press, Singapore, pp. 180-184.

Ge, P.; Q. WU and Y. SUN (2007). The Design of Fruit Automated Sorting System. In *International Conference on Computer and Computing Technologies in Agriculture* (pp. 165-170). Springer, Boston, MA.

Hassan, H.E. (2002). study of sortingand grading operations of Egyptian mature oranges using visible laser. Ph.D. Thesis, National Institute of laser enhanced science Cairo Univ., Egypt.

Kang, S.P.; A. R. East and F. J. Trujillo (2008). Colour Vision System Evaluation of Bicolour Fruit: A case study with 'B74' mango. Postharvest Biology and Technology 49. pp, 77–85.

Khoshnam, F.; A. Tabatabaeefar; M. Ghasemi-Varnamkhasti and A. M. Borghei (2007). Mass modeling of pomegranate (PunicagranatumL) fruit with some physical Characteristics. Sci. Hortic. pp. 114, 21–26.

MATLAB (20·۹). Image processing toolbox help.

Mohsenin, N. N. (1986). Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York, NY., pp.94 - 100.

Moreda, G.P.; J. Ortiz-Cañavate; F. J. García-Ramos and M. Ruiz-Altisent (2009). Nondestructive technologies for fruit and vegetable size determination –A review. J.Food Eng. 92 (2), 119–136.

Naik, S.; and B., Patel (2017). Machine vision-based fruit classification and grading-a review. International Journal of Computer Applications, 170(9), 22-34.

Omobuwajo, T.O.; E. A. Akande and L. A. Sanni (1999). Selected physical, mechanical, and Aerodynamic properties of African breadfruit (Treaulia Africana) seeds. J. Food Eng. 40, 241–244.

Papadakis, S.; S. Abdul-Malek; R. E. Kamdem and K. L. Jam (2000). A versatile and Inexpensive technique for measuring color of foods. Food Technol.-Chicago 54, 48–51.

Razmjooy, N.; B.S. Mousavi; F. Soleymani (2012). A realtime mathematical computer method for potato inspection using machine vision. Computer. Math. Appl. 63 (1), 268-279.

Sadegaonkar, V.D. and K.H. Wagh (2015). Automatic Sorting Using Computer Vision & Image Processing for Improving Apple Quality. *International Journal of Innovative Research and Development*, *4*(1), pp. 543-546.

Sessiz, A.; R. Esgici and S. Kizil (2007). Moisture-dependent physical properties of caper (Capparisssp.) Fruit. J. Food Eng. 79, 1426–1431.
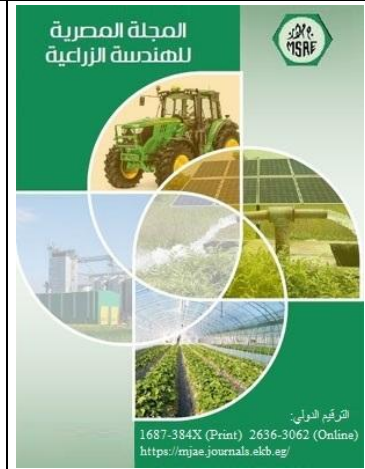
Zhou, L.; V. Chalana and Y. Kim(1998). A PC-based machine vision system for real-time computeraided potato inspection. Int. J. Imaging Syst. Technol. 9(6), 423-433.

التصنيف التلقائي لثمار البرتقال باستخدام تقنية معالجة الصور في MATLAB

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الكلمات المفتاحية:
عملية الفرز، معالجة الصور، المقاس، الحجم، الرؤية الآلية

الملخص العربي

يطور هذا البحث خوارزمية آلية لتقنية معالجة صور فرز ثمار البرتقال في برنامج MATLAB (7.8). تم استخدام غرفة إضاءة خاصة لالتقاط الصور وبواسطة كاميرا رقمية ومن ثم الحصول على صور الثمار. تم بناء خوارزمية وعمل واجهة للمستخدم لمعالجة الصور لتقدير الحجم والمقاس باستخدام معالج الصور في برنامج MATLAB. وكانت مراحل العمل كالتالي: تم التقاط وجهين متعامدين من الثمار، ثم تم معالجة الصور الملتقطة بإخلاء الاضطراب والظل منها، وكذلك تم فصل الخلفية، تبع ذلك مرحلة تصنيف الثمار وفي هذه المرحلة تم تقدير القطر والحجم الحقيقي باستخدام القدمة ذات الورنية وطريقة الماء المزاح على الترتيب، ثم الحصول على الحجم والقطر عن طريق معالجة الصور باستخدام البرنامج. تمت معايرة طريقة معالجة الصور ومقارنة القيم الحقيقية لكل من الحجم والقطر بالقيم المتحصل عليها من معالجة الصور لكلاهما. أظهرت النتائج توافقا كبيرا بين الحجم الحقيقي للثمار المقدر بطريقة إزاحة الماء مع الحجم المقدر بتقنية معالجة الصور، وكان معامل الارتباط أكبر من ٩٨%، وكذا كان تصنيف المقاس للثمار متوافق في كلا الطريقتين وكان معامل الارتباط يعادل ٩٩% مما يدل على ان تقنية معالجة الصور مناسبة لتقدير الحجم والمقاس. توفر معالجة الصور تقنية دقيقة ومباشرة وسريعة وغير موسعة لتقييم حجم ثمار البرتقال ويمكن تنفيذها بسهولة في تصنيف ثمار البرتقال مما يسهل عملية تداول الثمار بعد الحصاد، وتستخدم معالجة الصور في تقنية الرؤية الالية لتسهيل عملية الفرز والتدريج في بيوت التعبئة.