

# Object Sorter Robotic Arm

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**Abstract**— In general, sorting of objects is carried out manually using human labor. Recognizing a particular object and placing it in the required position is a tough process especially in the field of industry. This is when automation comes into play. So, this paper considers all these factors along with the cost to make the process more efficient and accurate. The model uses a Raspberry Pi module, which is an open- source Linux based board. Further it makes use of a camera module which captures the image of the object. Camera captures real- time images, which are processed by the Raspberry Pi using OpenCV for object detection. The implementation demonstrates the feasibility of using a cost-effective, versatile platform like the Raspberry Pi for complex automation tasks. This module also underscores the potential for scalable and adaptable solutions in various industrial applications, showcasing a significant advancement in the field of robotics and embedded systems. The results indicate a promising direction for future research and development in low-cost, high-efficiency robotic systems, potentially revolutionizing automation processes across multiple domains.

**Keywords**— *Raspberry Pi, Object Detection, Pick and Place Robot, Image processing, Machine Learning*

## I. INTRODUCTION

Nowadays, Robotic arms are being used in industries to minimize the human errors and increase efficiency, productivity, precision of the operations taking place. One of the most important advantages of introducing Robotic arm in Industries is that it can work in crucial conditions where it's risky for humans to work. Industries, military undertakings, medical sector are some of the fields where these robots are now being used [1].

They're at the core of industry and they're soon to be at the forefront of modern medical surgery. Robot arms also make brilliant learning tools, especially for those wanting to utilize GPIO pins on their Raspberry Pi [2]. They are certainly one of the key elements in achieving the intended objectives proposed by the fourth industrial revolution [3].

The Raspberry pi module gives the opportunity to build control device that does what humans want it to do. The robotic arm is controlled by a program that has been written [4]. Sorting is one of the important tasks in production line. This paper showcases a sorting system based on Robot that can identify the position and properties of objects [5].

In the proposed system different hardware components are integrated with the robotic arm which includes Raspberry pi, camera, and servo motors. Each servo motors contains three outputs which are the pulse width modulation (PWM) pin, VCC pin and GND pin [6].

Computer vision is focused on motion analysis of robot arm revealed that gesture can be characterized based on four different aspects: shape, motion, position, and orientation [7]. The main objective will be to examine its utility and effective use as a mechanical system in sorting of objects. The camera captures and scans the image of the particular object to be sorted. The scanned image is then processed using OpenCV to detect the shape of the object. OpenCV (Open- Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision [8].

The Raspberry Pi module is equipped with a TensorFlow which is employed for object recognition. Spyder IDE was used for training the TensorFlow module, which was done using python language. The program was then transferred into the Raspberry pi module. Based on this algorithm the module takes the decision on which object is placed in front of robotic arm [9]. This model aims in classifying the objects by size, picking and placing the objects in its respective pre-programmed place. There by eliminating the

monotonous work done by human. The microcontroller sends signal to circuit which drives the various motors of the arm to grip the object and place it in the specified location and then resets them to the original position [10].

II. TECHNICAL BLOCK DIAGRAM

Fig1 shows the block diagram of the object sorting robotic arm. The Raspberry pi camera module captures the image of the object placed within the range of camera detection. The captured image is sent to the Raspberry Pi. The Raspberry Pi processes the images using OpenCV for object detection. The model identifies and locates objects within the image. The OpenCV library along with COCO data set identifies the object and provides their coordinates. These coordinates are present as nested list in object info. The Raspberry Pi calculates the precise movements required for the robotic arm to reach the detected objects. Accordingly, it sends the PWM signals to the servo motors. These change the initial angle of the servos to the desired angle for object sorting. Therefore, according to the angles mentioned in the code, the arm moves the object and places them in the desired location. This model sorts two different objects. It places the cylinder on one side and the sphere on other side.

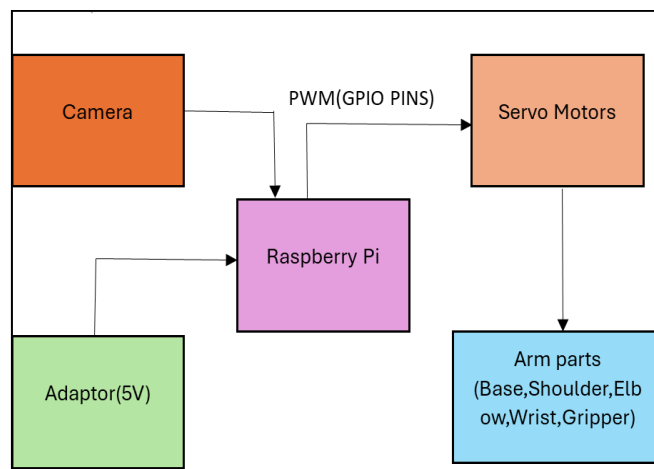


Fig. 1 Block Diagram for Object Sorter Robotic Arm

III. METHODOLOGY

The model incorporates multiple engineering domains, including Robotics, Image processing, and Machine Learning-based image detection. The primary objective is to develop a robotic arm capable of detecting, sorting, and placing objects into designated containers.

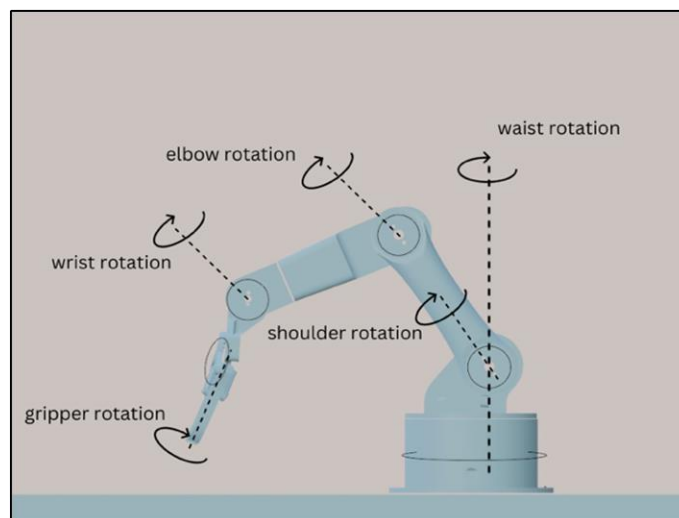
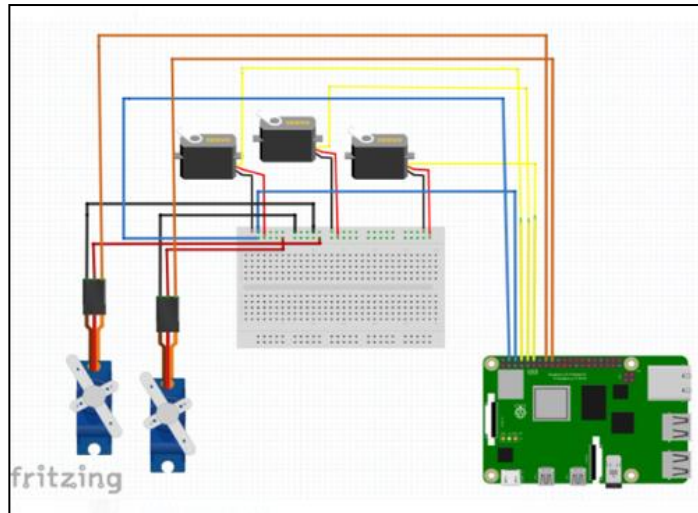


Fig. 2 Robotic Arm with 5 DOF

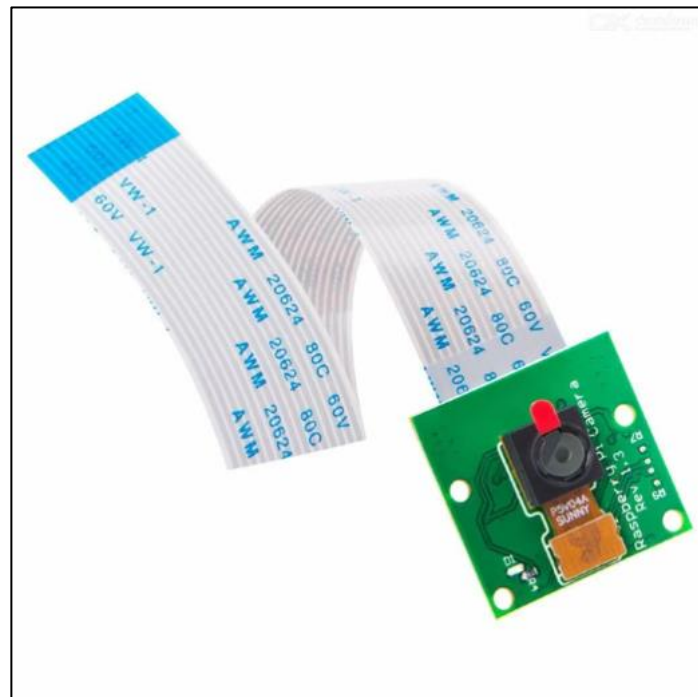
The experimental setup comprises a 5 DOF robotic arm, which includes rotations along the waist, shoulder, elbow, wrist, and gripper as shown in Fig 2. These rotations are controlled by a total of 3 High-Torque servo motors and 2 Micro Servo motors.

The PWM channel of the Micro servo motors and the High-Torque servo motors are connected to the GPIO (General-Purpose Input/Output) pins of the Raspberry Pi 4 Microprocessor board.



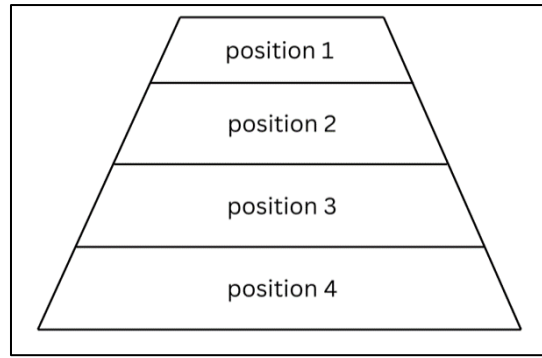
**Fig. 3 Raspberry Pi with servo motors interface**

Fig 3 showcases the integration of the servo motors with the Raspberry Pi 4 microprocessor, which acts as the brain of the Robotic Arm. In doing so, a multitude of functions can be achieved, such as robotic arm movement, image processing, and object detection.



**Fig. 4 Raspberry Pi Camera Module**

The Raspberry Pi Camera Module Rev 1.3 which is shown in Fig 4 serves the purpose of real-time video streaming, facilitating the capture and detection of objects placed within a specific range.



**Fig. 5 Specific positions for Camera Detection**

The area visible within the range of the fixed camera module, is divided into four positions along the y axis as shown in Fig 5 to facilitate detection along different positions.

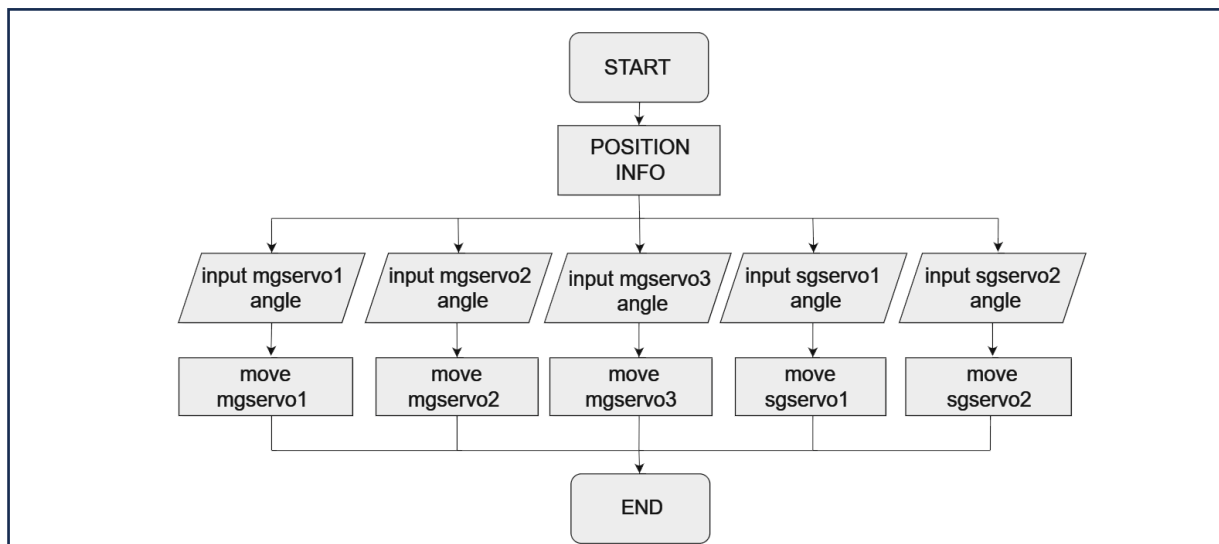


**Fig. 6 Raspberry Pi and Camera Interfacing**

Fig 6 shows the camera module interfaced with the Raspberry Pi board. The components are then connected and interfaced using a Raspberry Pi 4 microprocessor. The model facilitates real-time interaction to achieve sorting between objects. The training of the model is accomplished by employing COCO's pre-trained dataset and the OpenCV Library. The object detection process returns the object's label and its corresponding orientation.

The two cases have been analyzed:

**Case 1: PICKING AND PLACING OBJECTS ALONG DIFFERENT AXES**



**Fig. 7 Flowchart for place movement**

As mentioned earlier, the object detection process returns the object’s label and its corresponding orientation. Depending on the orientation (in this case the y\_center), appropriate angle values are passed to servo motors (through means of a functions in the program) such that any object placed can be picked accordingly. The algorithm for the above process is shown in Fig 7 and Fig 8.

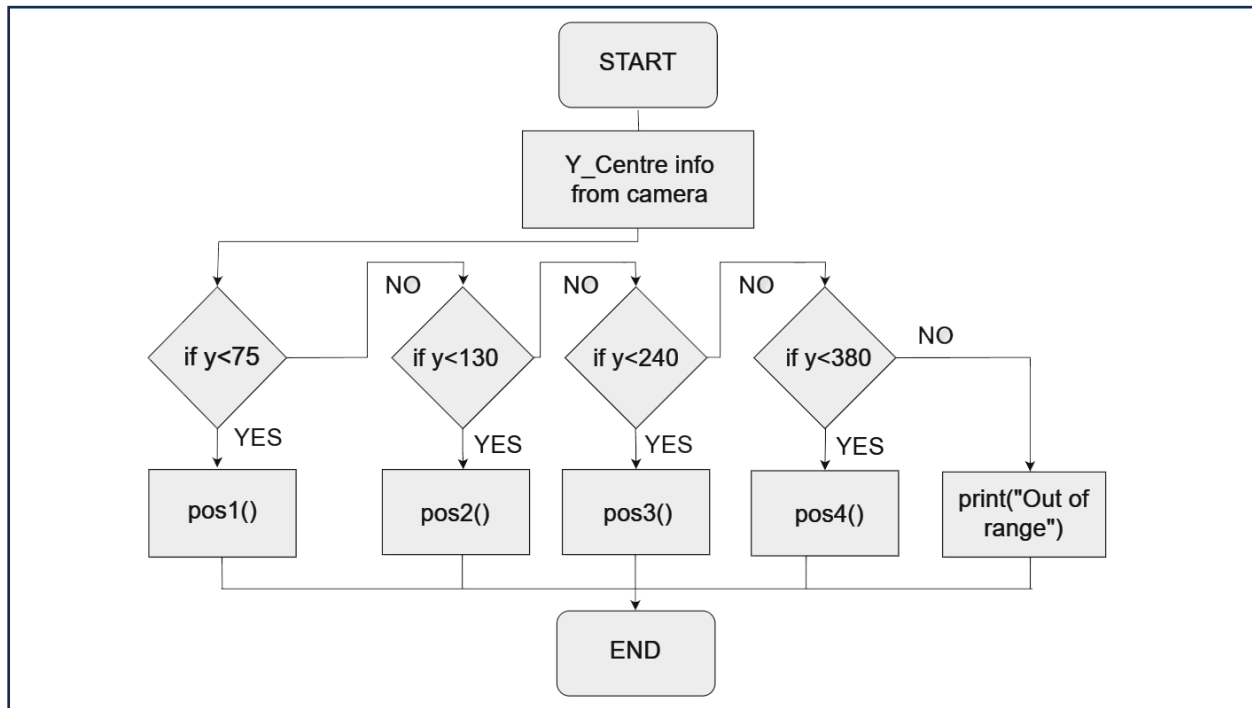


Fig. 8 Flowchart for assigning positions

CASE 2: OBJECT DETECTION AND SORTING

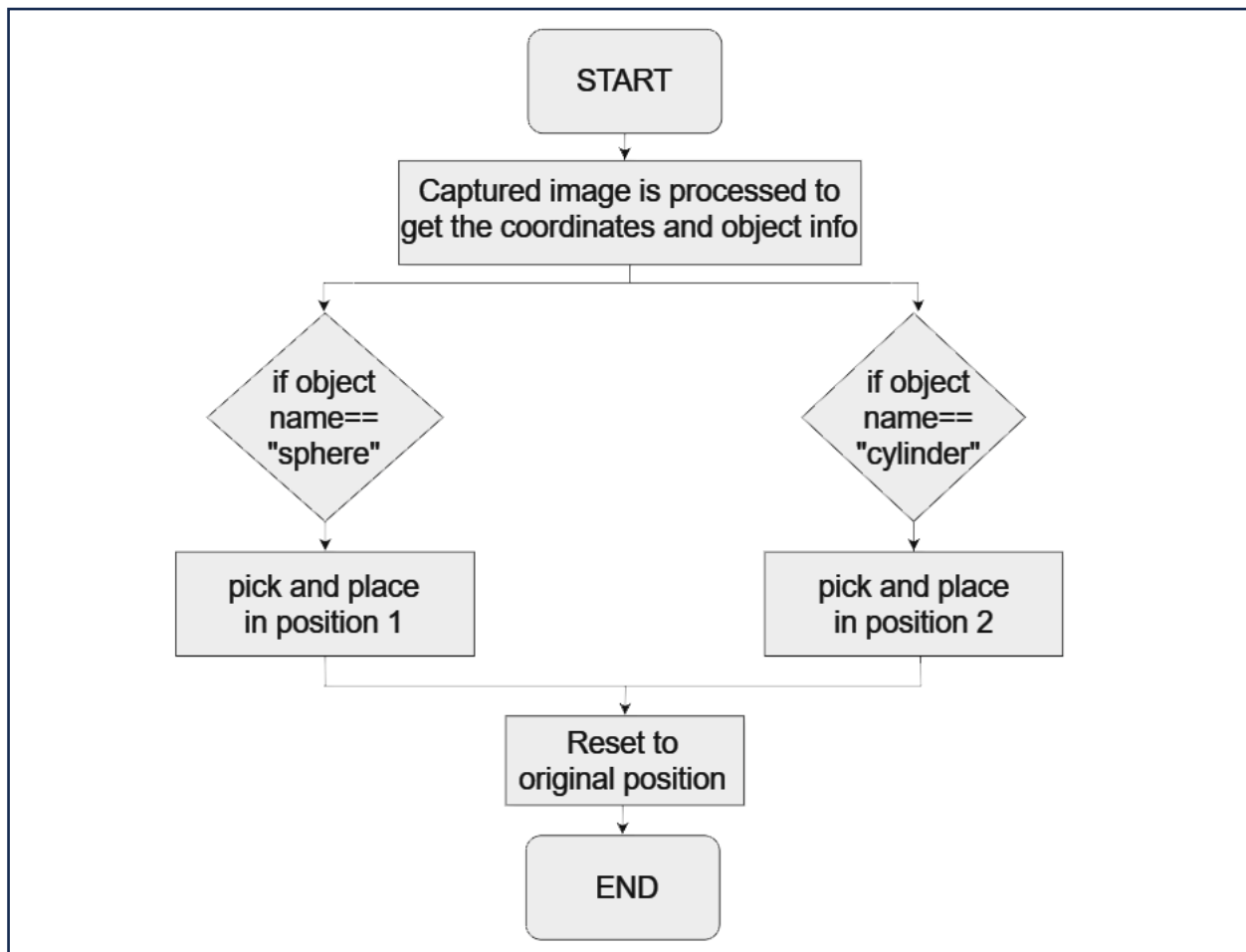


Fig. 9 Flowchart for sorting objects

Object Detection is carried out using the OpenCV Library, resulting in the return of the object label. The program utilizes a function to transfer complementary angle values to servo motors, which subsequently position objects on opposing sides. The algorithm for the same is depicted through means of a flowchart in Fig 9.

#### IV. RESULTS

The set-up encompasses two systems, which are a robotic arm and an object detection interface. In summary, the robotic arm utilizes servo motors for movement control and a raspberry pi camera module for real-time video streaming. This video feed is transmitted to the raspberry pi, which serves as the model's brain. With the assistance of the OpenCV library, the arm detects objects and executes the sorting process accordingly. Fig 10 shows the front view of the robotic arm with all its interfaces.

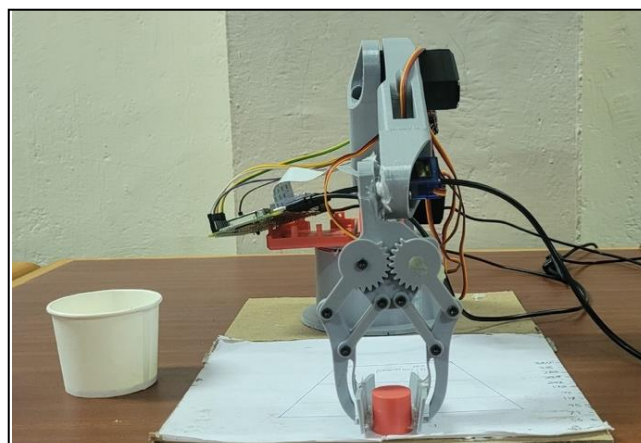


**Fig. 10 Object Sorter Robotic Arm**

#### Result of Case 1: PICKING AND PLACING OBJECTS ALONG DIFFERENT AXES

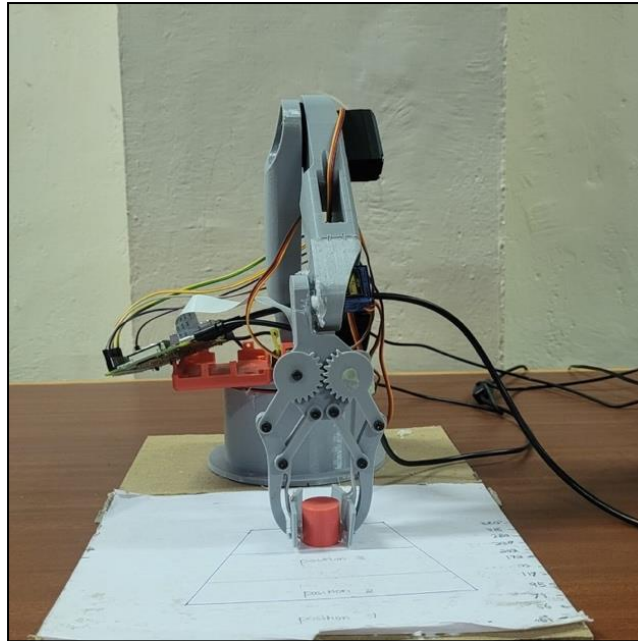
When objects are positioned at specific locations within the camera's field of view, the robotic arm responds by moving to pick up the object and place it in its designated carrier, based on the orientation information obtained from the object detection process.

Case 1.a: Picking from position 4:



**Fig. 11 Picking object from Y position 4**

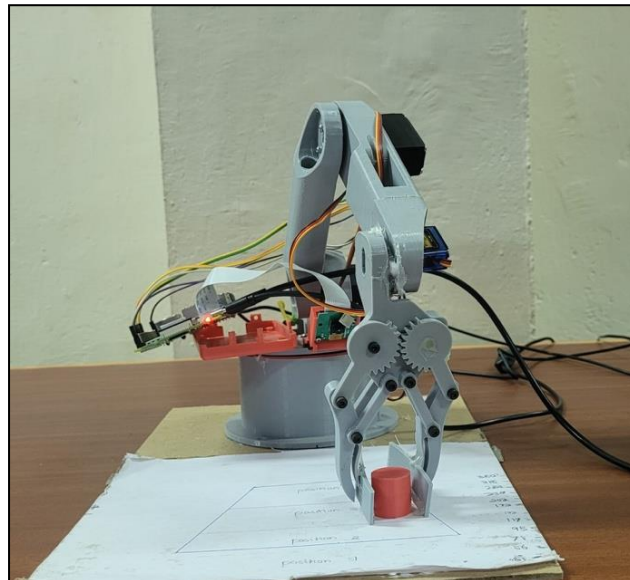
Case 1.b: Picking from position 1:



**Fig. 12 Picking object from Y position 1**

When the object is placed in positions 4 and 1 respectively, the robotic arm detects the position of the object through the camera module and subsequently the arm picks up the object.

Case 1.c: Picking from different positions along x axis:



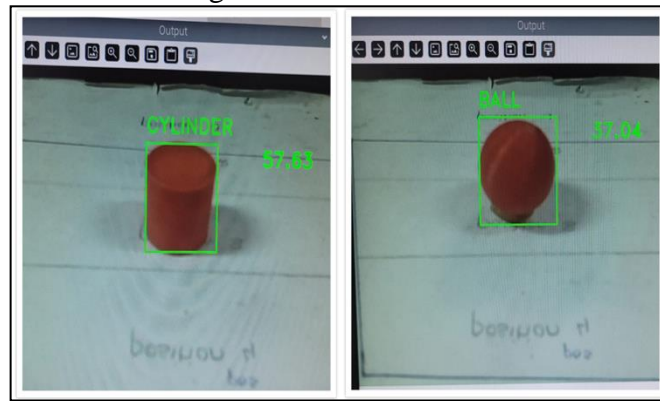
**Fig. 13 Picking object from X position**

Fig 11, Fig 12, and Fig 13 show the results of case one.

#### Result of Case 2: OBJECT DETECTION AND SORTING

The model has been trained to classify objects into two categories: cylinders and spheres. Once an object is placed within the camera's field of view, the camera module proceeds to transmit a live stream in real-time to the raspberry pi. The raspberry pi utilizes the OpenCV library to carry out object detection. The

output from the object detection process consists of a list comprising the object's orientation, label, and confidence score. This has been shown in Fig 14.

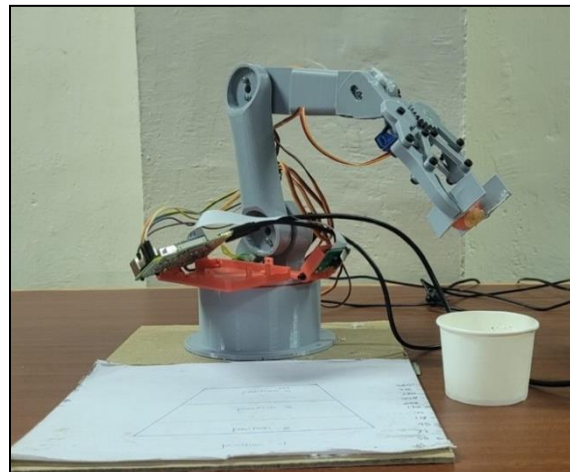


**Fig. 14 Cylinder and Sphere Detection**

Finally, the robotic arm accomplishes its sorting task by placing the two distinct objects on opposite sides.

**Case 2.a: Sphere Detection and Sorting:**

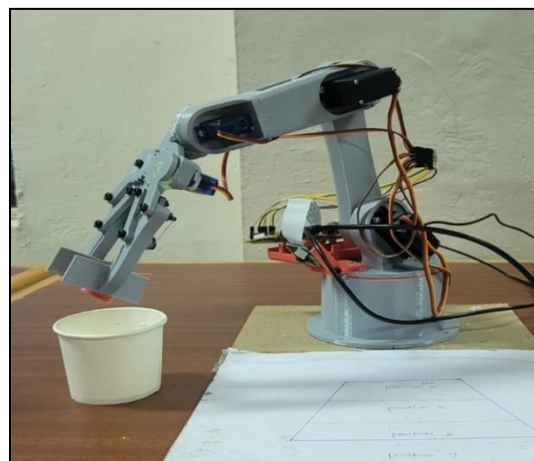
The output displays the live video feed of the camera's field of view, indicating the position of the object. The program utilizes the OpenCV Library to provide the label and confidence score of the object and the arm places the ball on one side as shown in Fig 15.



**Fig. 15 Sphere Detection of robotic arm**

**Case 2.b: Cylinder Detection and Sorting:**

Similarly, when the camera detects the cylinder, the arm moves accordingly and places the cylinder on the opposite side as shown in Fig 16.



**Fig. 16 Cylinder Detection of Robotic Arm**

Fig 15 and Fig 16 show the results of case two.



## V. KEY FINDINGS AND OUTCOMES

The following observations were made:

- The Object Sorter Robotic Arm was made possible by the integration of both hardware components: (Robotic Arm, Servo motors, Raspberry pi 4 microprocessor, raspberry pi camera module) and the software system, allowing a diverse range of technologies to be involved in carrying out the sorting process from scratch.
- The integration of Robotics and Machine Learning eliminates the need of human intervention to control the movement of the robotic arm or carry out the sorting process. Thus, the object sorter robotic arm carries out its operation without human manipulation, that can pave the way for other innovations in this domain.
- Real-time data, that is, the live video stream is transmitted to the raspberry pi, and it carries out the object detection process returning the orientation (x\_center, y\_center), label (cylinder/sphere) and the confidence score.
- As the object detection returns the orientation of the identified object, the robotic arm can locate the position of the object and the servo motors rotate accordingly resulting in the movement of the robotic arm to pick the object and place it in their corresponding containers.

## VI. SIGNIFICANCE OF THE MODEL

The 'Object Sorter Robotic Arm' holds significance in the following ways.

- **AUTOMATION AND EFFICIENCY:**

The model provides full automation of the machine as the object detection variables are fed to the raspberry pi for movement of the robotic arm. It minimizes errors, reduces manual labour and increases the overall productivity and cost efficiency.

- **INTEGRATION OF TECHNOLOGIES:**

The successful integration of AI and robotics demonstrates the ability to incorporate advanced deep learning models enabling the machines to interact with the environment in a smart and effective way. This accomplishment can inspire further AI based machines.

- **ACCURACY AND FLEXIBILITY:**

By using a pre-trained data set for object detection, the model can be modified flexibly to recognize a wide range of objects. The object detection model trained using many images greatly improves the accuracy of the object detection.

- **SCALABILITY:**

The model is designed with scalability in mind, with potential expansion to large scale and small-scale operations down to the molecular level sorting. It allows for deployment in various field such as healthcare and agriculture.

'Object Sorter Robotic Arm' is a remarkable achievement in robotics. It successfully integrates the hardware and software components to provide seamless movement, efficient automation, and accurate sorting. Its design value lies in its automation technology, integration of technologies, accuracy, and scalability, making it a remarkable innovation in robotics.

## VII. CONCLUSION

In conclusion, 'Object Sorter Robotic Arm' marks a significant milestone in robotics. The co-ordination between the object detection camera and raspberry pi is an original approach to the sorting mechanism. It opens up new possibilities for large scale and small-scale industry applications.

This work focuses on addressing the issues of human errors in sorting objects. By utilizing object detection model, the prototype robotic arm with a fixed camera module captures and analyses the real time images, allowing for automated sorting of the captured object. The integration of the pre-trained COCO dataset enhances the flexibility and accuracy, which helps in the efficient working of the machine.

The model demonstrates its potential in analyzing the object and changing its functionality with respect to the different positions captured. Future research should prioritize the development of similar machines on a molecular scale and in fields such as healthcare. The 'Object Sorter Robotic Arm' not only exemplifies the successful integration of AI with robotics, but also paves way for the future technological innovations in the field of robotics.

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