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Image Processing Techniques for Measuring Diameter Tomato Vegetable Using MATLAB Applications

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Abstract: In this study the identification of tomato diameter based on quality and size in image processing are very useful for the analysis it can be successfully done by measuring the diameter. The use of image processing for identifying the quality and size can be applied not only to tomatoes but also to other fruits such as oranges, apples, melons, etc. and also vegetables with more accuracy. Thus, this will enable the technology to be applied in many products in this case we proposed an away in to measuring the diameter of tomatoes, measuring diameter to the original image of tomatoes and the second one with the grayscale with five methods, Sobel, Perwitt, Roberts, Log and Canny methods to detect the edge of image with these methods, we get more accuracy of measuring the diameters. Farther than we use the value of threshold of each image to get clear image without noise. And the results can affect not only the use or management of the specific lot of products but also the general procedures in order to obtain better thresholds for the stages of the processing to get a good image. Four steps we applied in the program, i.e., pre-processing, segmentation, analysis and presentation of significant results (on the same device) and appling it to Sobel, Perwitt, Roberts, Log and Canny methods to obtain a good accuracy in results. Its also it is important to optimize the processing to get the exact diameter.

Key words: Size of tomato, diameter, edge detection, image processing, pre-processing, segmentation

INTRODUCTION

Minerals and vitamins found in tomatoes: Tomato is one of the main vegetables in the world cuisine. It is indispensable in most foods and it also has many health benefits to the human body. Because it contains many nutrients needed by the body. Its also one of the most mineral rich vegetables and the importance of these minerals is of great benefit in strengthening the body and activating and calming the nerves as well. The minerals found in them are (Du and Sun, 2004; Dang *et al*., 2010; Gunawan, 2013).

Potassium: Potassium is one of the most important elements that must be available in the human body because the lack of it may lead to serious health complications such as mental disorders and memory impairment.

Magnesium: Magnesium is a catalyst for enzymes, especially enzymes that are related to the production of energy in the body and helps to absorb calcium and potassium.

Chlorine: The chlorine component performs vital functions of the human body, the most important of which is the maintenance of water balance, base, acid and osmotic pressure in the living cells of the body as well as muscle control.

Phosphorus: The phosphorus component is closely related to the health of the body which is considered to be an important mineral element which is primarily involved in the health and construction of bones and also benefits from other parts of the body such as teeth.

Copper: Copper is a mineral element necessary for the human body in small amounts and the body can not self-replenish where it needs to get it from food.

Chrome: Chromium is an essential ingredient and is required in very small quantities for human health it is used to treat diabetes and high blood pressure is also used to treat PCOS.

Iron: Iron is one of the most important minerals needed by the human body any deficiency of this metal in the body leads to many problems, the most important anemia.

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Vitamins found in tomatoes: Tomatoes contain some important vitamins that the body needs (Kalaivani *et al*., 2013; Pandey *et al*., 2013; Rokunuzzaman and Jayasuriya, 2013).

Vitamin A: The most important benefit of this vitamin is that it preserves the safety of human eyes. In general, vitamins in tomatoes help to remove toxins from the body.

Vitamin B: Vitamin B helps digestion and breakdown of fat in the body.

Vitamin C: Vitamin C or ascorbic acid is a water-soluble vitamin that plays an important role in mineral metabolism and cellular functions. Vitamin C acts as an antioxidant and thus prevents cells from oxidative damage. It is essential for maintaining the health of the immune system, preventing heart disease and maintaining lung function. It also has a prominent role in stimulating the production of collagen.

One serving of tomatoes provides 27-33% of the daily needs of men and adult women, respectively, i.e., vitamin C. Vitamin availability is higher than that provided by oranges. Tomatoes are therefore the most important source of vitamin C rich.

Manganese and vitamin K: One serving of tomatoes provides about 5-10% of the recommended daily requirements of these nutrients. Vitamin K is a fat-soluble vitamin that is essential for bone formation and blood clotting. While manganese is one of the rare elements that the body needs in small quantities and is necessary for metabolism, tissue formation and reproduction.

Biotin: Biotin is one of the group B vitamins that are soluble in water. It is essential to maintain healthy skin, prevent hair loss and keep the nails strong and healthy. Tomatoes provide a high percentage of biotin up to 24% of the recommended daily needs.

Folate: Tomatoes provide about 7% of the recommended daily intake of folic acid. Folic acid is one of the vitamins of group B. It has many health benefits, most commonly preventing congenital malformations, forming red blood cells and thus preventing anemia or anemia.

Lycopene is found in tomatoes: Lycopene is the substance in the tomato that gives it the red color and the benefits of lycopene for the body (Devi and Vijayarekha, 2014; Mishra *et al*., 2014; Pandey *et al*., 2014; Kaur and Sharma, 2015).

- Minimize the chance of malignant diseases such as breast and prostate cancer
- Protects against atherosclerosis and thus protects against heart attack

The nutritional value of tomatoes: Tomatoes contain a lot of minerals, vitamins, mineral salts, fatty substances as well as carbohydrates, proteins, natural colors and cellulose but contain some toxic alkaloids when they are green, the following table shows the dietary composition of each 100 g fresh mature tomatoes (Lino *et al*., 2008; Khoshroo *et al*., 2014).

Nutrients in tomatoes: The most important nutrients contained in tomatoes or tomatoes tomato or tomato contains a large number of essential Nutrient Elements of vitamins, minerals and others.

In addition to Lycopene, there is a distinct variety of plant nutrients such as Carotenoids, Flavonoids, Hydroxycinnamic acids, Glycosides and fatty acid derivatives.

Tomatoes contain dozens of vitamins and minerals in different proportions between excellent and acceptable. The following table lists the most important elements, their presence in a cup of tomato slices weighing 180 g, the proportion of the daily body needs of each component of Daily Daily Value (DRI or DV%) and nutrient density compared to its thermal content of 32 calories in 180 g) and classification of the rich tomatoes by: the status of the ingredient in tomato is classified as follow.

Excellent: If more than 10% of the daily need of the body in 180 g tomato slices with a feeding density of more than 7.6.

Very good: If more than 5% of the daily need is filled with a feeding density equal to or >3.4.

Good: if it contains more than 2.5% of the daily need with a feeding density equal to or >1.5. Tomato is one of the many vegetables that produce vitamin C. The size of tomatoes will affect the selling price in the market. Large tomatoes will be sold at higher prices and even become export commodities. Tomato vegetables are valued by two factors; size and quality. The measure itself is measured using standard SNI with four levels; unity = 70, sec = 61-70, third = 51-60 and fourth = 40-50 mm, specifically size is the dominant parameter that determines the price of tomatoes. The tomato size determination is done visually by comparing tomatoes.

Table 1: Minerals and vitamins found in tomatoes

Food ingredient	Nutritional value
Water	94.52 g
Protein	0.88 g
Carbohydrate	3.89 g
Calcium	10 mg
Magnesium	11 mg
Phosphorus	24 mg
Zinc	0.17 mg
Vitamin B1	0.037 mg
Vitamin B3	0.594 mg
Folic acid	15 mg
Vitamin A	833 IU
Vitamin E	0.54 mg
Energy	18 Kcal
Total fat	0.2 g
Fiber	1.2 g
Iron	0.27 mg
Potassium	237 mg
Sodium	5 mg
Vitamin C	13.7 mg
Vitamin B2	0.019 mg
Vitamin B6	0.080 mg
Vitamin B12	0 µg
Vitamin K	7.9 mg

Table 2: Nutrients in tomatoes

For the nutrient	Quantity	Percentage of daily need (%)	Nutrition intensity	Classification of richness
Vitamin C	24.66 mg	33	18.3	Excellent
Biotin	7.22 mcg	24	13.3	Excellent
Molybdenum Mo	9.00 mk	20	11.1	Excellent
Vitamin K	14.22 mcg	16	8.8	Excellent
Copper Cu	0.11 mg	12	6.8	Very good
Potassium K	426.60 mg	12	6.8	Very good
Manganese Mn	0.21 mg	11	5.8	Very good
Fiber	2.16 g	9	4.8	Very good

Table 3: The standard size of tomatoes measurements

Size	Diameter (mm)	Diameter (pixels)
Extra small	48-54	181-204
Small	54-58	204-219
Medium	58-64	219-241
Large	64-73	241-275
Extra large	73-88	275-332
Maximum large	>88	>332

Each 1 mm = 3.779528 pixel

This process is highly subjective in nature. Therefore, this study aims to develop an automated system to determine the size of tomatoes by adopting the requirements of the Iraqi National Standard on the quality of tomato (SNI 3932:2008) using image processing techniques. Features used to distinguish the size of tomatoes in diameter according to SNI. This process is highly subjective in nature. Therefore, this study aims to develop an automated system to determine the size of tomatoes based on diameter size through image processing techniques.

Several studies have shown that image processing can be applied to analyze the edges of the drawing and the shape of tomato vegetables that can be used as a reference in the process of identifying tomato vegetable

Fig. 1: Dividing tomato to measuring the diameter manually

sizes. Next, evaluate edge detection and see the diameter size. This research focuses on image development (Agrawal *et al*., 2016; Devalatkar and Koli, 2016). The diameter tomatoes are classified as shown in the following Table 1-3. The measuring of diameter manually can be divide tomato in two parts as shown in the following (Fig. 1).

Tomato benefit for pregnant women: The tomato is a vegetable that should be eaten by the pregnant woman permanently because it contains iron which is heavily pregnant women where iron works on the rapid growth of human bones as it supplies the body's cells with oxygen and energize and provide energy (Belsha and Hariprasad, 2017).

Other benefits of tomatoes: Reducing respiratory diseases. Tomatoes are vegetables that help the body recover from bronchial congestion.

Reduce body temperature: When you eat tomatoes, they reduce the temperature of the body and thus help people with fever to get rid of the symptoms and pains that suffer because of high temperature (Sudhir *et al*., 2017).

Building and strengthening bones: The vegetable of tomatoes is rich in calcium and vitamin K which are needed to build and strengthen bones and the lycopene found in them has a significant and effective effect in the elimination of osteoporosis (Raut and Fulsunge, 2017).

Theoretical basis

Image processing: Image is another term of the photo which is visual information. An image is obtained from capturing the power of light reflected by the object. When the light source illuminates the object, the object reflects back some of the light. This reflection is captured by optical sensing devices such as human eyes, cameras, scanners and, so on.

The shadow of the object will be recorded according to the intensity of the reflection of light. When an optical device that records a reflection of light is a digital machine such as a digital camera, the resulting image is a digital

image. In digital imagery, the intensity of light intensity is quantized according to the resolution of the recording device.

Image processing is a processing whose input is image. The output can be an image or set of characteristics or parameters associated with the image. The term digital image processing is generally defined as processing two-dimensional images with a computer. In a broader definition, digital image processing also includes all two dimensional data. Digital imagery is a sequence of real or complex numbers represented by certain bits. Image processing has several functions, including.

Used as a process of improving image quality for easy interpretation by humans or computers. Used for image processing techniques by transforming the image into another image. Example: image compression as the preprocessing of the computer vision.

Grayscale: Grayscale is a variety of shades of monochromatic color from black to white. Therefore, grayscale images have only gray and colorless colors. A digital image can be saved as grayscale (black and white), even a colored image containing grayscale information. This is because each pixel has a luminance value, regardless of color. Luminance can also be described as brightness or intensity which can be measured on a scale from black (zero intensity) to white (full intensity). Most image file formats support at least 8 bit grayscale which provides 2^8 or 256 pixel lighting levels. Some formats support 16 bit grayscale which provides 2^{16} or 65,536 lighting levels.

Edge detection: Edge is a sudden change of degree of gray (short) value within a short distance. Some techniques for edge detection:

- Sobel operator
- Prewitt operator
- Roberts operator
- Log operator
- Canny operator

Diameter: In geometry, the diameter (from Greek, diairo = divide and metro = size) of a circle is a line segment through the center point and connecting two points on the circle or in modern usage, the diameter means the length of the line segment. In a sphere, the diameter connects two points on the surface of the ball and threw the ball center point. The diameter of the circle is two times the radius length. Diameter can be used to know the circumference and the area of the circle. In a 3-dimensional ball, the diameter can be used to determine the surface area and volume of the sphere. In addition, the diameter is the longest arc string in the circle.

MATLAB application: MATLAB is an application with advanced language and interactive environment specially created for numerical computing, programming and visualization. Multi paradigm numeric computing environment. By using MATLAB, we can analyze data, create applications, model and develop algorithms by tools offered, language and built-in math functions.

We can examine different approaches and find solutions that are much faster than traditional programming languages and spreadsheets. MATLAB can be used for a wide range of applications ranging from communication and signal processing to control systems, video processing, finance and computational biology, testing and measurement.

Numerical calculations we can use the built-in mathematical functions of MATLAB to solve all kinds of science techniques and problems. The availability of numerical calculation methods can help us develop algorithms, analyze data or create models.

The MATLAB language has various mathematical functions with support for popular science and engineering operations. Vector and matrix calculations are very smoothly executed to optimized processor libraries used by core math functions.

Data analysis and visualizer, MATLAB comes with the tools necessary to collect, analyze and visualize data in order to gain a better understanding of our data. We can also document and share the results obtained by using complex plots and reports.

MATERIALS AND METHODS

In this study we describe some of the earlier research taken as a review of studies in this research. One of them is the study which aim to make measurements on the round wood is required as a standardized way of wood measurement where the current way is potentially harmful to various parties. This is because the use of ruler tool has potential errors due to differences in perception of measurement in determining the diameter value when determining the grade value of a wood, so that, the measurement device is needed to overcome the error problem of the measurement method.

The study attempts to determine the diameter of the wood as a reference to overcome the loss due to measurement error in the wood industry using MATLAB

as a processing using gray scale analysis, soothing, obtaining edge with threshold, bounding box and end result by labeling the smallest diameter value.

The second study aims to design a classification system of tomato vegetables based on color and size features using Euclidean distance approach. In the design and implementation this research uses 5 types of process namely color feature extraction, greyscale, threshold, feature size extraction, euclidean distance. Test image and image data training from this application is an image of input with bitmap extension (*.bmp) and the output of information about the quality of tomato. Tests were conducted on all tomato images used as training data. In this testing process tomato farmers need assistance in advance to classify the tomatoes then taken its image.

In designing and implementing the application design used waterfall method or often called classic life cycle model. Waterfall model is a classical model that is systematic or sequential in building software. The model includes several stages:

- Requirements definition
- System and software design
- Implementation and unit testing
- Integration and system testing
- Operation and maintenance

RESULTS AND DISCUSSION

In SNI standard tomato is judged from 2 things: quality and size. One of these research uses the application of tomato image texture to measure whether the tomato has diameter size according to SNI standard, through MATLAB application we can know edge detection and diameter measurement automatically.

The research undertaken here tries to identify the diameter size of tomatoes vegetable by using image processing technique referring to Iraqi National Standard (SNI). Requirements of the size of the tomatoes are classified into four; Class 1-4. The size of tomatoes based on SNI is given in Table 4.

The edge detection observation was performed with perfection of the flash surface of the flashlight tomato and the digital camera >10 MP then the photo shoot was done with a distance of 30 cm with sufficient illumination.

Image acquisition is done vertically by varying the distance for image acquisition, camera resolution and acquisition angle. The distance used is 30 cm. And resolution >5 MP. Corner 45°. Image processing begins with several stages to produce an objective value. The stages can be seen in Fig. 1.

Table 4: Iraqi National Standard of tomato

Code size	Circle area (mm)	Circle area (pixel)
1	70	264
2	61-70	230-264
3	51-60	192-226
4	40-50	151-188

There are several stages to find the diameter. After the drawing is provided and made into grayscale, RGB and each stage is tested using five methods (Sobel, Perwitt, Roberts, Log and Canny) after being tested with the 5 methods then edge detection is done to see a clearer method for known diameter as shown in the following Table 5.

Image sample of tomatoes vegetable: In this research we tested 4 tomatoes which have various size variations, so, kit adapt know that every tomato sold have different size to be sold with different price. The image can be seen in Table 6.

Testing uses grayscale: RGB staining and edge detection methods from the four grape vegetable samples, the grayscale test which is mixed with four methods of Canny, Prewitt, Sobel and Robert. Test results can be seen in Fig. 2.

After testing with grayscale and five methods, further testing was performed by combining RGB staining with five methods of Sobel, Prewitt, Roberts, Log and Canny. The test results can be seen in Table 7.

From the results of Table 8 drawing produced images that have been in the process using the application MATLAB. It can be seen that the canny method is more clearly visible for the edges.

Edge detection testing: The previous image of edge detection by combining RGB staining does not produce a clear-cut edge for the author to try to test only by using edge detection on the Sobel, Prewitt, Roberts, Log and Canny methods. To obtain a maximum edge line for the measured diameter of each sample image. Test results can be seen in Table 9.

Calculation of diameter: Of the four tested methods it can be seen clearly that the canny method looks more detailed to produce the edge line so that the entire surface looks full of streaks of lines. But in this study the researchers did not examine the entire surface of the tomato vegetable but only see the edge of the more real line for further measured diameter automatically using MATLAB application.

The final stage of this research is the measurement of the diameter of each tomato vegetable that has been tested grayscale, RGB staining and edge detection. At

Table 5: Measurement diameters of five methods, Sobel, Perwitt, Roberts, Log and Canny

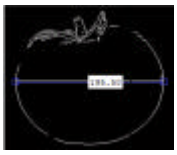
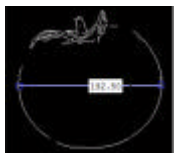
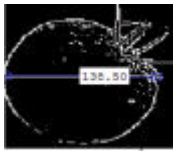
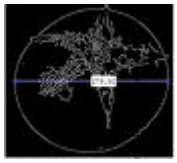
Orignal image	Diameter	Threshold	Value of diameter (pixel)	Value of diameter (mm)
		0.035	195.50	51.726
		0.4	192.50	50.932
		0.8	138.50	36.644
		0.001	279.50	73.951
		0.043	280.50	74.083

Table 6: Measuring the diameters of the original image of tomatoes for four samples

Original image	Testing diameter	Diameter (pixel)	Diameter (mm)
		277.1281	73.3234
		283.00	74.8770
		97.01	25.6645
		280.50	74.2156

Table 7: Grayscale test results with all five methods of Sobel, Prewitt, Roberts, Log and Canny

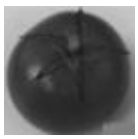
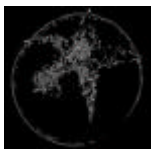
Orginal Image	Sobel	Prewitt	Roberts	Log	Canny
					
Threshold	0.035	0.6	0.05	0.001	0.008
					
Threshold	0.035	0.4	0.045	0.004	0.009
					
Threshold	0.07	0.6	0.8	0.006	0.049
					
Threshold	0.02	0.019	0.07	0.001	0.043

Table 8: Tomato test results on RGB staining by the method of Sobel, Prewitt, Roberts, Log and Canny

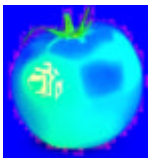
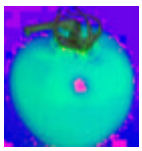
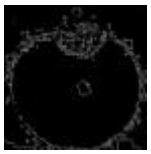
Orginal image	Sobel	Prewitt	Roberts	Log	Canny
					
Threshold	0.095	0.1	0.12	0.005	0.265
					
Threshold	0.037	0.037	0.029	0.01	0.3565
					
Threshold	0.01	0.05	0.05	0.0499	0.05
Threshold	0.035	0.035	0.035	0.002	0.05

Table 9: Edge detection results of Sobel, Prewitt, Roberts, Log and Canny Methods

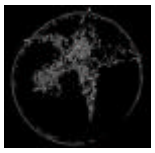
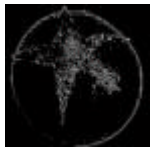
Orginal image	Sobel	Prewitt	Roberts	Log	Canny
					
Threshold	0.035	0.6	0.05	0.001	0.008
					
Threshold	0.035	0.4	0.045	0.004	0.009
					
Threshold	0.07	0.6	0.8	0.006	0.049
					
Threshold	0.02	0.019	0.07	0.001	0.043

Fig. 2: The original photograph of tomatoes

Fig. 3: The original photograph of gray scale tomatoes

Fig. 4: Results of diameter calculation

this stage the processing of diameter values can be tested directly by using source code calculating the diameter. To see how the diameter value of each picture of tomatoes can be seen from the test result through MATLAB application, the result can be seen in Fig. 3 and 4. Can be seen that each vegetable has a different diameter that will affect the selling value, the greater the size it will be more expensive also the sale value. Besides, the government has set the standard of SNI of tomatoes vegetable which is feasible to be sold and consumed, considering the importance of the standard the managers of tomato vegetable cultivation harvest the tomato plantation according to the standard that has been determined. In addition to the standard size there are also other standards of special concern that the quality of the tomato peel can be observed to determine the level of vegetable maturity. Of the four selected samples have met the requirements of the Iraqi National Standard, the four samples can be sold and consumed.

CONCLUSION

In this study we conclude that, the identification of tomato diameter based on quality and size in image processing are very useful for the analysis it can be successfully done by measuring the diameter. The use of

image processing for identifying the quality and size can be applied not only to tomatoes but also to other fruits such as oranges, apples, melons, etc. and also vegetables with more accuracy. Thus, this will enable the technology to be applied in many products in this case we proposed an away in to measuring the diameter of tomatoes, measuring diameter to the original image of tomatoes and the second one with the grayscale with five methods, Sobel, Perwitt, Roberts, Log and Canny methods to detect the edge of image with these methods we get more accuracy of measuring the diameters.

Farther than, we use the value of threshold of each image to get clear image without noise. And the results can affect not only the use or management of the specific lot of products but also the general procedures in order to obtain better thresholds for the stages of the processing to get a good image. Four steps we applied in the program, i.e., pre-processing, segmentation, analysis and presentation of significant results (on the same device) and appling it to Sobel, Perwitt, Roberts, Log and Canny methods to obtain a good accuracy in results. Its also it is important to optimize the processing to get the exact diameter.

With using five methods, Sobel, Perwitt, Roberts, Log and Canny methods to detect the edge of image with these methods we get more accuracy of measuring the diameters and the specifically, good quality fruit obtains a good measurement. The results presented above allow concluding that classification of tomatoes by size can be supported by image analysis open software. The correlation of tomatoes diameter with pixel surface supports the application of this software to evaluate equatorial diameter.

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