

Volume Estimation of An Object Using 2D Images

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Abstract

Images are used to record and represent information, they are present everywhere and influence how we perceive information about a particular subject. In this paper, we propose a unique method for estimation of the volume of a solid object with the help of image processing without 3D reconstruction. The input to our system consists of mere images of the object of interest from different views. Present methods to estimate the volume of an object with the help of images such as the one involving Monte Carlo method require minimum five images, whereas the idea proposed by us requires 2-3 images depending on the type of the object. It is advantageous over water displacement method for volume calculation as the object is not tempered during the process. The proposed idea incorporates edge detection, image segmentation, and feature extraction to identify the object and find its dimensions, after which, the object is broken down into infinitesimally slices along

the horizontal axis and volume is calculated for each slice. The addition of all volumes of these slices results in the estimated volume of the object.

Key Words and Phrases: Image Processing, Edge Detection, Image Segmentation, Feature Extraction, 2D to 3D Image Conversion, Volume Estimation using Image Processing.

1 Introduction

The world we live in today is influenced by technology to such drastic measures that imagining life without it seems impossible. We have come a long way from the invention of the camera, as everybody around us has a camera in his pocket nowadays. Although it is worth noting that the history of the camera started even before the advent of photography, it was the invention of the modern day cameras that paved the way for photography as more than just a mere pastime. Photos allow us to communicate and facilitate communication in an artistic manner, preserve history, and move people in ways that words sometimes cannot.

These recent developments haven't stopped at just capturing high quality images but have also paved way for many exciting and remarkable developments in image processing. The 2D to 3D conversion system has burgeoned in the recent years. This conversion system is based on the parallax visual function [1] which is the combination of the multiple 2D views that are perceived while watching an actual 3D object. This technology has seen a direct impact in our daily lives in the form of 3D movies and 3D television sets.

2D to 3D conversion has seen a significant proportion of research in the recent years. The field is relatively obscure due to the lack of perception possessed by the machines as compared to humans. This is one of the few fields in science where human intellect is more powerful than the machine as it cannot perceive depth as easily as human eyes can. Moreover, the depth calculation cannot be estimated on the basis of a single image but needs multiple images taken from different angles so as to give the machine a complete idea of the object that needs to be rendered [2].

One of the associated concepts with 2D to 3D conversion is object recognition assuming that the object given as input is unknown objects. Object recognition uses techniques like edge detection, recognition by parts, appearance-based methods using stored

templates of the object from which it can be compared with, feature-based methods using the standout object features like surface patches, corners or linear edges as reference points, et cetera. Many algorithms are developed for object recognition using Computer Vision (CV), using illumination and rotation invariants, gray scale video image processing with a static camera, et cetera[3].

Although many methods have been laid down for the conversion of 2D images to 3D spatial reprints, most successful approaches demand human intervention, and therefore, time-consuming and slow. Other methods, which try to automate the process by embedding stereoscopic vision, depth learning [2] and depth maps [4] turn out to be complicated and, sometimes, inaccurate due to the complexity of the functions involved.



Fig 1: The evolution of cameras from Daguerreotype to the modern day DSLRs.

2 Preliminaries

A. Edge Detection

Various algorithms are available for edge detection process. Canny, Differential, Sobel, and Roberts cross are few of the edge detection algorithms [5]. Canny edge detection was devised by John F. Canny in 1986(). It is widely used algorithm and MATLAB and OpenCV supports Canny edge detection method. Canny edge detection algorithm aims at notably reducing the data in an image while still keeping the key features that are to be used in image processing [6].

B. Image Segmentation

Image segmentation is an interesting topic for research and variety of methods are present for the same. Some methods thresholding method (Otsu's method), Colour based method. (K-means clustering method), Transform method. (Watershed Segmentation), Texture method. (Texture filters).

C. Feature Extraction

Feature extraction along with feature detection and matching is used in object recognition, face detection and recognition and CBIR (context based image retrieval). The extracted features from the input data are reliable and the desired operations can be carried out by using these features rather than the large redundant input data. If the input data has high complexity i.e. the number of variables is high the features extracted from it could be a poor representation of the actual data. Independent component analysis, iso map, Kernel PCA and deep feature synthesis are few of the examples.

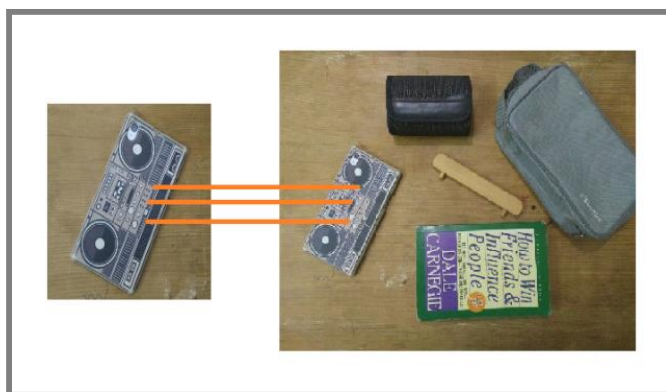


Fig 2: Feature Extraction

D. Monte-Carlo Method

One good example of Monte Carlo method is its use for volume estimation of a food object such as a solid fruit without the requirement of 3D Object reconstruction [7]. This volume estimation process merely requires few images of the food objects from different angles and it estimates the volume of the food object without tampering it. This method is advantageous as it works on the idea of randomization and only requires knowing whether a certain random point lies inside or outside the object.

3 Proposed Module for Volume Estimation

Our approach is based on the idea of automating the volume

estimation process of the irregular object in such a way that the implementation method would be less complicated and the results do not suffer a drop in accuracy at the same time. This method calculates the volume of the irregular object by breaking it down into thin strips along the horizontal direction. It is important for the strips to be very thin for the result to be accurate in the proposed method. The idea behind it is that any curved surface that is broken down into infinitesimally small pieces, can be viewed along the surface as a straight line due to its small size. This can be denoted by δh , where δh is so small that it can be imagined as a straight line. Hence, the problem arising due to lack of uniformity during height calculation can be solved.

Let us take a look at the entire process right from the beginning, from the time when the input has to be given to the system in the form of multiple 2D images. These images need to be taken at the user end and can be taken at varying distances by the user as long the entire side of the object is captured in the image. This, however, can cause a problem as the distance from which the user might capture the image may vary and would render it difficult to exact the dimensions even on a 2-dimensional scale.

This problem can be solved using a scale which would be captured along with the object in every image. The dimensions of the scale have to be known to the user, preferably, set by the user to a size which would be easy for computation, but also is bigger than the object. The scale's size would be corresponded to the object's size in the image to get the actual image size.

For, example, let's assume that the scale has size 10 units. The image is captured such that the object and scale are both visible in the frame. Here, the size of the scale turns out to be 3 units and the object turns out to be 2 units. These distances would not give us an estimate of the size just on their own, but, the size of the object can be calculated by comparing the relative sizes in the image to the size of the scale, i.e.

$$\frac{\text{size of the object}}{10} = \frac{2}{3} \quad (1)$$

The proposed system requires a minimum of three photos taken from different directions for the volume estimation and for object recognition. Even though the side views of the object would be enough for volume estimation up to some extent, the top view would be important for the object recognition as well as for checking for any cavities in the object from the top side (e.g. apple).

It is achieved by removing traditional inductor and focusing on the right-aligned sequence of pulses. For the volume calculation part, we would require the size of the object from the two side views to calculate the area of the object, which, on multiplying with height could give us an estimate of the volume. This, however, could not be done directly as discussed before due to the many discontinuities that the object may pose. Hence, the idea of breaking the object into small parts comes into picture here. The breaking up of the object into these many small slices solves the problem that would be posed due to the curvatures in the surface of the object. Thus, a divide and conquer strategy could be applied effectively, wherein, we would need to calculate the area of the slice under consideration.

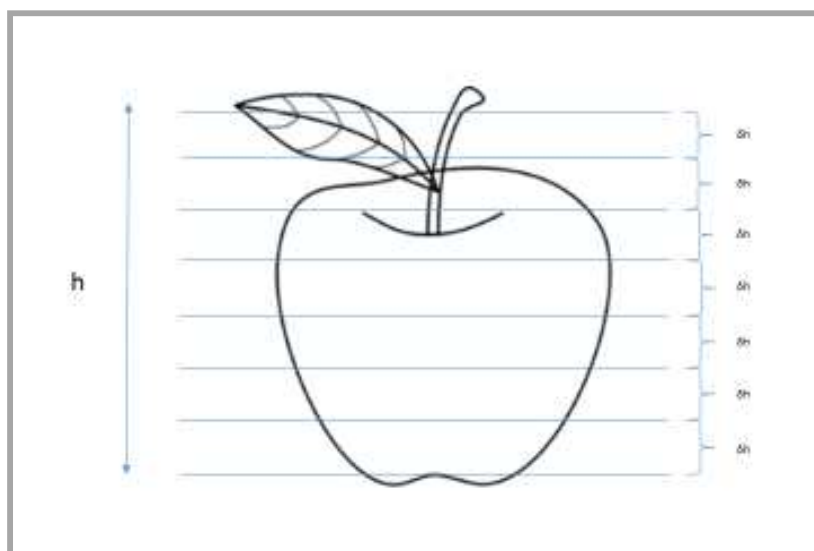


Fig 3: Breaking up the object in small parts

Let us consider the object in consideration here to be an apple. The apple has a somewhat a circular shape, where, the top and bottom parts are small in size and distending at the middle. The area of each slice could be calculated by considering the entire apple to be broken down into many small cylindrical slices. Thus, all the areas could be added together and multiplied with the common height in which they are broken in, i.e. δh . Now, the area can be calculated easily by multiplying the half the lengths (radii) of the two side views at that particular height with a pi. For example, at height 1 unit above ground axis, the length of the apple from both the sides would be considered to be as its diameters such that assuming one's length to be 4 units (assume it to be 'a' units) from one angle

and 5 units (assume it to be ‘b’ units) from another angle. Hence, the area for this strip would be,

$$A_{at\ 1\ unit\ height} = \pi * \frac{a}{2} * \frac{b}{2} \quad (2)$$

It could be noted that the accuracy of the volume calculations would go on to improve if the number of the input images of the object would increase as would give a more accurate set of data for each area to be calculated.

Thus, volume for just the above-mentioned strip would be calculated by,

$$V_{at\ 1\ unit\ height} = \pi * \frac{a}{2} * \frac{b}{2} * \delta h \quad (3)$$

Adding all such volumes would give us the final volume estimate. Furthermore, some volume can be deducted from the final calculation after careful consideration of the gap at the top and bottom of the apple, for a more accurate calculation of the final volume. The mass of the object can be estimated using the calculated volume and density values which can be referred from a database filled with density values. This, however, is possible after the object recognition phase. The object has to be recognized so as to give its density values.

The mass calculation can be calculated using the formula,

$$mass = volume * density \quad (4)$$

4 Conclusion

Breaking up the object into small slices ensures that the curved surface that an irregular object usually has, would be countered upon as the size of the slice would be very small, allowing us to consider the irregular pattern as a straight line. The volume of each slice would be calculated, using the dimensions of the object at that particular height. These volumes would be calculated using the mean of the two measures of the radius obtained from the scale. The sum of the volumes of all the slices will be a close approximation of the actual volume of the object. The proposed idea is a simpler and cost-effective solution as compared to the other methods.

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