Volume Estimation of Mango

Savan Dhameliya
Department of Computer Science & Technology, UTU, Bardoli, India

Jay Kakadiya
Department of Computer Science & Technology, UTU, Bardoli, India

Rakesh Savant
Department of Computer Science & Technology, UTU, Bardoli, India

ABSTRACT
This paper observes the possibility of volume estimate of mango using image processing technique that are used in commercial packaging industry for increase the quality of fruits. Image processing is used to provide automation and cost-effective service to packaging industry for volume estimation of mango. Sizes featured are extracted from digit profile image using many image processing technique. The volume of fruit is obtained using single or multiple camera setups. The sizes featured are used to estimated volume of mango and compare with actual volume of mango. That program can measure the size property of mango such as height, width and area from image but there is one problem is that the size feature of mango is not accurate. We have to done some changes to achieve high accuracy of size featured of mango.

Keywords
Fruit, Volume measurement, Segmentation.

1. INTRODUCTION
India is the prime producer of fruits in the world. Huge post-harvest losses (25-30%) occur in fruits in the period flanked by harvesting and consumption [8]. Thus, there is an imperative need to adopt proper post-harvest management practices by adopting improved packaging, handling and efficient transportation methods. Packaging is required to keep the mangoes in good condition until these are sold and consumed. The package should also protect the produce from rotting.

Volume estimation of mango is basis of image processing which is very useful because it enhances the quality and reduces the manual work and grading of mango. The process of volume estimation of mango mangoes generally base on its physical characteristics such as height, width and diameter. This process is presently done using manual labor and is dependent on the human visual system. Uniformity in the volume estimation process is important so that its output is guaranteed to satisfy the necessities for exporting mangoes.

Customers are expecting better quality. For example, supermarkets and stores are under escalating pressure to provide fruit and vegetable produce of the highest quality and have big problem of packaging. Now, more than ever before, fruit is displayed and sold to consumers in batches of uniform quality, shape, color, weight, volume and density.

Volume estimation of fruit is used in packaging industries. Traditionally, packaging of mango was done manually which is time consuming process and require more labor work , due to which an algorithm for volume estimation of mango for automation was developed. Lots of methods and algorithms were developed for volume estimation of fruits but that have some problem in time and accuracy. The above disadvantages have motivated the development of method which estimates fruit volume from the digital image.

This paper contains definition, motivation, objective and scope of the study work, study about existing volume estimation system, basic observation model and comparative analysis of machine learning techniques, proposed scheme for mango grading system, results obtained from the proposed approach and finally the proposed work and the future work.

1.1 Fundamentals of Image Processing
The fundamental of image processing is to acquire a digital image (Image acquisition), to improve the image so that increase the chance for success of the other process (Preprocessing),to partition image into subpart for the further process (Segmentation), To convert input data into to a form suitable for the computer processing (Representation), to extract feature that result provide some information of interest and features that are basic for differentiating one class of objects from another (Description), To assign a label of object base on the information provide by its description (Recognition), to assign meaning to an together of recognized objects (Interpretation).

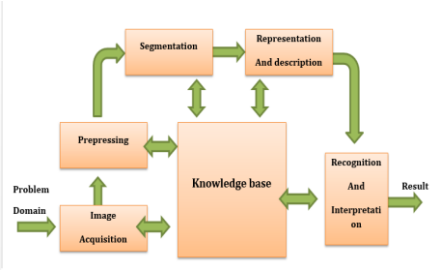


Figure 1: Fundamental steps in digital image processing.

1.2 Research objective and Scope
The aim of this work is to develop method based on image processing and machine vision system for volume estimation of mango. Below are the listed points for the study.

- Develop an algorithm for extract size feature such as height, width, area and diameter of mango from digital image.
- Using this extract feature apply in volume measurement formula for estimate volume of mango.
- Compare time and accuracy with other algorithm.
- The practical work in the dissertation work included photographing and measuring the actual volumes of fruit samples to form data sets.

2. LITERATURE REVIEW

2.1 Observation Model

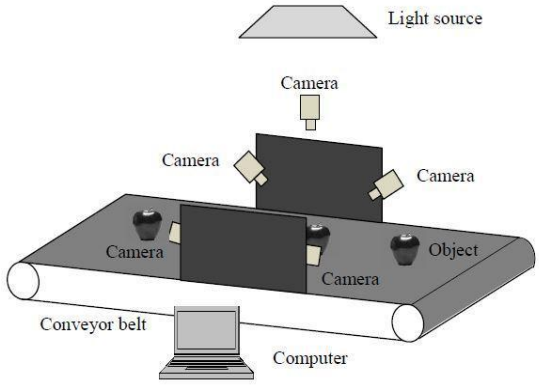


Figure 2: The hardware of computer vision for volume measurement [3]

Firstly image acquisition is performed for this purpose five camera to capture image of object from the different angle. Images are capture while object are moving on the conveyor belt with predefine speed. The quality of image is enhancing by removing noise and increasing contrast for this specific task image transformed to gray scale. Enhanced images are then segmented to extract the silhouettes of object from background. Then thresholding is performed to segment the image of object. Generate the threshold value T automatically base on iterative value. The intensity of image are greater than T then assign object pixel is white with binary value 1 otherwise background pixel is black with binary value 0. Then process different algorithm for measure volume of mango.

2.1.1 Competing volume estimation methods.

The first solution to the problem of volume measurement of mango seems with the field of multiple geometry view. Reconstruct of the three dimensional surface the mango from the multiple view provide by two or more camera. Using this approach we have time and cost disadvantage:

- If the multiple positioned cameras were available, the problem of matching points in the different image would be difficult because the fruit not having visible features such as flat surface which is observed by camera.
- Using two cameras, less than half of fruit's three-dimensional surface could be reconstruct. Many cameras are used to determine three dimension surfaces of whole fruit but the problem is that joint the various pieces together would be very difficult and may be occurred error.

2.1.2 Fruit Size Measurement Process

In the fruit's size measurement process image acquisition and pre-processing, segmentation, feature extraction steps are involved. These steps are shown in below (Figure.2.2).

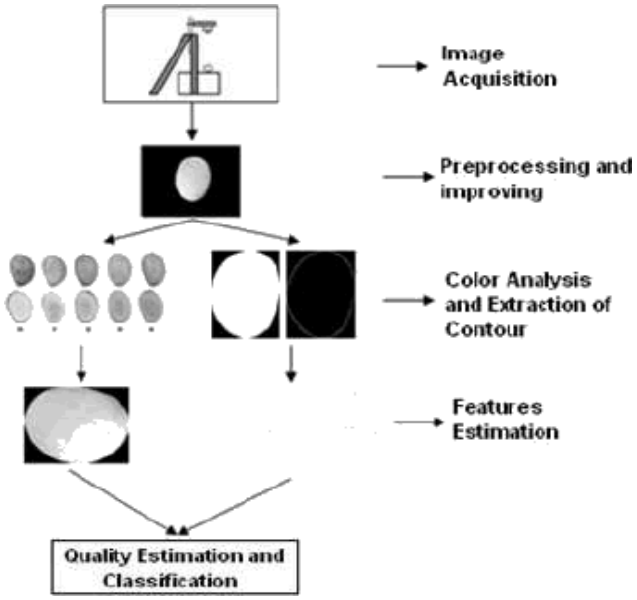


Figure 3: Fruit Size Measurement Process [30]

2.1.3 Image Acquisition and Pre-Processing

Image acquisition and pre-processing are important step of computer vision system. Image acquisition is the first process shown in Fig 2.2. The images of mango take from camera. Note that acquisition could be as simple as being given an image that is already in digital form. The image of mango is taken from top of the image and sounding of the image. Then reduce the resolution of image such as resize the image. If we use original image then it will take more time for processing data rather than resize image. There are lots of image segmentation method are available such as Clustering Technique, Edge Based Techniques, Region Based Techniques, Split and merge Techniques . Edge detection is a problem of fundamental in image processing. Edge detection techniques are generally used for finding discontinuities boundary in images. The major task is extract edge from image like as corners, lines, curves.

Split and merge technique follow two parts in the first part split the image base on some rule the merge the image. If too much variety occurs then the image is split into regions using thresholding. In merging phase, where two regions are merged if they are adjacent and similar. Merging is repeated until no more further merging is possible.

In image segmentation, each pixel is classified according to the background or to the fruit. The range of pixel is [(0:r),(0:g),(0:b)], where r, g and b are threshold value for the RGB color model in image which is considering the background then set the value is 0 for each channel. So we identify that other pixel represent the fruits and its value cannot be modify. Hence, if C(x, y) denotes the intensity value of a channel C for a pixel in the point (x, y) of a RGB image, G(x, y)

Denotes the value obtained by filtering the color and μ denotes the filter threshold for the channel C, then we get [link 1]:

$$G(x,y) = \begin{cases} C(x,y) \in [\mu, 255] \\ 0 \quad \notin [\mu, 255] \end{cases} \qquad \text{E.q 2.1}$$

If the color filter is applied then both object and background are different with each other without any ambiguity. In this process the image is converting to gray scale and binary image using thresholding method.

2.1.4 Feature Extraction

In volume estimation of mango, some of the extract features are necessary such as minor axis, major axis, height, width and diameter. Feature extraction process is done after completion of segmentation process that will be use analysis extract feature of image. If you want to find the volume of the fruit you can use many different methods. Standard digital camera was used to capture images of the fruits. You can get height and width from 1D image but you want to get diameter of mango that time use 2D image and you want to get surface of mango that time use 3D image. 2D to 3D image conversion is a very hard process.

2.1.5 Volume Estimation

First image are convert into threshold image which is describe in below section after this task is complete the features related to fruits are extracts such as volume. The analysis of the mango's features is the basis for volume estimation which the total volume is the sum of the volume of all section in the form of across cut along the length of the fruits which in show below figure (28).

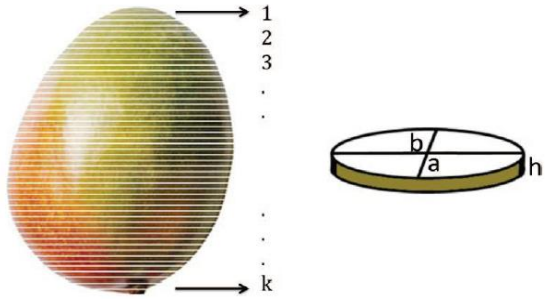


Figure 4: A cross section of the fruit [28].

$$Minoraxis = regionprops(B, 'MinorAxisLength')$$

Here to find the volume of the fruit we can use Standard digital camera was used to capture images of the fruits. You can get height and width from 1D image but you want to get diameter of mango that time use 2D image and you want to get surface of mango that time use 3D image. 2D to 3D image conversion is a very hard process. If we take height of each cross section, it is possible to approximate the volume of each section to be oval cylinder volume. The ratio analysis of the axis a and b at different points along the length of mango (see figure) that describe the constant relationship between the value of the axes which is known as Depth Factor (DF).

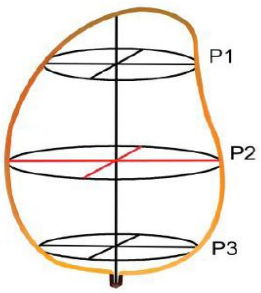
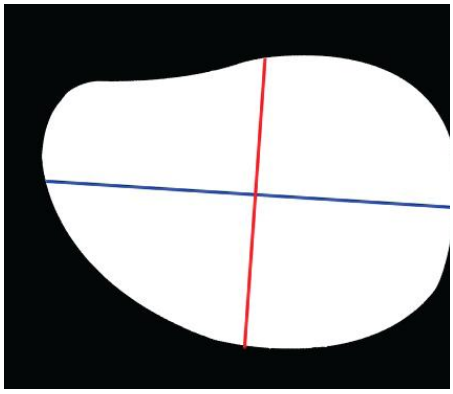


Figure 5: Ratio analysis at different points[28]

Before volume estimation process was complete, calculate length of minor axis (width of mango) using the region props function which is provided by Mat lab.



$$\boldsymbol{Df = \frac{Max(Majoraxis)}{Min(Minoraxis)}} \qquad \text{E.q 2.3}$$

2.3 Color feature extraction techniques

Here, we want to find volume of the mango so it is not depending on color of mango. So we can simply convert image into black and white format. For this purpose image convert into gray scale image. Then apply thresholding on the image.Then thresholding is performing to segment the image of object. Generate the threshold value T automatically base on iterative value. The intensity of image are greater than T then assign object pixel is white with binary value 1 otherwise background pixel is black with binary value 0. Then process different algorithm for measure volume of mango.

2.3.1 Non-uniform background.

Due to non-uniform background in image some problem occurred during shape extraction process [17].Most probably the problem is occurs in dark or light image using technique of segmentation, edge detection and other image processing algorithm based on region of interest means the region is more than actual region. The region of interest may be same as either background or neighboring pixels.

2.4 Volume estimate techniques

The fruit size is a quality attribute for volume estimation technique. This is also described the quality of fruit. Size can be determined based on minor axis, major axis, and height, width and diameter of mango. Fruit volume was described as a dependent variable, while length, weight, and diameter were independent variables.

2.4.1 Traditional Technique

It is a traditional method for volume calculation. This method required some type of hardware like as bowl. The fruits are put on bowl which also has water then we can easily guest volume of fruit. But the result of method is not accurate and it is required to use hardware.

Disadvantages:

1. It is a time consuming process.
2. It will use impractical under field conditions. They are concluding that the actual volume and result volume are not same and result is not accurate.

2.4.2 Monte Carlo Method

The use of Monte Carlo Method in [2] this method describe size can be measured from 1D image like as length and width. Diameter can be measured from 2D image and the surface of fruit can be assessed from 3D image.

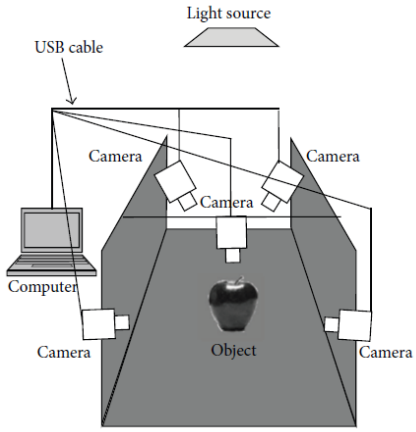


Figure 6: Camera Calibration systems [2]

The object is located at the center of a computer vision system as shown in Figure 2. Five images of the mango were acquired using five cameras. This image is used to extract Length, height, surface and diameter of the mango. Using this variable we can easily get the volume of fruit.

We can get shape of fruits using computer vision system. This system required some of hardware and software like as camera calibration, image acquisition, image processing. Using cameras get image of fruit from different position like as top view and surrounding view. Cameras are connecting to the computer using USB cables. In the image acquisition, capture image from different direction. These images describe RGB color space, dimension, and resolution in both vertical and horizontal direction. We can get the RGB color space into HSV color space. Using HSV we can easily separate background of the fruit. A grayscale image was constructed from the weighted sum of H, S, and V components using in [2]

2.4.3 Acoustic resonance technique

Develop equipment to measured volume of mango base on acoustic resonance technique [3]. This tool is generating frequency that is use extract shape of mango. This tool have pipe of polyvinyl chloride (PVC) pipe in cylinder shape. At the bottom of the tool have one plastic plate and the speaker is installing at the top of the tools. The microphone was mounted, on the cylinder wall at a height of 15 cm from the base. Sound card of a personal computer and the speaker was connected with the audio output of the sound card. The response signals are

Sense by the microphone and come into sound card of personal computer. The MATLAB program convert receive signal into frequency using fast Fourier transform (FFT). The mango put on resonator then frequency are measured. Mangos are put on this resonator with different position and size. The basic method for the calculation of effectiveness of volume estimation algorithm which is describe in below steps:

1. Accurately measure the actual volume of mango from digital image profile.
2. Acquire multiple image of mango.
3. Preprocess and segmentation on the mango's image to identify the fruit profile extract features.
4. Extract the appropriate size features of mango from the mango's image.
5. Create function to estimate the volume of mango from extracted features from multiple images.
6. Test and compare the performance, accuracy and time of the result of the different volume estimation methods.

2.5 Estimating the volume and associated error of an ellipsoid

The estimation volume of mango and the calculation of the uncertainty on the volume estimation can be complex. Each image of the mango is an ellipsoid with two of its three semi-axes equal. Such as ellipsoid is a surface of revolution of mango fruits [29]. It can be obtain by around the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, Z = 0 around the x-axis, this type of ellipsoid shown in figure 2.6 at base on random choice orientation.

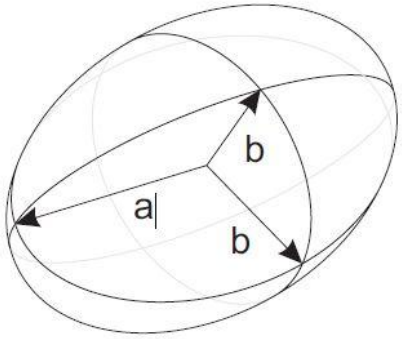


Figure 7: An ellipsoid with two of its semi-axes equal [29].

2.6 Size feature extraction technique

The fruit size is a quality attribute for volume estimation technique. This is also describe the quality of fruit. Size can be determine base on minor axis, major axis, and height, width and diameter of mango. Fruit volume was described as a dependent variable, while length, weight, and diameter were independent variables.

2.6.1 Physical Property Analysis

Here we discuss some of popular size measurement property is height, width, area and perimeter. All are counted based on number of pixel are in binary image. If you want to find area of mango that time necessary to convert image in to binary image because it will provide difference between object and background that was discuss in previous section. The Matlab provide inbuilt method that can count area of object automatically base on number of pixel.

The height and width of binary image determine base on counting number of pixel in the binary image. After counting of number of pixel then we convert pixel in to centimeter for getting height and width of mango.

Formula is : Centimeters = pixels * 2.54 / 96

Where; Area is defined as the area of the 2D projection image of the top view mango. This can be easily estimated by counting number of pixels inside the boundary [15], Length is defined as the distance between the pole and the tip of the

mango. The line between the pole and the tip called mango's major axis [15] and width is defined as the maximum distance from a boundary pixel to another boundary pixel that is on the other side of the major axis, and the line between them, which is called mango's minor axis, is a straight line at an angle of 90° to the major axis [15].

- **Surface Area**

Surface area is defined as the area of the surface of mango in 3D. To measure surface area of the mango, all the mangoes were peeled using hand peelers. The peels images are then captured and digitized using a scanner at 300dpi. The image is then binarized, where white pixels correspond to mango peel and black pixels correspond to background. However, the image obtaining from scanner is not clean. A salt-and-pepper noise reduction technique must be applied [15].

- **Roundness**

An object's roundness [29] is the ratio of its area to its maximum diameter:

$$\text{roundness} = \frac{4.\,\text{area}}{\pi.\,\text{maximum diameter}}$$

The maximum diameter is estimated by using the above.

3. MATERIALS AND METHODS

In this work, we describe a simple algorithm for volume estimation of mango. In above section we describe the drawbacks of method of volume estimation of mango and try to solve these drawbacks for better result. We are in a channel to develop algorithm for volume calculation for fruit to solve the problem of time and accuracy.

3.1 Sample Collection

For experiment, we have created database, this database has four varieties of 600 mango such as"Totapuri","Badami","Kesar" and "Neelam" were collected from mango orchard of navsari and olpad (Surat District, Gujarat) as shown in Figure.3.2. Mangoes were randomly collected with different color and size in the production season 2014.

Figure 8: Mango Samples (Left to right, Badami, Kesar, Totapuri, Neelum)

3.2 Image Acquisition and Image Pre-processing

The computer vision system is used to implements algorithm for volume estimation of mango consists of hardware and software. The hardware structure consists of camera, Light source, and Personal computer as show in figure 2. One camera is located at the top of mango and other camera located surrounding of mango. Cameras are connected to the personal computer via USB cable. The background of the image must be white for better segmentation process. Personal computer is use to process acquire image through algorithm.

3.3 Image Segmentation

Image segmentation is used for image analysis. The purpose of the segmentation is that image is subdivided image into meaningful part for further analysis of image. Here, segmentation is implement to obtain area of mango and height and width.

3.3.1 Mango region segmentation

Image enhancement is performed to improve image quality by removing noise and increase contrast. The image is convert into gray scale before image enhancement. After image enhancement thresholding extract object from its background by assigning intensity value T for each pixel is classify either it is object or background

A pixel in gray scale image with intensity greater than T is assign as object pixel white with binary value 1 otherwise background pixel is black with binary value 0. That we show in below image.

Figure 9: Binary image conversation of mango.

4. CONCLUSION AND FUTURESCOPE

This dissertation work involve develop and testing of algorithm that produce volume estimation of fruits from digital image of mango which are used many commercial industry for packaging and increase quality of mango. Unfortunately, we do not determine the volume of mango. But we can find the area, height and width of mango. But the result of algorithm is provide 80% accuracy. We would like to develop algorithm for volume estimation of mango. So main future task is to develop algorithm for volume estimation of mango. After mango's volume is estimate then this algorithm are combine with mango grading system to it will highly useful for industry.

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