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Integrating Computer Vision and Fusion Sensor for Object Dimensioning and Weight Measurement

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Abstract: In the logistics industry, measuring the dimensions and weight of packages is crucial for optimizing cost expenditures, storage space, and inventory management. Traditional measurement methods often consume time and are prone to human errors. The objective of this research is to utilize load cell sensors, webcams, and image processing techniques to automatically and, in real-time, measure the three dimensions and weight of packages. The main contribution is to provide an effective solution for measuring package dimensions without the need for human intervention. The proposed solution includes the use of a 50kg half-bridge load cell sensor with HX711 for measuring package weight, HC-SR04 ultrasonic sensor for measuring the distance between the sensor and the package using Arduino Uno, and image processing using OpenCV to analyze the visual characteristics of the package. The system will be tested using various types of objects with varying sizes and shapes to determine the accuracy of the system in measuring package weight and dimensions. Measurement results indicate that the system can measure package dimensions, volume, and weight with a success rate of 92.45%. The system has a response time of around 1-2 seconds in its capacity to detect and measure objects. Conversely, when executed in simultaneously, it often has a duration of approximately 5 to 7 seconds.

Keywords: OpenCV, Arduino Uno, Logistic, Package, Ultrasonik Sensor

1. INTRODUCTION

With the growth of e-commerce and trade globalization, the number of packages shipped both internationally and domestically continues to increase. In 2018, the Indonesian Logistics Association (ALI) revealed that the logistics industry grew by 10%. In the logistics industry, particularly in the courier services, measuring the objects within packages is a critical aspect of logistics management[1]. Typically, at every courier company's office, all packages received undergo a process of dimension measurement and weighing[2]. This process is manually conducted using tools such as scales, rulers, or tape measures[3]. Although this measurement and weighing process has become standard in the industry, it can lead to delays in delivery and potential loss of operational efficiency[4].

In the current digital era, Computer Vision technology is a fascinating aspect of the computer and Artificial Intelligence (AI) world[5]. This research harnesses Computer Vision technology, specifically object detection algorithms utilizing image processing, contour identification, adaptive thresholding, and serial communication, to measure package volume and weight in real-time. The objective is to overcome the manual measurement process. Meanwhile, an HC-SR04 ultrasonic sensor is utilized to measure the height of the package, and the weight measurement employs a 50kg half-bridge load cell sensor with the addition of a Kalman filter algorithm[6].

This research will focus on the development of an integrated object dimension measurement system, utilizing a load cell sensor to measure weight, an ultrasonic sensor to measure height, and image processing to measure the length and width of the object. The system is expected to address issues by speeding up the package dimension measurement process and improving operational efficiency.

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2. Research Methodology

This research is structured based on the prototyping method approach. The research will begin with a literature review to grasp relevant theoretical foundations, followed by design planning and prototype structure formation for package dimension and weight measurement. Subsequently, the prototype will undergo testing across various scenarios. Afterward, the testing results will be evaluated to draw conclusions.

A. Literature Review

At this stage, a literature review is conducted regarding previous research, or similar studies used to detect the dimensions of a package. With the advancement of technology, a technique utilizing video recordings or images[7] from the surrounding environment obtained from a computer webcam or external camera is employed as input to recognize, measure dimensions, and identify objects directly.

Additionally, there are other technologies for measuring package dimensions, such as using ultrasonic sensors. These sensors can measure the distance between the sensor and the package surface, enabling precise calculation of length, width, and height. Besides ultrasonic sensors, computer vision is another technology used for measuring package dimensions. With computer vision technology, the length, width, and height can be accurately calculated using image analysis. This indicates the presence of more advanced alternatives in package dimension measurement apart from using ultrasonic sensors. Meanwhile, sensor load cells are commonly employed for weight measurement. These sensors are typically installed beneath weighing platforms, and when a package is placed on them, the load cell measures the package's weight with high accuracy.

In this study, the system integrates a 50kg strain gauge load cell and HX711, as shown in Figure 1. Strain gauge load cells[8] typically consist of four strain gauges arranged in a Wheatstone bridge circuit[9]. However, there are also types of strain gauge load cells that utilize two strain gauges, known as half-bridge load cells, which still require a Wheatstone bridge circuit[10].

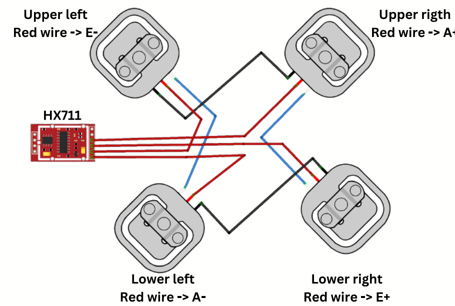

Figure 1. Half bridge Load cell and HX711

HX711, an A/D converter, amplifies the signals generated by the load cell and converts analog signals into digital ones with high precision[11]. It is specifically designed for industrial applications and usage in weighing systems. Previous research has applied strain gauge load cell sensors, such as in the development of innovative waste bin systems aimed at facilitating the weighing process in waste composition[12]. In other studies, load cell sensors have been utilized for real-time load monitoring and waterline estimation on ships[13]. Additionally, another notable application involved the creation of an IoT-based smart scale device for LPG monitoring aimed at providing real-time information about the gas level inside cylinders[14].

Moreover, ultrasonic sensor technology offers non-contact distance measurement with affordability and accuracy[15]. Figure 2 illustrates the HC-SR04 ultrasonic sensor, widely used in research and applications. The ultrasonic sensor operates by emitting waves through a transmitter and then reading the wave reflection using a receiver when no object is detected. The emitted and reflected ultrasonic waves have a frequency of 40 kHz[16]. Ultrasonic sensors can also be implemented to measure the height of water tanks[17]. Furthermore, an array of ultrasonic sensors has been integrated to detect 3D shape recognition with genetic algorithms[18], and ultrasonic sensors can also be designed for parallel parking assistance systems[19].

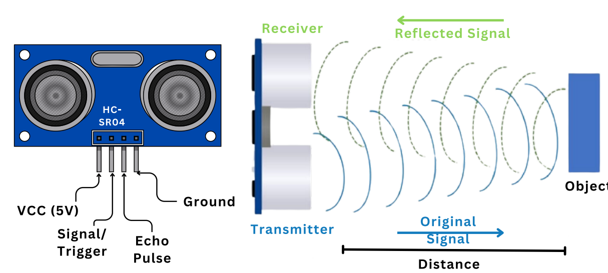

Figure 2. Ultrasonic HC-SR04 and working principle

Other studies identify objects and their dimensions in real-time by leveraging OpenCV and Numpy libraries to calculate object height and width[20]. OpenCV can also detect faces, estimate age, and identify gender using feature extraction methods like Local Binary Patterns (LBP) to obtain image anchor points at various scales and orientations[21]. Several algorithms available in OpenCV, such as the Viola and Jones algorithm, are also utilized in finger number detection research[22]. OpenCV can also be involved in image processing to measure leaf area using Simpson's algorithm [23][24].

This system operates using both Python and C++ programming languages. Python, a high-level language, is widely employed in machine learning and artificial intelligence applications[25]. Python is recognized as one of the most popular and in-demand languages due to its rapid development and ability to develop various types of applications[26]. Python programming can be used for object detection[27], and three-dimensional measurements[28] using the OpenCV library. On the other hand, C++ programming is used for low-level computation, data abstraction, and object-oriented programming[29]. C++ programming is applied in the context of the Arduino IDE application, a platform for writing code to be executed on the Arduino Uno board[30]. This platform is open-source software that can be downloaded and installed for free on a computer[31].

In the previous discussion, it has been explained about the use of the C++ programming language within the Arduino IDE[32] environment to write code that will be executed on the Arduino Uno board. This code is an intermediary to connect the load cell sensor, HX711 IC, and ultrasonic sensor with the Arduino Uno. The goal is to integrate these two sensors with computer vision technology to measure the volume and weight of packages in realtime.

In this research, the algorithm used for object detection involves image processing techniques such as contour identification[33][1], adaptive thresholding[34] and serial communication[35]. Object detection employs image processing, which is a part of the OpenCV library[36]. Contour identification is done by using the 'cv2.findContours()' function to locate contours in binary or grayscale images[37]. Adaptive thresholding is used to separate objects from the background based on the brightness level or color of pixels[38]. This function helps to determine the length and width of the package. The program code determines the length and width, converting them from pixels to centimeters (cm), as shown in Figure. 3. Import the serial module (import serial) from the PySerial library[39] to receive data from the ultrasonic sensor and load cell to measure package height and weight.

```
# Compare with the threshold distance value set by the trackbar
if (width_pixel / 20.5 < initial_distance_threshold and length_pixel
        / 20.5 < initial_distance_threshold):
    length = (length_pixel / focal_length) * known_distance
    width = (width_pixel / focal_length) * known_distance
    volume = length * width * height
    cargo_volume = volume / 6000
```

Figure 3. Program code for converting pixels into centimeters

The proposed system will calculate the volume value of an object. Object shipped via land, sea, or air freight services will typically undergo a weighing process. This stage involves weighing the object based on its actual weight in kilograms (kg) or volumetric weight in kilograms (kg), which can also be expressed as cubic volume(cm^3). Actual weight is the original weight obtained from weighing the object in kilograms (kg). Volumetric weight, on the other hand, is a weight measure determined based on volume using the basic formula for the volume of a rectangular prism(1). Equation(2) is used to calculate the object's weight for shipments via sea and air routes, while equation(3) is used to calculate the volumetric weight of the object for shipments via air routes[40].

$$Volume\ (cm^3) = Length\ \ x\ Width\ x\ Depth \quad (1)$$

$$Volume\ (kg) = \frac{Length\ x\ Width\ x\ Depth}{4000} x\ 1\ kg \quad (2)$$

$$Volume\ (kg) = \frac{Length\ x\ Width\ x\ Depth}{6000} x\ 1\ kg \quad (3)$$

The calculation of cubic volume is also useful for determining the volume of an object, especially in the context of shipping large quantities of goods. The formula for calculating cubic volume can be found in equation(1) and applied in equation(4). Equation (4) applies when shipping objects with a volume exceeding 18,000 cm^3, regardless of the shipping method[41].

$$Volume\ (m^3) = \frac{Length\ x\ Width\ x\ Depth}{1.000.000} \quad (4)$$

This calculation has great significance in properly evaluating the space requirements and logistical aspects involved in shipping goods in bulk. Using formulas (2), (3), (4), logistics companies can optimize cargo space utilization and plan freight shipments more efficiently through land, sea, or air shipping services. In addition, an accurate understanding of cubic volume allows for more accurate estimation of shipping costs.

B. Design Proposed System

Based on the literature review, the next step is to design a system with a configuration similar to that shown in Figure 4. This diagram depicts an automated measurement system for determining the dimensions and weight of an object using multiple sensors and electronic devices. The system consists of key components such as ultrasonic sensors, a webcam, Arduino Uno, an HX711 module, and load cells. The load cells and HX711 module are used for weight measurement in kilograms.

An ultrasonic sensor mounted at the top of the rack functions to measure the vertical distance (height) of the object with high precision. A webcam is installed to measure the length and width of the object through image analysis. All sensor data, including the weight measured by the load cells connected to the HX711 module, are controlled and stored by the Arduino Uno. The Arduino Uno serves as the central controller that gathers and processes data from all sensors to produce accurate measurements.

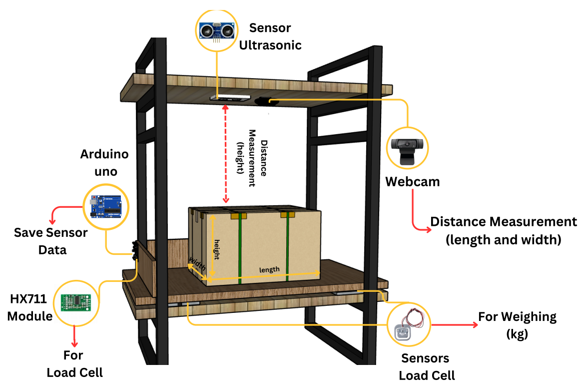

Figure 4. Design of an automated measurement system

To use load cell strain gauges effectively, the load cells are designed in an H-Bridge configuration as depicted in Figure 5. This weight measurement system employs four load cells placed at each corner of the platform. Each load cell is connected to an HX711 module, which in turn connects to an Arduino Uno for data processing. Each load cell is positioned according to standard platform corner designations: left top (E-), right top (A+), left bottom (A-), and right bottom (E+). Each load cell is wired using specific color-coded cables: red (C), white (+), and black (-). In this setup, the output from each load cell is transmitted to the HX711 module.

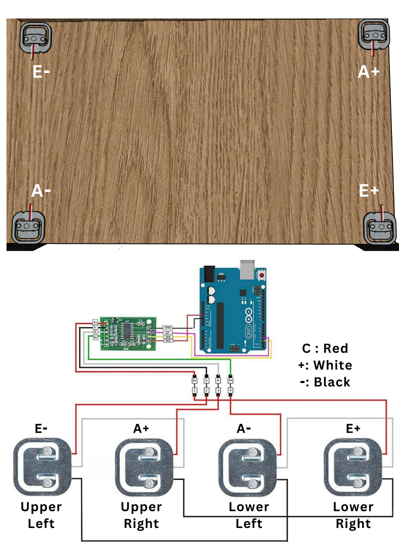

Figure 5. System design for Load cell

The HX711 module functions as a signal amplifier and analog-to-digital converter (ADC). The digital data resulting from the conversion by the HX711 is then transmitted to the Arduino Uno, where it is processed and stored. The use of four load cells is crucial to ensure accurate and uniform weight distribution across the entire platform. This enables the system to perform weight measurements with high precision. This configuration offers significant benefits in applications requiring high accuracy in weight measurements, such as industrial scales and automated weighing systems.

Based on the block diagram seen in Figure 6, it depicts the process flow of automated dimension and weight measurement of cargo. This process begins by running a program on a computer or laptop, responsible for controlling the entire measurement process and coordinating various sensors and devices involved. Once the program is initiated, the cargo is placed on the measurement platform equipped with sensors, such as a load cell for weight measurement and ultrasonic sensors to assist the webcam in measuring height.

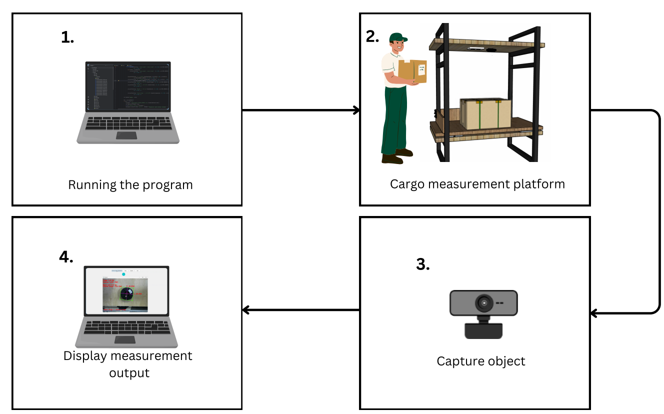

Figure 6. Block diagram of the proposed system

The next step involves a webcam capturing images of the object placed on the platform. This webcam is used to measure and verify the dimensions of the cargo through image processing. The captured image data is then sent back to the computer for further analysis. Measurement results, including weight, dimensions, cargo volume, volumetric weight, as well as comparisons between actual weight and volumetric weight, are displayed on the computer screen for documentation and logistics management purposes. Ultimately, the volume will be measured based on the volume measurement results as indicated in equations (2), (3), and (4). In determining package volume in the logistics industry, regardless of the packaging shape, volume measurement will be conducted with reference to the box volume.[42]. This diagram illustrates a brief workflow of automated measurement that integrates sensor technology and image processing to achieve highly efficient and accurate measurements of cargo weight and dimensions.

In Figure 7, the overall flowchart of the system begins with the system initialization stage, where the sensors and webcam are initialized. Then, a GUI (Graphical User Interface)[43] is displayed on the desktop using the Tkinter library[44], there is a menu selection with three functional buttons, play, stop, and capture. When the play button is pressed, the system will initiate a series of processes. First, sensor data from Arduino will be read to retrieve the height and weight values of the object. Once these values are obtained, the following process is to display the camera frame, where the camera will detect the object through several stages. The first stage involves separating the object from the background adaptively and then identifying the object's contours. Subsequently, the length and width of the object are measured in pixels, which are then converted into centimeters. The measurement results are then displayed on the monitor screen.

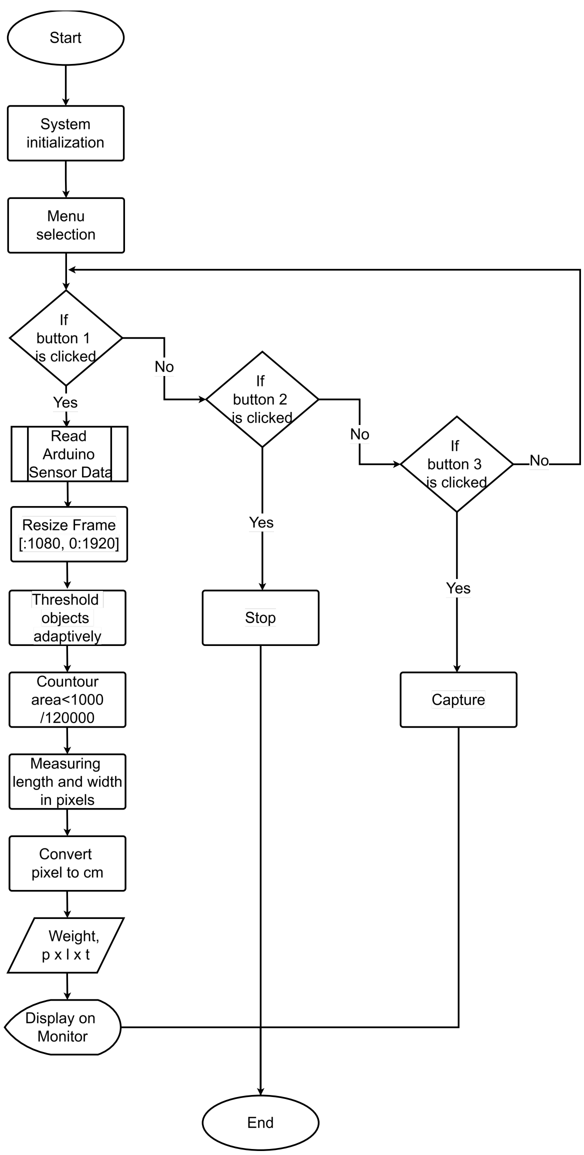

Figure 7. Flowchart of the proposed system

The second button function, stop, halts the real-time webcam display. The image capture process will cease, and the camera frame view will close. The third button, capture, captures and saves an image from the webcam in the format "capture_{timestamp}.png". The system will return to the menu selection if none of these three buttons are pressed.

During the process of measuring a detected object, the height, length, width, and weight values are obtained using the formulas as seen in equations (5), (6), (7), and (8).

$$Height = 98 - distance\ between\ sensor\ and\ object \quad (5)$$

$$Length = \left(\frac{length\ pixel}{focal\ length}\right) \times distance\ between\ sensor\ and\ object \quad (6)$$

$$Width = \left(\frac{width\ pixel}{focal\ width}\right) \times distance\ between\ sensor\ and\ object \quad (7)$$

$$Weight(kg) = \frac{nmax}{1000} \quad (8)$$

In equation (5), the value 98 represents the distance between the ultrasonic sensor height and the bottom surface of the metal rack. Meanwhile, in equation (8), nmax represents the maximum value measured by the load cell. Ultimately, the volume will be calculated using formulas (2), (3), or (4) based on the largest measured volume. After the measurement is completed, the system can proceed to measure another object.

C. Experimental

The testing scheme for the proposed system involves using a metal rack measuring 100 cm x 60 cm x 200 cm, as shown in Figure 8. This test aims to evaluate the accuracy of the proposed system in measuring the volume of various objects. The measurement component is positioned approximately 10 cm from the floor surface. Then, the proposed system is examined by taking measurements from several shapes of objects.

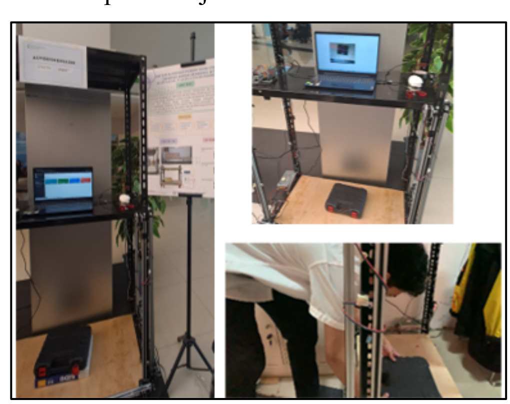

Figure 8. Testing scenario

In this experiment, the types of objects measured include a large box with dimensions of 42.5 cm x 32 cm x 22 cm and a weight of 4 kg, a small box with dimensions of 35 cm x 27 cm x 9 cm and a weight of 2.7 kg, and a small cylindrical container with dimensions of 19 cm x 19 cm x 6 cm and a weight of 0.9521 kg. Each object is tested in 30 trials.

3. Result

Based on the testing scenario outlined in the literature review and method section, the test results are as follows.

A. Measurement Results for Object 1 (Package)

The test results on the first object displayed in Figure 9 show a package with measured dimensions a height of 22.4 cm, a width of 33.1 cm, and a length of 46. cm. These measurements result in a volume of 34,122 cm³, and a volumetric weight of 5.7 cm³. Additionally, the package's weight was determined to be 4.0 kg. The data shown in the figure indicate that the package's actual weight is less than the weight calculated based on its volume. The volume in cubic centimeters (cm³) can be converted into kilograms using a standard conversion factor. The conversion formula is stated in equations (2) and (3).

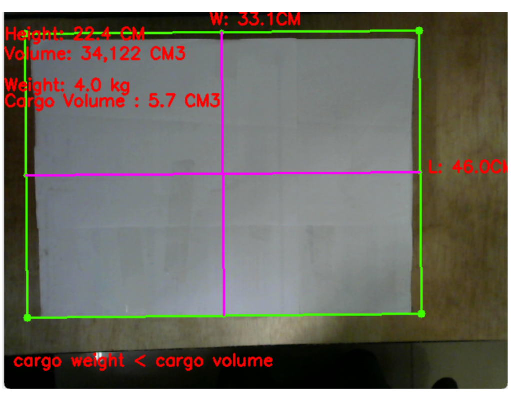

Figure 9. Measurement output of package

These results indicate that the package's actual weight, 4.0 kg, is less than the weight calculated based on its volume using the conversion factor. This suggests that the package, despite having a large volume, is relatively light, which may be due to the material's low density or empty space within the package.

The results from the experiments in this study are depicted in the graph shown in Figure 10, which demonstrates consistency in the measurement of the package dimensions. The graph illustrates that the package length ranges from 45.1 cm to 46 cm, the width varies between 33.5 cm and 34.8 cm, and the height ranges from 21.85 cm to 22.03 cm. The overall variation range of the measurements is only 1.3 cm, indicating the stability and reliability of the measuring instrument used.

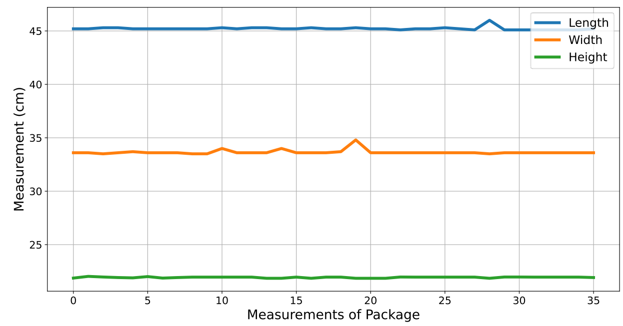

Figure 10. Dimension measurement graph of package

The weight measurements of the package taken during the testing were also plotted in a graph. In Figure 11, the manual and automatic measurements show nearly identical results, with only a minimal difference, averaging a discrepancy of 0.110 kg. The slight difference between manual and automatic measurements confirms that the instrument used functions well and provides consistent results.

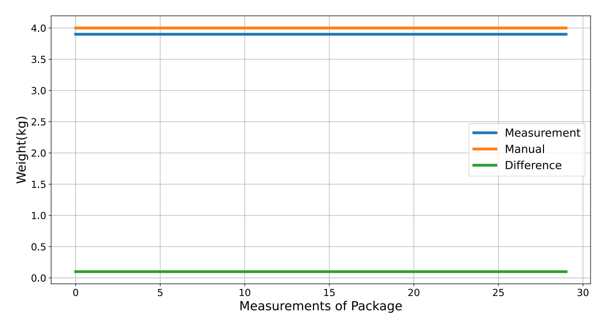

Figure 11. Weight measurement graph of package

The test results show that a package with dimensions of 45.3 cm in length, 33.6 cm in width, and 21.8 cm in height has a volume of 33,322 cm³ and an actual weight of 4.0 kg, which is lower than the estimated weight based on its volume. From 30 trials, consistency in the measurement of package dimensions was found, indicating the reliability of the measuring instrument used. The difference between manual and automatic weight measurements is slight, only 0.110 kg. Using formulas (9) and (10), the percentage accuracy of the measurements was determined to be 91.94%.

B. Measurement Results for Object 2 (Toolbox)

In Figure 12, the measurement results show the characteristics of the toolbox. Based on the test results, the toolbox has dimensions of 35.7 cm in length, 27.3 cm in width, and 9.5 cm in height, weighing 2.7 kg. The volume of the toolbox is also recorded at 8,894 cm³, and a volumetric weight of 1.5 cm³. The notes indicate that the weight of the cargo exceeds its volume in cubic centimeters (cm³). The conversion formulas specified in (2) and (3) were used to determine the cargo volume in these units.

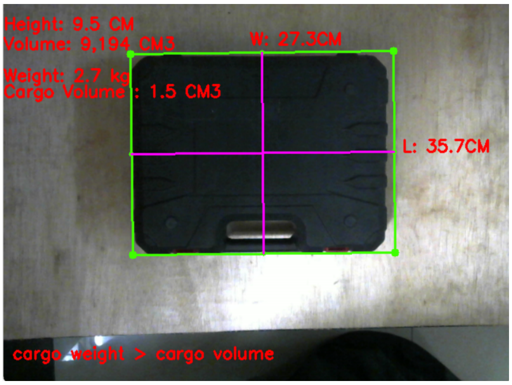

Figure 12. Measurement output of toolbox

The test results are presented in graphical form. The first graph, found in Figure 13, is a dimension graph. This graph illustrates the variation in the object's dimensions. The package length ranges from 34.9 cm to 35.2 cm, with most measurements clustering around 35.1 cm. The package width varies between 27.3 cm and 27.6 cm, while the package height ranges from 9.45 cm to 9.93 cm, with most measurements near 9.47 cm.

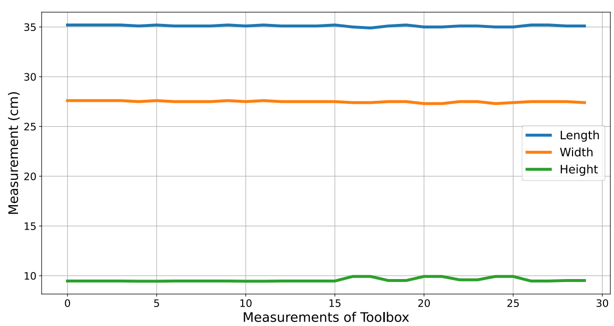

Figure 13. Dimension measurement graph of toolbox

Next, the second graph is shown in Figure 14. This graph compares the measurements taken by the instrument and the manual measurements, as well as the differences between these measurements. It shows that the measured and manual measurements are very close, with a consistent weight of 2.5 kg for the toolbox. The differences range from 0.01 cm to 0.07 cm.

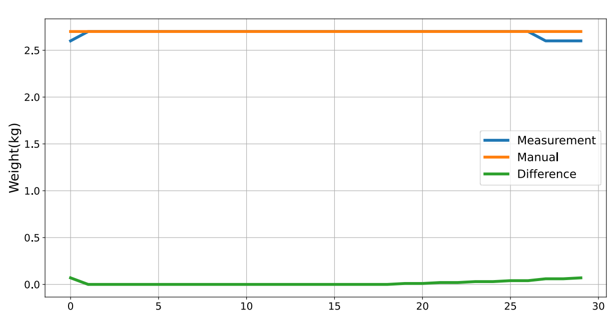

Figure 14. Weight measurement graph of toolbox

Overall, the test results for the toolbox indicate that the measuring instrument provides accurate and consistent measurements of the toolbox's dimensions and weight, with minimal differences between the instrument and manual measurements. Similarly, the percentage accuracy of the toolbox measurements using this instrument is 91.94%.

C. Measurement Results for Object 3 (Cookies Jar)

The test results shown in Figure 15 indicate that the cookies jar has a length of 19.5 cm, a width of 19.3 cm, and a height of 5.7 cm. With a volume of 2,126 cm³, a weight of 1 kg, and a volumetric weight of 0.4 cm³, it is also explained that the weight of the cookies jar is greater than its volume.

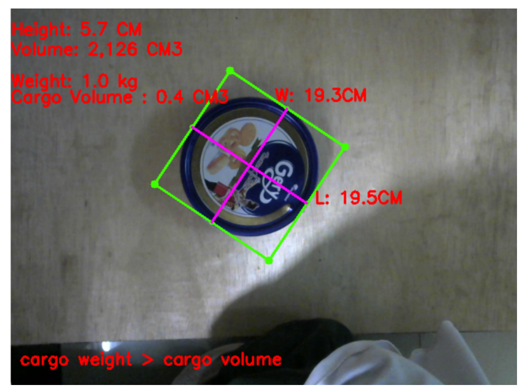

Figure 15. Measurement output of cookies jar

Figure 16 displays a graph of the dimensional measurements of the cookie jar, indicating that the average length measurement is 19.5 cm with very little fluctuation, signifying the measuring tool's consistency in measuring length. The average width measurement is 19.3 cm, with slight variation in results but still within acceptable tolerance limits. Meanwhile, the average height measurement is 5.7 cm with almost no variation, demonstrating that the measuring tool is highly reliable in measuring the height of the jar.

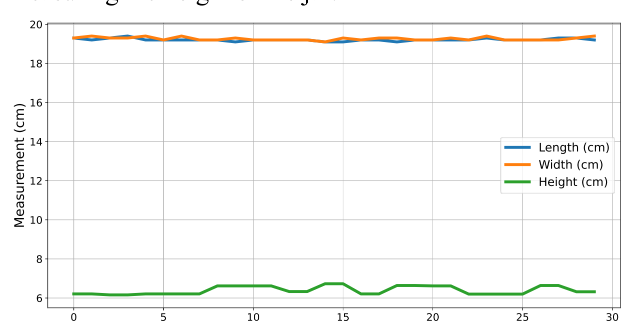

Figure 16. Dimension measurement graph of cookies jar

Furthermore, the weight measurements shown in the graph in Figure 17, taken with an instrument, indicate an average weight of 1.0 kg, which is very close to the manual measurement of 1.05 kg. The difference between the instrument and manual measurements is very small, with an average difference of less than 0.05 kg.

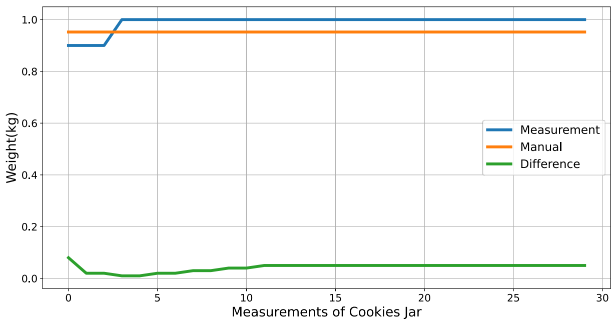

Figure 17. Weight measurement graph of cookies jar

The graphs in Figure 16 and Figure 17 show that this instrument is capable of providing consistent and accurate results in measuring the length, width, height, and weight of the cookie jar. The reliability of the instrument in measuring the jar's length, width, and height is demonstrated by the minimal fluctuation in the measurement results, while the accuracy of the instrument in measuring the weight is shown by the very small difference between the instrument measurements and the manual measurements.

4. DISCUSSION

This study designs an automated system for measuring package dimensions to simplify the weight measurement process and volume calculation. The system comprises HC-SR04 ultrasonic sensor, load cell, HX711 IC, Arduino Uno, and a webcam. The ultrasonic sensor is statically positioned at a height of1 meter to measure the package height, while the webcam is also statically placed at the same height to measure the length and width of the package. The load cell and HX711 IC are utilized to measure the package weight. Experiments are conducted on three packages with regular shapes. The test results indicate a larger discrepancy in length measurements compared to width and height measurements. Additionally, no significant differences is observed between automated and manual weight measurements.

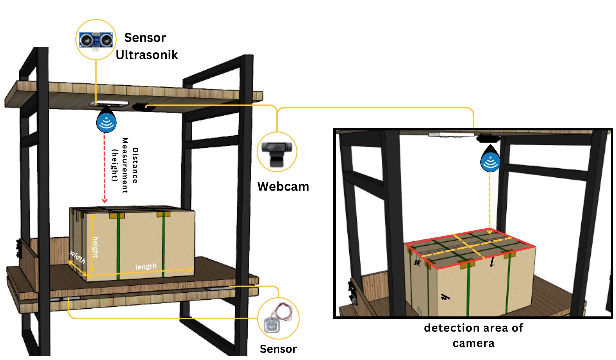

Figure 18. Detection area of Auto-dimension

The design depicted in Figure 18 constitutes a stable scanning area for measuring height. This is attributed to the presence of supports on side and at the back of the metal rack, aiding the ultrasonic sensor waves to automatically detect the designated area. However, measurements of length and width may become unstable due to environmental factors, such as inconsistent lighting or object color. This is because the webcam operates in real time. Furthermore, if weight measurements are unstable, it may be due to improper object placement or not being positioned in the middle between the load cell as seen in Figure 5.

The next step after obtaining the three-dimensional package measurement is calculating the package volume. Package volume calculation is done using volume formulas appropriate for rectangular shapes, as described in equations (1), (2), (3), and (4) in the logistics context. The results from these volumetric formulas will be compared with the weight measurement results, and the largest result will be chosen. This is important because the larger result will be used as the basis for determining the shipping cost.

This discussion will also explain the average success percentage in the conducted tests. The initial calculation uses the formula in equation (9) to determine the percentage calculation results, which is then substituted with equation (10).

$$Average\ Multiple\ Difference = \frac{\sum sum\ of\ absolute\ values}{n\ trial} \qquad (9)$$

$$Succes\ rate\ (\%) = \left(1 - \frac{average\ multiple\ difference}{manual\ measurement}\right) \times 100\% \qquad (10)$$

The results are then displayed in Figure 19, which shows that the overall success rate of volume calculation and final weight measurement compared to manual calculation reaches 92,45%. The average success rate for measuring regular cylinder objects (cookie jar) is 91,94% for object 2 (toolbox), it is 93,81% and for object 3 (package box), it is 91,6%. If objects 2 and 3 have the same shape, their average achievement rate is 90,4%.

Implementing the three-dimensional and weight measuring tool expedites the process of automatically measuring volume. This method combines ultrasonic sensors and webcam to measure the dimensions of objects, as well as load cells an IC HX711 to measure their weight. Particularly for objects with regular and flat shapes, constituting approximately 91% of the total measured objects. The system has a response time of around 1-2 seconds in its capacity to detect and measure objects. Conversely, when executed in simultaneously, it often has a duration of approximately 5 to 7 seconds.

However, its weakness lies in determining the dimensions of objects when they have colors similar to the background and when lighting conditions are not optimal, as the threshold for adaptive coding has already been set.

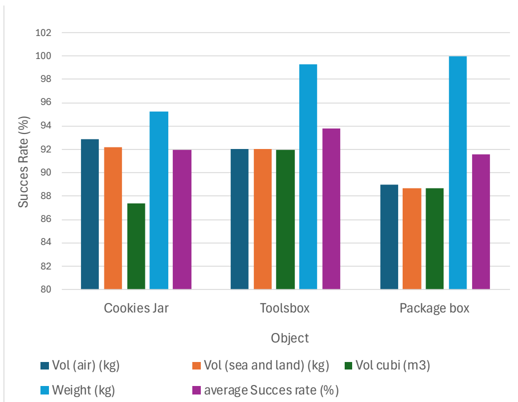

Figure 19. Success rate percentage

In future research, it is essential to develop further when objects have colors similar to the background and lighting conditions are not optimal. One possible approach is to introduce additional image processing techniques or artificial intelligence algorithms to adaptively adjust threshold settings and better distinguish objects from the background. Moreover, it is advisable to consider additional sensors or modifications to existing sensors ro enhance measurement accuracy, mainly for objects with irregular or complex shapes. Therefore, this tool is expected to become more effective and reliable in various measurement conditions.

5. CONCLUSION

This research involves the use of a load cell sensor and an HX711 IC to measure the weight of a package, as well as an ultrasonic sensor and a webcam applied with image processing to measure the dimensions of a package. The system is implemented within a metal rack measuring 100 cm x 60 cm x 200 cm and operated under static conditions. To evaluate the system's accuracy in measuring the dimensions, volume, and weight of packages, tests were conducted on several scenarios. Each scenario involved dimension measurement, volume calculation, and weight measurement, as well as comparison with manual measurement. The types of packages used include packages with regular shapes such as boxes and cylinders with flat surfaces. According to the measurement data, the system has a 92.45% success rate for measuring package dimensions, weight, and volume for all package kinds, 90.4% for flat box-shaped packages, and 91.94% for cylindrical forms. There are two objects for packages in the shape of flat boxes: the first has a success rate of 92.81%, and the second has a success rate of 91.6%.

This approach still has weaknesses in handling situations where objects have colors similar to the background and when lighting conditions are mot optimal. This can result in difficulties in accurately determining the dimensions of objects, especially for objects with irregular or complex shapes. Additionally, the use of ultrasonic sensors may also have limitations in measuring objects with uneven surfaces and utilizing additional sensors that can enhance the accuracy and precision of measurements, especially in irregular or complex package conditions. Thus, it is expected that the system can be more effective in a variety of different measurement scenarios.

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