Weight Estimation through Image Analysis

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Abstract *Automation system or robotic system depends upon surveillance based camera which captures images from all around view. From these multiple view the image object's dimension can be calculated. A number of research work has been progressed on this area based upon 2-D images using different techniques. In this paper from multiple views (side view and top view) of a single image taken by handheld camera or surveillance camera the weight of an object is calculated. In Pouladzadeh et al.'s work [1] the food items weight have been estimated by segmentation process. But in the case of cast iron or steel bar produced from refactory. While wielding in production line they need to be placed in proper assembly channel according to their weight. In this case it is impossible to calculate the weight of bars using simple weighting machine. In such case the weight can be approximated using image analysis technique. In our paper the image segmentation based technique has been applied and using dimension of the image object weight has been calculated using density based formula. The density for different object has been stored in different location. It was observed through experimental process, an average of 92%-94% success has been achieved for various object targets.*

Keywords — *Image Processing, Segmentation, Side View, Top View, Clustering, Weight Estimation, Image weight, Mobile Image, Scaling Factor, Grid Area*

Introduction

In the present scenario, the use of computers and mobile applications to do most of the information sensitive task is becoming dominant. Automation, convenience and intelligent computing are the most cutting edge trends for recent research area. Mainly all applications we use are 40-60% image or vision based technologies. In everyday's life starting from jugging to sleeping we are used to use these technologies. In most of working area like automotive industries, refectories, retailers, shipping industries also use technology such as surveillance based security, food processing, robotics or automation image or vision based analysis is done. In this paper an application which can be used to approximate the weight of an object by using two dimensional images of the object can prove to be very useful and time efficient in many industries and in daily life also (Chaitanya C. et. al, 2015) [2].In this work an attempt has been made to approximate the weight of an object using two dimensional images of the object.

An image is a two dimensional numeric representations denoted as f(x, y) where x, y are spatial coordinate and amplitude f at coordinate (x, y) is called intensity of image. In image x, y and f are finite and discrete values. The image consists of picture elements or pixels which may be represented as rgb values at coordinate (x, y).From the image captured for a distinct object the various attributes such as shape, boundary, height, length, and colour can be retrieved using various image processing and segmentation technique.

They are known as primary attributes and they are measurable in terms of float or integer values. From this primary attributes other attributes can also be calculated. The calculation of weight and volume using these attributes or parameters from a two dimensional image is such challenging task in the computer vision or robotic vision domain. Image segmentation is the process of partitioning or distributing image into several segments based on their uniformity. The segments are also called as set of pixels or super-pixels. The goal of segmentation is to simplify or change the representation of image into a particular region of interest which is used to locate the object or boundaries. More precisely image segmentation is the process of assigning label to each pixel such that that each pixel shares certain characteristics.

The result of segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of pixels in a region is similar with respect to some characteristics or computer property, such as colour, intensity or texture.Adjasent regions differ from each other with some distinguishing attribute or characteristics. The image segmentation technique that is implemented in methodology is watershed segmentation algorithm [4] (Amit Chaturvedi. Et. al, 2012) algorithm because of its straight forward approach and its property of segmenting image based on the seeded region growing techniques as this is gaining more popularity now a days. This technique is best suited for the problem statement as the image of the object is needed to be divided into multiple segments which ultimately create region of interests.

From the object's cluster properties like area, height and volume of the object is calculated. To find the original object size from the input image the technique of scaling is applied. This is a process of obtaining ratio as factor by which the cluster size is to be multiplied to get the actual size. To obtain the scaling ratio, a fixed background size is defined in which the object is placed. The significance of taking the background image ratio helps to determine the scaling factor. The area approximation is also a major challenging area because of noises present in image. The problems like lighting which can be resolved by pre-processing the image and using subsection of image discarding noisy background. This methodology reduces error, making the approximation more accurate.

The proposed method uses the basic concept of weight calculation making the process simple to comprehend. Weight (w) is defined as force on object caused by gravitational pull, this is defined as product of mass (m) and gravity (g).On the other hand mass is calculated as product of volume and density.

I. METHODOLOGY

The general principle of the technique presented in this paper is based on density database for the object. Firstly the scaling ratio is calculated to convert the apparent sizes to actual dimensions. The actual dimensions of the fixed background, which is selected for the process, are known as L_{actual} x B_{actual}. After capturing the image and pre-processing it, let the final dimensions of the image be $l_{apparent}$ x $b_{apparent}$. Then the scaling ratio will be:

Scaling ratio $= L_{actual} / l_{apparent}$ or $B_{actual} / b_{apparent}$ (1)

The activities done are shown in figure -1 briefly which indicates that the input image is captured using camera. Let f(x, y) be the input from front view and s(x, y) be the input from side view of the image which is pre-processed to obtain f'(x, y) and s'(x, y).These pre-processed images are passed through the segmentation function (H [.]) to get the clustered images of front and side view, that is g(x, y) and h(x, y) respectively. The subsection of g(x, y) and h(x, y) containing the object's cluster. The grid area technique is applied on g(x, y) and h(x, y).The M x N subsection is selected for grid area calculation of the object. This sub-section consisting object's cluster O and background's cluster G is then subdivided into smaller grids of size m x n.The M x N rectangle is then iterated for every grid cell column wise. For each grid the count of pixels belonging to O is calculated. If the count of O exceeds 50% of the total pixels in the grid then this grid is considered to be part of the object's cluster. The iteration gives the total number of grids belonging to O, that is, O[n].The count O[n] is stored in a vector for every column in the grid array. The grid area technique returns two vectors, $C_{ocfront\,()}$ and $C_{ocside\,()}$, for the segmented images g(x, y) and h(x, y) respectively. After applying grid area technique, the following cases might arise:

- The vectors have unequal dimensions, or
- The vectors have equal dimensions

The former case must be handled before going ahead with area calculation. To equalize the dimension, the larger vector's extra elements are removes and the average of these are taken and inserted back into vector. Now the two equal lengths vectors are used to obtain the total number of grid cubes that the object's cluster comprises of. Thus the estimated volume of the object can be calculated by using the formula

Volume $= (\sum^{n}_{i=0} C_{ocfront}(i) + C_{ocside}(i)) * Vgrid * sf^3$ (2)

Where V_{grid} = volume of the grid cube

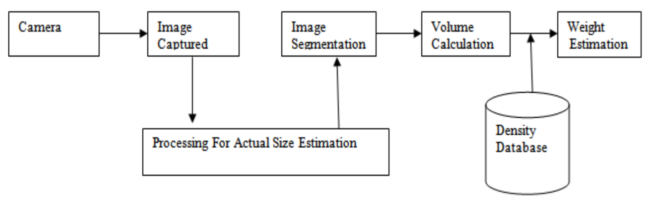
sf = scaling factor

A comparative analysis was done with real object weight and with the obtained weight. The analysis was done by considering the metric 'accuracy'. The accuracy of a system is the degree of closeness of measurements of a quantity to that quantity's true value. The accuracy percentage is calculated as:

Error % = (actual value - estimated values) / actual value * 100 (3)

Accuracy % = 100 - Error % (4)

Figure 1: Flow Chart



II. FLOW PROCESS

The proposed technique consists of following steps.

Step-1. Pre-Processing *In pre-processing phase the image is downscaled for faster computation.*

Step-2. Pre-Processing *The pre-processed image is segmented using K-means clustering algorithm to extract the object from image. The image is divided in which subtraction of the image comprising the object cluster is used for further processing.*

Step-3. Image Segmentation *The pre-processed image is segmented using watershed segmentation algorithm [4] to extract the object from image. The image is divided in which subtraction of the image comprising the object cluster is used for further processing.*

Step-4. Volume Calculation

Following are the abbreviations used

segside = segmented side view image
segfront = segment front view image

$C_{oc()}$ *= count of the number of grids belonging to object's cluster column wise*
C_{opx} *= count the number of pixels belonging to object's cluster*
C_{bpix} *= count the number of pixels belonging to background's cluster*

gridArea (Segmented Images)

for each segmented image
do

for a subsection M x N of the segmented image, construct a grid array.
end for

for i = 0 to gridColumnmax

for j = 0 to gridRowmax

for x = 0 to widthcell
for y = 0 to heightcell
if pix(x, y) = object's pixel
$C_{opix} = C_{opix} + 1$
else

$C_{bpix} = C_{bpix} + 1$
end if
end for
end for

if $C_{opix} > C_{bpix}$

C oc(i) = C oc(i) + 1
end if
end for
end for
end for
end

equalize (Cocside, Cocfront)
diff = | length(C ocside) - length(C ocfront) |

for i = 0 to diff
avg = avg + Coc(n-i)
remove (Coc(n-i))
end for
avg = avg / (diff + 1);
Coc(n-i) = avg
end

Volume(Cocside, Cocfront)
for i = 0 to length (Coc)
vol = vol + Cocside(i) + Cocfront(i) + Vgrid
end for
end

Step-5. Mass Calculation *Using the volume of the object the mass can be determined using:*

*Mass = Density * Volume*

IV. EXPERIMENTAL RESULT

The proposed method is tested upon a similar type of objects (Figure 1) using MATLAB. Set of objects are selected upon the uniformity of the material. This method is based on image processing. The volume of each individual objects is eliminated from both the top and side view of the object's image. Using the density table weight of the object is estimated. The objects taken here are fruits, brick, PVC, steel blocks. It can be concluded from the experiment that approximately 90 percentage of accuracy is obtained in estimating the weight of the object using the proposed method. Further experiment is done for multiple objects using watershed segmentation technique using MATLAB.In the experiment the objects based on regions are detected and identified successfully and then corresponding density are retrieved from database. After this areas are calculated based on grid based technique as mentioned in [16] for calculation of volume as mentioned in section of flow process Step-4.

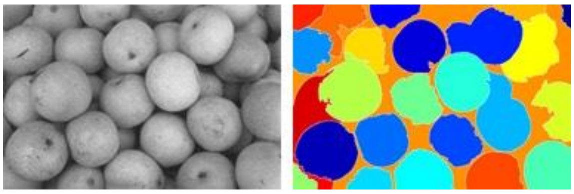


Figure 2: Color based object segmentations

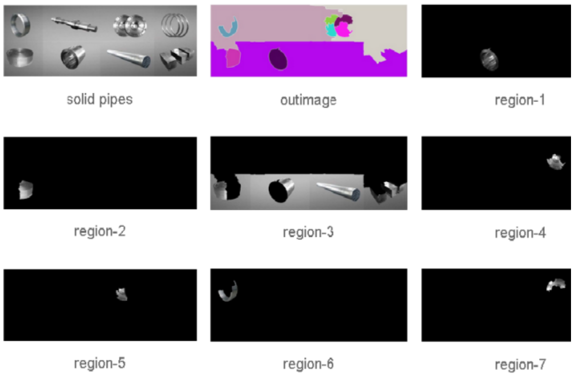


Figure 3: Watershed based object segmentations

A. Sample Calculations

gridArea output:

Cocfront() =

[12, 18, 22, 24, 28, 30, 32, 34, 36, 37, 38, 40, 41, 42, 42, 43, 44, 42, 39, 37, 37 ,37, 37, 39, 42, 44, 43, 42, 42,41, 40, 39, 38, 36, 35, 34, 32, 30, 28, 25, 22, 17, 11]

Cocside() =

[9,11,11,11,11,11,12,12,12,12,12,12,12,12,12,12, 12,12,12,12,12,12,12,11,11,12,13,13,13,13,13,12,12, 12,12,12,12,12,12,12,12,12,12,12,12,12,12,10,10, 8]

equalize () function output;

Cocfront() =

[12,18,22,24,28,30,32,34,36,37,38,40,41,42,42,43,4 4,42,39,37,37,37,37,39,42,44,43,42,42,41,40,39,38,3 6,35,34,32,30,28,25,22,17,11]

Cocside() =

[9,11,11,11,11,11,12,12,12,12,12,12,12,12,12,12,12, 12,12,12,12,12,12,11,11,12,13,13,13,13,13,12,12,12, 12,12,12,12,12,12,12,12,11]

Using equation (2)

$$Volume = (C_{ocfront(i)} + C_{ocside(i)}) + Vgrid + sf^3$$

$Volume_{object}$ = 1294.45 cm3
$Density_{object}$ = 1.45 gm/cm3

$Mass_{object}$(Weight) = 1294.45 * 1.45 = 18769.95 gm = 1.88kg

Error % = (2.00 - 1.88) / 2.00 x 100% = 6%

Accuracy % = 100 - 6 = 94%

V. TABLE 1: EXPERIMENTAL RESULTS

Object	Actual Wt.(Kg)	Density(g/cm3)	Volume(cm3)	Estimated Wt.(Kg)	Error
Brick	3.94	1.765	2669.75	4.7	19%
PVC	2.00	1.450	1294.45	1.88	6%
Alloy	0.22	2.100	112.85	0.237	6%

VI. CONCLUSIONS

The proposed method for weight estimation of objects from 2D images is built based on image processing. More accurate grading is made possible by obtaining a better estimate of the weight of each item. Conventional weighing methods are very expensive for high speed grading and packing. This paper demonstrates an approach to accurate, high speed weight estimation using image analysis. Two perpendicular views are utilized to obtain an estimate of the volume of each item, which is then related to the weight using pre-defined density of the object. Proposed method of weight calculation gives approximately 90% accurately.

The performance of the proposed system can be improved by using better shape recognition method where actual 3D [2] (Chaitanya C. et al. 2015) shape of object can be recognized. So, that volume can be calculated from a single image using appropriate volume calculating formula, which can result in accurate volume and weight calculation. This proposed technique will result in error prone estimation in cases when object is small or in case of precious metal etc.It also faces problems when the object has the characteristic of being hollow as such property cannot be determined using the 2D image of that object like in the case of an empty can of soft drink. Further challenge may arise in setups like dynamic camera and fixed object, and vice versa.

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