OPTIMIZING PACKAGE SIZE: A CUSTOMIZED APPROACH FOR SUSTAINABLE PACKAGING

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Abstract - The packaging industry is coping with a rise in demand for sustainable and eco-friendly solutions. Reducing the size of packages while assuring the safety and protection of the contents during transportation is one of the issues. This article suggests a technique for lowering package size while still protecting the contents. The process entails measuring the object's size and weight, choosing the best packing materials, and utilizing sophisticated design software to make a unique box that precisely fits the thing. The goal of the proposed project to make use artificial intelligence technology to carry out the dimensions of the box length and width so one can figure out the box structures and can fix position to place the goods according to the dimensions of the box.

Keywords: Package measurement, image processing, computer vision, dimension extraction, raspberry pi, convexhull

I.INTRODUCTION

Real-time systems that detect and measure objects are critical in industrial processes. In particular, object detection is frequently employed during product quality checks. The suggested system has potential applications in industrial quality control systems and can also be useful in a range of other industrial or security settings. Typically, the system identifies objects in public spaces and measures the dimensions of each one.
Actual videos taken with a Raspberry Pi camera have been used to show how effective the suggested technique is. The system's high processing speed is influenced by the resolution of the frames being used. Both object detection and background separation performance by the system have been astounding [1-4]. To determine the dimensions of individual object, it is necessary to select a reference based object first. This reference object's dimensions are then utilised for calculating the dimensions of various objects. Calibration for live feed camera is performed based on the reference object, which is always positioned on the left-most side of the image. The measured size of various objects in every frame can also be determined using the reference object to calibrate the pixels per metric variable. [5]. All of the computational procedures are performed using a Raspberry Pi 4 operating at 1.3 GHz, running on the Raspbian operating system [6-10]. OpenCV libraries are utilized in all of the procedures [11].
We have discovered multiple papers related to measurement systems, with each application serving a different purpose. One paper proposed a portable outdoor distance measurement system, which achieved 90% accuracy using the S3C2410 system. To improve accuracy, a temperature correction module was utilized [13]. Another paper proposed an ultrasonic distance based calculation device for embedded applications [14]. Meanwhile, computer vision methods were utilized to estimate the measured calculations of objects in a frame in a different paper [15].

II. Related Works

"Sustainable Packaging Design: A Review of the State of the Art" by Bocken et al. (2016) This study gives a general overview of life cycle assessment (LCA), ecodesign, and cradle-to-cradle principles as they apply to packaging design. The authors stress the significance of considering every stage of a product's life cycle, from conception to disposal, and they contend that specially designed packaging can lessen material waste while enhancing product safety.

"Designing Sustainable Packaging: Key Considerations and Challenges" by Lee and Bras (2018) The difficulties and important factors in creating sustainable packaging, such as material choice, packaging layout, and product protection, are discussed in this article. The authors contend that by minimising material waste and maximising product protection, customised packaging solutions can enhance sustainability.

"Customized Packaging: A Review of Its Potential Benefits and Limitations" by Gao et al. (2019) The possible advantages and drawbacks of customised packaging, such as better product protection, less material waste, and greater consumer experience, are examined in this review study. The writers also go through the complexity and expense of putting customised packaging options into practise.

III. PROPOSED METHODOLOGY

The system is made up of two primary components: object measurement and object detection. In the first section, frames are taken using the Raspberry Pi camera. In the second section, the system measures each object after using a computer vision module to identify them in the acquired frames. The system begins processing an item as soon as it is found in the current frame in order to determine its dimensions.

Pre-processing is a stage in the proposed system that starts with taking a picture using the camera. To speed up the process and improve accuracy, the frame is next converted to grayscale. The Canny edge detection technique, which can detect both single and numerous objects, is used to identify objects. The Canny edge algorithm, which scans the whole image, is used to process the transformed image. The gaps between the edges in the edge frame are then filled using dilation and erosion algorithms [16–18]. Figure 1 shows the flowchart for the suggested system.

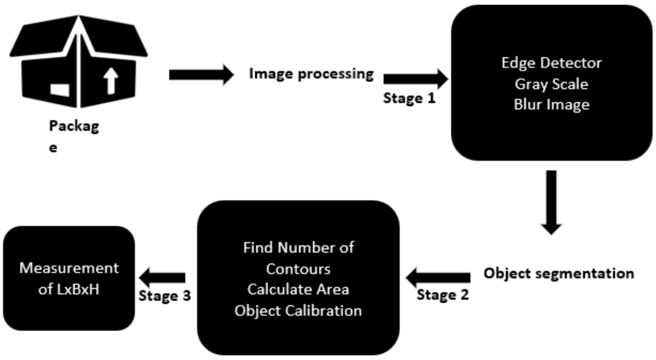

Figure 1 flow chart

Figure 2 shows the input frame used for clever edge detection. The frames' noise is eliminated using a Gaussian filter as the first step in the Canny edge identification process. Figure 3 displays the final frame after it has been made grayscale and the Gaussian filter has been used.

Figure 2 Gray scale on input image

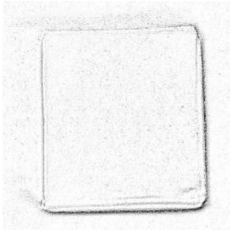

Figure 3 Edge detection using gray scale image

Each pixel's edge gradient and direction are determined during the calculate gradient stage. The Sobel operator is used to specify the gradient at each pixel of the smoothed frame in order to do this.

After obtaining the gradient's magnitude and direction, the entire frame is scanned to eliminate any undesired pixels that might not be edges. Only local maxima are taken into account as edges at this step due to the use of non-maximum suppression. This sharpens the rounded corners of the gradient magnitudes frame. The gradient image's local maximums are all maintained, while the remaining ones are removed using non-maximum suppression. The frame following the application of non-maximum suppression is shown in Figure 4.

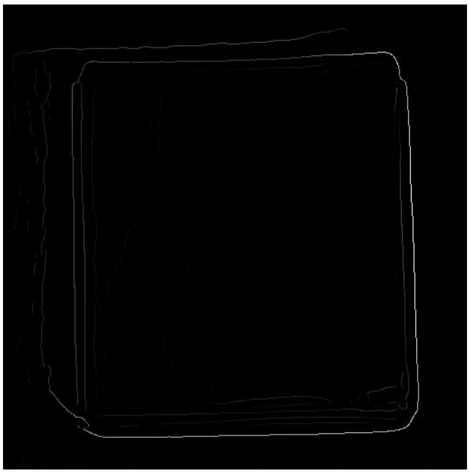

Figure 4 Non-Maximum Suppression

The canny edge detector algorithm's last step, hysteresis thresholding, distinguishes between edges that are indeed edges and those that are not. This is accomplished by choosing two experimentally determined threshold values depending on the frame's content. Edge pixels that are more powerful than the big threshold are designated as strong edges and are taken into account to be the final edges. On the other hand, an edge pixel is muted if its strength is lower than the tiny threshold. A weak edge is indicated when an edge pixel is located between the big and small thresholds.
In order to improve the accuracy of object detection in the system, morphological operations were applied to enhance the canny edge detection process [19]. These operations involve a combination of nonlinear procedures performed on the arrangement of pixels without altering their numerical values. The main operations used were erosion and dilation.
This study made use of a morphological technique that combines erosion and dilation. Erosive work is done during the opening procedure, then dilation. On the other hand, the closing procedure entails carrying out dilation first, followed by erosion. By using a combination of these processes, the researchers were able to achieve more accurate edge detection within the frame.
Convex hull algorithm: The Convex Hull algorithm is a vital tool in computational geometry used to determine the smallest convex polygon that encompasses a set of points in a plane. The algorithm can be implemented using various techniques, such as the Gift Wrapping or Jarvis march algorithm and the Graham scan algorithm. The Gift-Wrapping algorithm involves starting from the leftmost point and wrapping it around the other points to form a convex polygon. The Graham scan algorithm starts by identifying the point with the lowest y-coordinate and sorts the remaining points based on their angle with the identified point. The Convex Hull algorithm finds application in several fields, including computer graphics, collision detection, and geographical information systems, and its efficiency is crucial when dealing with large sets of points.
Edge detection is the initial stage in object measuring, and then gaps between edges are filled. The researchers utilised the OpenCV function cv2.findContours to arrange the contours from left to right, using the left object as the reference, in order to identify the forms of objects in the edge map. The parameter value was then set depending on the reference item once the camera had been calibrated. The points of the bounding box rectangle were then shown as tiny purple circles, and a green rectangle was created around each item after scanning its outlines. The ordered bounding box provided the midpoints. The researchers then used the reference item to determine the pixels per metric variable and measured the height and breadth distances in pixels. Finally, the distance method called Euclidean was calculated among sets of centre points.

IV. HARDWARE

The hardware development of the project is mainly considered about a point to make it in effective low price so that every citizen can afford to buy the kits. The hardware of the kit which is been proposed has major considerations:
1.It should have the best effective real-time support of camera access and detection of objects should be taken in milli seconds.
2.The hardware should be of light weight so that will be easy to handle with the body support of human.
3.The device which holds the vibration sensor should get best vibration apart from the free sensor handling to make it more sensitive for sensing data.

A. Raspberry pi: The raspberry pi is a device founded by eben Upton and his crew for a purpose to handle the computer in a single hand. This raspberry pi has the basic interfaces like the HDMI, Ethernet, USB, and sensor interfaces with analog and digital pins on it. The power supply to the raspberry pi is in between 10 to 12. These make the essential features for the raspberry pi to replace the desktop and to be carried out in single hand device for computing software's.

Figure 5 Raspberry pi-4 board

The raspberry pi which has changed in their evolution with many upgraded versions and improving its efficiency for the better performance. Presently we use the raspberry pi-4 which stands on high performance with 4GB Ram and 64-bit quad core processor which runs at 1.4GHz with provided heat sink. Dual band 2.4GHz and 5GHz wireless LAN, fast (300 mbps) Ethernet, and PoE capability via a separate PoE HAT. It consists of two micro-HDMI which is used for the display module at a time for two displays. The pi-4 works with great speed in performance and makes the best interface communication with better in all categories. This supports the GPIO pins to interface with the sensors and other communicating modules. So, with the raspberry pi we can make use of sensors direct interface and communication between any interface provided software interface with best compatible on to the device drivers.

As we know that in raspberry pi python is an inbuilt installed software in OS for functioning of various interfaces as source to compile data. The OpenCV has been installed for the computer vision projects in pi and it takes around 2 hours for the complete install of OpenCV in pi 4.

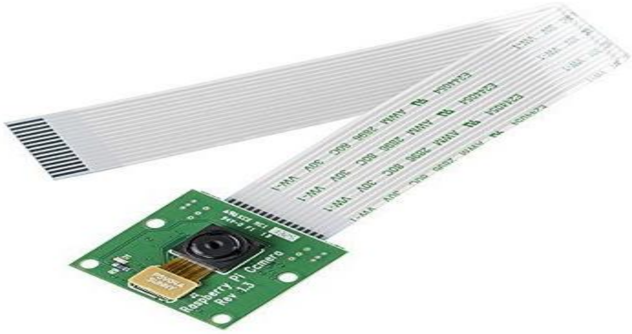

Figure 6 Pi-Camera

The raspberry pi camera module been implemented with the 5mp camera and is best interface with the camera and pi support. The pi camera has the communication modem with the camera and pi for transmission and receiving the digital pixels combined with NumPy array. These we make use for the video stream onto device with better flexible length for the focus of objects and make use of detection.

Block diagram of Proposed hardware

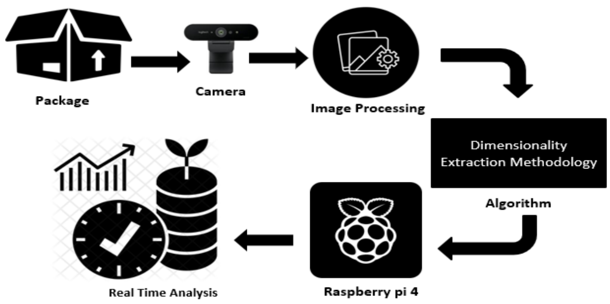

Figure 7 Block Diagram for proposed system

V. RESULTS

The proposed system aimed to measure objects in real-time videos and images, and several experimental setups were prepared to test the accuracy of the method. Python language was used to implement the proposed system, and Figure 6 shows the entire setup of the proposed system. Aside from the system hardware setup configuration, the necessary softwares was also installed and configured.

```
Selecting previously unselected package libqtgui4:armhf.
Preparing to unpack .../7-libqtgui4_4%3a4.8.7+dfsg-11+rpi1_armhf.deb
Unpacking libqtgui4:armht (4:4.8.7+dfsg-11+rp11) ...
Selecting previously unselected package qt-at-spi:armhf.
Preparing to unpack .../8-qt-at-spi_0.4.0-5_armhf.deb
Unpacking qt-at-spi:armhf (0.4.0-5) ...
Setting up qtchooser (63-913a3d08-1) ...
Processing triggers for libc-bin (2.24-11+deb9u3)
Processing triggers for man-db (2.7.6.1-2) ...
Setting up libgt4-xml:armhf (4:4.8.7+dfsg-11+rpi1) ..
_Setting up libjpegs:armhf (8d1-2) ...
*setting up libnngs:armhf (1.0.10+dfsg-3.1) ...
Setting up libqtdbus4:armhf (4:4.8.7+dfsg-11+rp11) ...
Setting up libqtgui4:armhf (4:4.8.7+dfsg-11+rpi1) ...
Setting up gdbus (4:4.8.7+dfsg-11+rpi1) ...
Setting up libqt4-dbus:armhf (4:4.8.7+dfsg-11+rpi1)
Setting up qt-at-spi:armhf (0.4.0-5) ...
Processing triggers for libc-bin (2.24-11+deb9u3)
pi@raspberrypi:- $ python3
Python 3.5.3 (default, Sep 27 2018, 17:25:39)
[GCC 6.3.0 20170516] on linux
(Tpe "help", "copyright", "credits" or "license" for more information.
(>>> import cv2
(»>
```

Figure 8 Modules installation in Raspbian OS

The experiment includes taking images using a camera effectively. The four processes included in the suggested system are recording frames, locating edges, locating objects, and determining object sizes. The output screen appears on the PC screen once the application has executed, as illustrated in Figure 9.

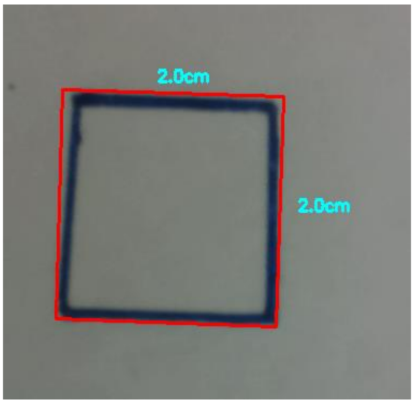

Figure 9 Calibration of the size measurement in cm’s

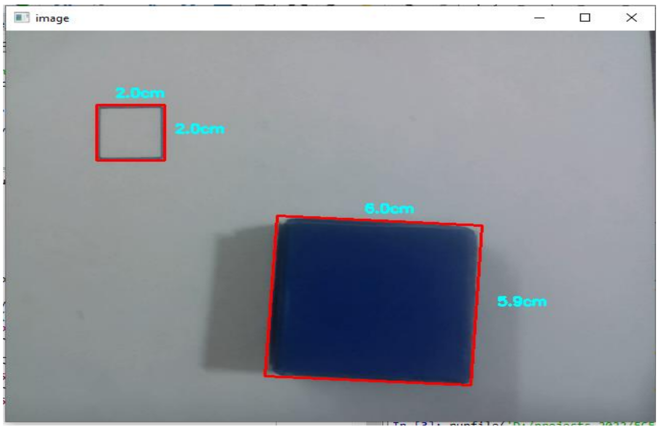

Figure 10 Realtime object measurement for packed object

The calibration of the object is so pure accurate with normal scale measured for accuracy score. The figure 11 describes the scaled measured for accurate measurement with realtime implementation of the object as shown.

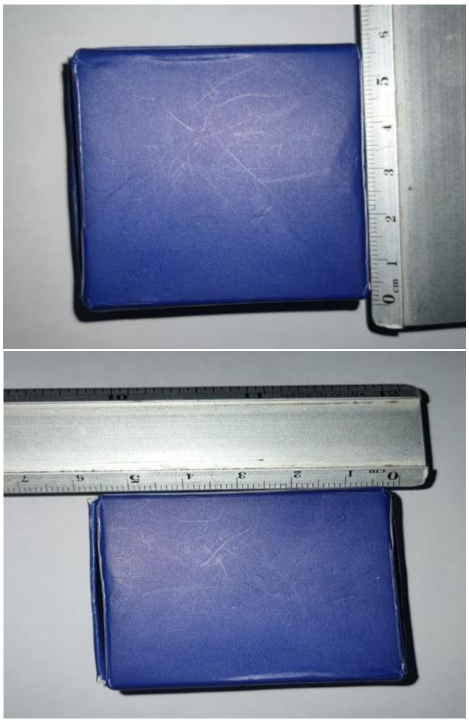

Figure 11 Describes about the measurement of realtime detection and compared with scaled in centimeters

The Object measurement for realtime has made an accurate results with accuracy of 98% after comparing with many such trials. The proposed methodology helps in accurate results and thus possibility increased for robotic vision in warehouse and manuacturing goods.

VI. CONCLUSION

The suggested strategy for customising sustainable packaging to optimise package size and protection offers a viable response to the problems the packaging industry is now facing. This strategy can decrease packaging waste, cut transportation costs, and improve the customer experience by analysing the precise dimensions of the article and designing a tailored box that fits. The usage of cutting-edge design software brings a fresh perspective to the packaging process and can boost the sector's productivity and sustainability. The findings from the case studies show how effective the suggested strategy is and point to the possibility of a wider adoption in other industries. Overall, this investigation has important significance for environmentally friendly packaging methods, and its findings could.

This study proposes a real-time method for measuring objects in industrial systems. The technique includes measuring and detecting items in a video stream using computer vision. The process begins by using a canny edge detector to identify objects in the video. OpenCV functions are then used to obtain the size of each object. To improve the accuracy of the canny edge detector, the study utilizes Morphological operations, which help to eliminate noise and smooth the shape of objects. This results in a clearer outline and more accurate size measurement for each object. As a result, the system is able to preserve the outlines of different objects in the video stream.

The technique proposed in this study is highly efficient, with the ability to process five frames within a second. To implement the system, the researchers chose to use Raspberry Pi 4, a low-cost embedded equipment platform known for its great features.

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