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Research Article

Web Application to Measure Box Volume for Warehouse and Logistics using ArUco Marker and Mobile Camera

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ABSTRACT

Effective space management poses a significant challenge for logistics firms and warehouses. To effective utilization of available space, time and money, logistics firms, warehouses and postal service providers are interested in volume measurement devices. The existing product for volume measurement is available for very high cost and their setup itself is not affordable to small scale businesses. Non-destructive measurement systems, which are primarily based on image processing methods, have become the trend in this field. This paper presents an affordable system which makes use of Mobile phone along with ArUco marker for calculation of volume of boxes and provide a solution to warehouses to optimize the space so maximum objects can be placed in limited area. The proposed system tested with various external disturbances and provides and accuracy of 96%. This system presented in this paper is not only handy, but also saves times, efforts required to measurement of volume and eliminate human error.

Keywords: Aruco Marker,Camera,Contours,Measurement,Volume,Warehouse

INTRODUCTION

There is a growing interest in volume measurement devices for logistics and postal service providers due to the need to save time and money. Image processing techniques are the primary focus of research in this field, as they provide non-destructive measurement systems. Currently, several hardware options such as laser-based sensors, infrared sensors, stereo systems, and acoustic systems are available. However, laser sensors are expensive and may lead to inaccurate measurements due to misalignment and package surface deformation. Various approaches were used in literature which make use of sensors to increase accuracy. Another approaches are to use point laser sources and cameras together, which have been successful in measuring volume on moving platforms. Camera-based techniques such as stereo camera and structured light systems were also utilized for volume measurement. Stereo systems use calibrated camera pairs to determine depth data, while structured light systems use vanishing points to create a 3D model. However, the accuracy of these systems depends on various factors such as calibration, image resolution, and quality of cameras and lenses. Additionally, the environment's lighting conditions may affect the accuracy of camera-based systems, and artificial light sources may be required for optimal performance.

According to [1]a brand-new supervised learning algorithm that can quantify the displacement of the ArUco marker is described. This paper has made it easier for us to comprehend the origins and components of the ArUco marker and how to use it in place of other instruments to measure the separation between an object and the camera. According to [2] states that the Kinect sensor was used to determine a box's volume. According to [3] laser and image processing work together to produce the intended outcome. In this method, two lasers and a Sony camera are used to measure an object's dimensions and determine its volume. Object measurement technique in real time using AI and IoT technologies like OpenCV[4][5] libraries and webcam respectively were also proposed in. In [6] an ArUco marker is placed on top of the mobile robot, which is detected by a camera placed on the ceiling. In [7] a UAV equipped with a low-cost camera is able to detect ArUco markers sized 56 × 56 cm from an altitude of up to 30 m. In [8][9] comparison between Aruco marker and AprilTag marker is presented and recommended that detection rate of ArUco marker is better. In [10] a circular-ring visual location marker based on a global image-matching model is proposed.

In [11] a skeleton based approach is introduced to calibrate [12] multiple RGB-D Kinect cameras in a closed setup, automatically without any intervention. In [13][14] deep learning approach is proposed for box volume measurement whereasa novel mobile structured light system propsed in [15][16].

This paper proposed a portable way to measure the volume of a box which makes use of ArUco markers. ArUco Marker is binary square fiducial markers that can be used for camera pose estimation as shown in fig. 1. One can generate ArUco marker by using aruco.drawMarker function available using OpenCV in python.

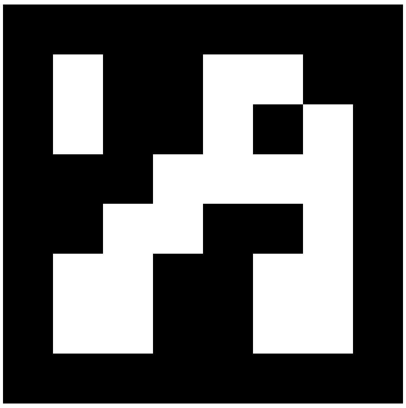

Fig. 1 A Sample ArUCO marker

RESEARCH METHODOLOGY

Fig. 2 shows the system architecture which begins by accepting two jpeg/jpg images (i.e. top view and side view) of box for whose volume [17] to be measured. The image is then preprocessed where image is converted into grayscale. The next crucial step is to identify the objects in the image, using canny edge detection and contour detection algorithm. In addition to object detection, ArUco markeris also detected using OpenCV lib's ArUco package. The ArUco marker [18] and object are used to mark the boundary corners, and the pixel distance is then converted to centimetres. The function returns the object's height and width as well as the ArUco marker. As above procedure is carried out on two images at the same time, and the dimensions are obtained. From received dimensions the side which is common for both image is considered once and box's three edges are then multiplied to determine the volume.

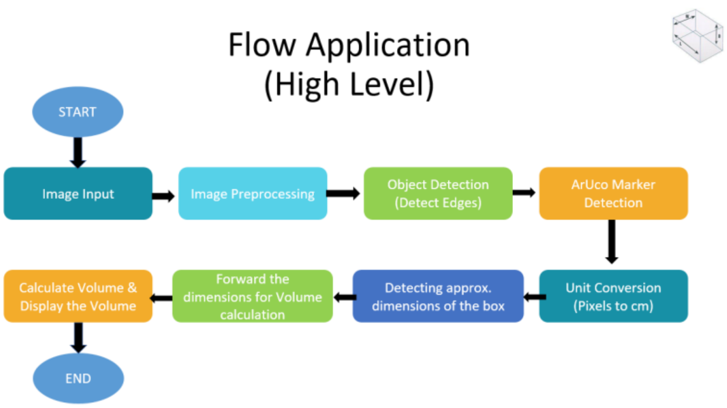

Fig.2.System Architecture

A crucial task in computer vision [19] is edge detection [20]. An edge is often a sharp change in colour from one pixel value to another, like from black to white. Finding edges in an image is, in a nutshell, the technique of edge detection [21][22].

➢ Canny Edge Detector:

The multi-stage canny edge detector technique finds edges in a picture. John F. Canny developed it and published it in the article "A computational method for edge detection" in 1986. It is one of the most well-liked edge detection methods, and not just because it is straightforward and produces excellent outcomes.

There are four steps in the Canny edge detection algorithm:

1. Noise reduction by applying a Gaussian blur [23] to the image.

2. Calculating the image's intensity gradients.

3. Edge suppression.

4. Hysteresis thresholding is used.

The system starts working by loading image, converting it to grayscale, and blurring and removing noise withcv2.GaussianBlur. The Canny edge sensor is also applied using thecv2.canny function as shown in fig.3 . This function takes 3 needed parameters and 3 voluntary parameters. The first argument is the image from which the edges are to be detected. The alternate and third arguments are the hysteresis procedure thresholds.

Fig. 3. Edge Detection

➢ Contour Detection

The fundamental building blocks of computer vision are contours [24]. They give computers the ability to recognize the general sizes and forms of things in an image so that they may be categorized, segmented, and identified as shown in fig. 4. The steps to determine contours with OpenCV are the following:

1. Create a binary image from the original image. Edge detection or thresholding are options.

2. Use the cv2.findContours function to locate the contours.

3. Use the cv2.drawContours method to draw the image's outlines.

In this work, the cv2.findContours method to locate the contours. There are 3 necessary arguments and 3 optional arguments for this function. The binary image is the first argument. The contour retrieval mode is the second argument. Here only the exterior contours of the objects are recovered in the image by using cv2.RETR EXTERNAL.The contour approximation technique is the third input to this function. Here cv2.CHAIN APPROX SIMPLE option is used, which will only maintain the end points of diagonal, vertical, and horizontal segments after compression. The options are listed under ContourApproximationModes.The function then gives back a pair of items in a tuple (this is the case for OpenCV v4). The image's contours are the first element, and the hierarchy of the contours is the second. The original image is then copied, and this copy will be used to trace the outlines.

The cv2.drawContours function is used to draw the contours. The image on which to draw the contours is the first input to this function. The contours are the second argument, and the index of the contour to draw is the third. A negative number will draw every contour. The fourth input is the contours' colour and the final argument is the thickness of the contour lines.

Fig .4.Contour Detection

EXPERIMENTAL RESULTS

Fig. 5 shows the flow of Web Application to Measure Box Volume for Warehouse and Logistics using ArUco Marker and Mobile Camera.

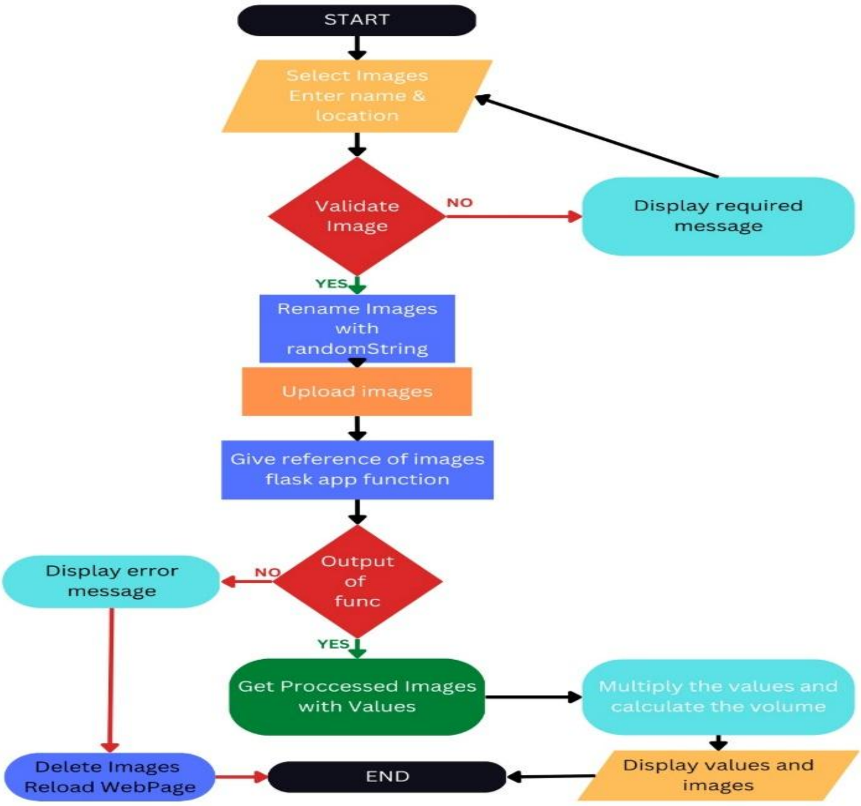

Fig. 5. Flow Diagram

Fig. 6 and 7. Shows the graphical user interface of web application where user has to upload the images of top view and side view of box. After uploading the images of top view and side view, system will detect ArUco marker and dimensions of an object will be calculated. Once the dimension of an object is calculated, there will be two values of common side. So, to eliminate this, the average function will be initiated and takes average of common side. Once all the dimensions of an object are calculated, the volume function is triggered.

Fig.6. Experimental Results-Sample1

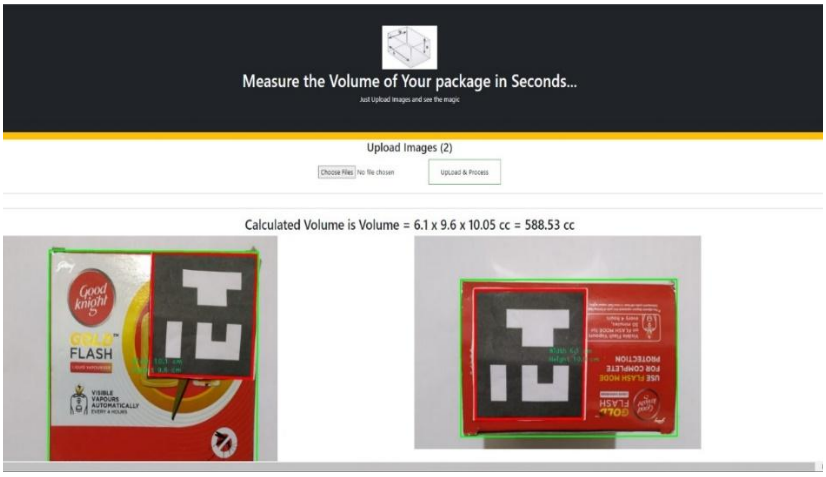

Fig.7. Experimental Results-sample2

The volume function will calculate the volume of an object and it will be displayed on the home page along with the images of an object. Following is some of the benefits of this web application

- Measurement and calculation of any object using labour will take approximately 2-3 min per object but using this application it can be done within 2-3 sec.
- To eradicate human error and maintain accuracy and efficiency, this system will be helpful.
- To reduce paper or any physical resources, this system uses cloud services to decrease the usage of physical resources.
- This system will be cost effective with respect to other such volume measurement [25] system which are costly and require lots of hardware and real-estate.

Table 1 shows the experimental results of 8 different boxes with Top view, Side view of images, Calculated value, Actual value and Efficiency of the System.

Table 1 : Experiment Result of 8 different box samples

Sr. no.	Top view (TV)	Side view(SV)	Actual value	Calculated value	Efficiency
1.			SV_(10.0x6.1)cm TV_(10.0x9.5)cm	SV_(10.1x6.1)cm TV(10.0x9.6)cm	97.97%

2.			SV_(13.0x29.5)cm TV_(29.5x15.0)cm	SV_(13.2x29.5)cm TV_(29.5x14.5)cm	98.48%
3.			SV_(6.0x18.8)cm TV_(18.8x9.5)cm	SV_(5.8x18.8)cm TV_(18.8x9.5)cm	96.66%
4.			SV_(11.0x11.4)m TV_(18.0x11.4)cm	SV_(11.7x11.4)cm TV_(18.0x11.4)cm	95.00%
5.			SV_(15.3x17.8)cm TV_(17.8x17.6)cm	SV_(15.7x17.8)cm TV_(17.8x17.6)cm	97.45%
6.			SV_(17.8x9.9)cm TV_(16.9x16.3)cm	SV_(17.8 x 9.9)cm TV_(16.9x16.3)cm	100%
7.			SV_(13.5x5.5)cm TV_(10.7x13.9)cm	SV_(8.9X5.2)cm TV_(10.7x13.9)cm	86.42%

The overall efficiency of the system from experimental results is 96%. All the experiments on sample are done in day light without applying any filtering.

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CONCLUSION

The objective of this work is to introduce a model that enables volume measurement of objects using mobile device cameras, which was not possible using traditional methods. The proposed web-based application is helpful for warehouses to optimize the space so maximum objects can be placed in limited area. To achieve this, the model utilizes an ArUco marker for object detection, which helps eliminate the distance between the object and the camera. The model was tested on objects with varying dimensions, and a web page was created to facilitate image upload for analysis. The images are validated upon selection, and if the image format is incorrect, an error message is displayed and if the image is correct its name is replaced by random generated strings. The dimensions of various objects were measured with 96% accuracy. In the future, weight measurement can also be added with volume measurement.

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