# ROBOTIC ARM INTEGRATED WITH SMART CLEANER FOR OBJECT CLASSIFICATION USING YOLO

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**Abstract:** The integration of computer vision with robotic arm manipulation significantly improves the efficiency, accuracy, and autonomy of modern robotic systems. This project focuses on the design and implementation of a robotic arm integrated with real-time object classification using the YOLO (You Only Look Once) algorithm. The system is developed to identify, classify, and manipulate objects accurately through a vision-guided mechanism, enabling intelligent pick-and-place operations in dynamic and unstructured environments.

A camera mounted above the workspace continuously captures live video streams. These frames are processed using a YOLO-based object detection model, selected for its high speed and single-stage detection architecture, which ensures real-time performance. The algorithm detects multiple objects simultaneously, providing bounding box coordinates, class labels, and confidence scores for each object. Based on the detected object's position and category, control signals are generated and transmitted to the robotic arm controller for precise movement and gripping actions. The model is trained using a custom dataset to improve classification accuracy for specific target objects. Experimental results demonstrate reliable detection and successful manipulation under varying lighting conditions and object orientations. Overall, integrating YOLO with robotic arm control enhances system speed, adaptability, and operational accuracy compared to conventional vision-based robotic systems.

**Keywords:** Smart Cleaner, Object Classification, USB Camera, YOLO

## I. INTRODUCTION

Automation and robotics have rapid transformation in the modern industries and daily life by improving efficiency, accuracy, and its productivity. One of the important application of robotics is automatic cleaning systems, which help maintain hygiene in homes, industries, and public spaces while reducing human effort. The integration of robotic technology with smart cleaning robots has led to the development of intelligent machines capable of performing cleaning tasks autonomously. In this context, the integration of a robotic arm with a smart cleaner provides an innovative solution for efficient and automated floor maintenance.

A smart cleaning robot is designed to move across surfaces and remove dust and dirt using sensors and programmed control systems. However, the conventional cleaning robots mainly focuses on the surface cleaning and may not effectively handle objects or obstacles present on the floor. To overcome this, a robotic arm can be integrated with the smart cleaner. The robotic arm enhances the system by enabling it to identify, pick up, place and remove small objects which obstructs the cleaning path. The robotic arm operates using servo motors and a microcontroller control system that allows precise movement and manipulation. With the help of sensors or vision-based detection techniques, the system can be used to identify the objects on the floor and instruct the robotic arm to pick and place them in its designated location. Meanwhile, the smart cleaner continues its floor cleaning operation efficiently using the DC Fan suction Pump. This coordinated operation improves the overall performance of the cleaning system and reduces the need for manual intervention.

The proposed system demonstrates the effective combination of robotics, embedded systems, and automation technologies. By integrating object handling capability with an automated floor cleaning mechanism, the system provides a smarter and more versatile cleaning solution. Such systems have potential applications in households, hospitals, offices, and industrial environments where maintaining cleanliness and minimizing human labor are essential.

## I. I. LITERATURE SURVEY

In this research paper, it combines augmented reality, brain-computer interface, and computer vision to control a robotic arm more efficiently. Using EEG signals and the visual inputs, users can be used to select and move objects without switching focus between devices. This system improves accuracy and makes robotic control easier for people with movement disabilities [1].This paper depicts about the robotic system that uses vision-based control to automatically by moving objects with a (2DOF) robotic arm. This system employs deep learning for using the object detection and it uses image-based visual serving for real-time control. It aims to improve the tracking accuracy, response time, and system adaptability while reducing the need for multiple sensors [2].This research focuses on creating an efficient path planning system for an apple-picking robotic arm that can avoid obstacles. It combines the Artificial Potential Field (APF) method with the A* algorithm to find the smooth and safe paths. The study helps improve the robot's ability to pick apples accurately and safely in complex environment [3].This study introduces a 3D robotic arm that can be controlled using both brain signals and computer vision. The system allows users to perform tasks like grasping or drinking by detecting brain activity and recognizing objects visually. It improves accuracy and reduces effort, helping people with movement disabilities interact with their environment more easily [4]. This paper introduces a lightweight model called the TDPPL-Net for detecting the tomatoes and locating picking points in real time. It helps harvesting robots, identify and pick tomatoes accurately using computer vision. The system works efficiently even on the low-cost hardware, making it suitable for real-world agricultural use [5].This research presents a new trajectory planning method for Delta robots to perform smooth and flexible pick-and-place tasks. The approach uses special mathematical curves to create adjustable motion paths for different working conditions. Simulations and experiments show that the method improves accuracy and adaptability in robotic operations [6].This study focuses on improving the speed and efficiency of robotic pick-and-place operations in footwear manufacturing. It uses a decision tree model to identify shoe parts and determine the best order for picking them up. The method helps reduce processing time and prevents possible collisions between robotic arms [7].The study introduced a vision-based interface that replaces the traditional pendant used in industrial robots. This approach enables users to operate the robotic arm in a more natural and interactive manner without requiring complex programming or physical control devices [8]. In this study focuses on the cutleries are sorted here using the Principal Component Analysis Method. This helps in easy sorting of cutleries according to their structures and box [9]. This paper depicts about the real-time seedling detection and autonomous transplantation system for agricultural robots. It focuses on developing a robot-mounted cameras to capture field images, and YOLOv5 to process these images detect and localize individual seedlings [10]. In this research paper it tells about an automated system combining computer vision and YOLO-based deep learning enables real-time defect detection, diagnosis, and autonomous repair to enhance productivity in manufacturing and service robotics [11]. In this research paper it depicts about an automated computer vision and robotic manipulation system uses YOLO-based detection to classify tomato maturity stages in real time, improving sorting accuracy and reducing post-harvest losses. The system classified tomatoes based on ripeness using image processing and machine learning algorithms [12]. In this paper it evident that integrating computer vision techniques with robotic systems enables efficient object detection, classification and manipulation. This work proposes a voice-controlled robotic gripper using neural networks for efficient speech-based object detection and manipulation [13].

In this paper, the section 2 represents the Hardware connections in the robotic arm and it also gives a detailed working of its block diagram, schematic diagram and its working. The section 3 of this paper depicts the software used in the Robotic Arm gives it's coding structure. The section 4 tells about the results and discussions of this paper. The section 5 represents the conclusion of this paper.

## II. HARDWARE USED IN ROBOTIC ARM

### II. I. BLOCK DIAGRAM OF THE ROBOTIC ARM WITH SMART CLEANER

The **Fig 1** illustrates the overall architecture of the robotic arm integrated with a smart floor cleaning system. The power supply provides the required electrical energy to operate the entire system. The Arduino UNO microcontroller acts as the main control unit that manages all system operations. It receives data from the camera or object detection module, which performs image processing to identify objects present in the workspace. At the same time, the ultrasonic sensor detects obstacles and sends distance information to the microcontroller to avoid collisions.

Based on the received data, the Arduino sends control signals to the PWM driver or motor controller, which regulates the operation of motors in the system. The robotic arm, consisting of servo motors and a gripper, performs object handling tasks such as picking and placing obstacles. Simultaneously, the smart cleaner, whichincludes a brush motor
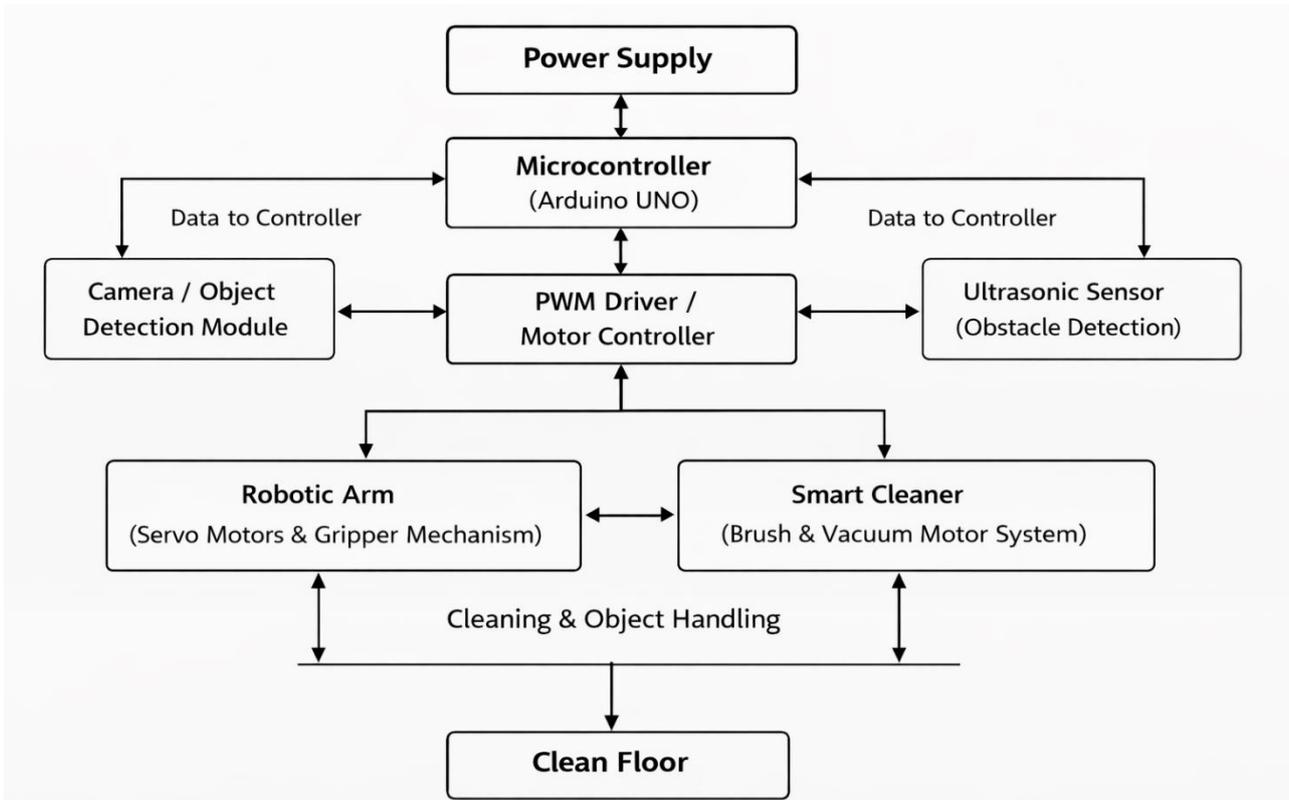
Fig 1. Block Diagram of the Robotic Arm Integrated with Smart Cleaner
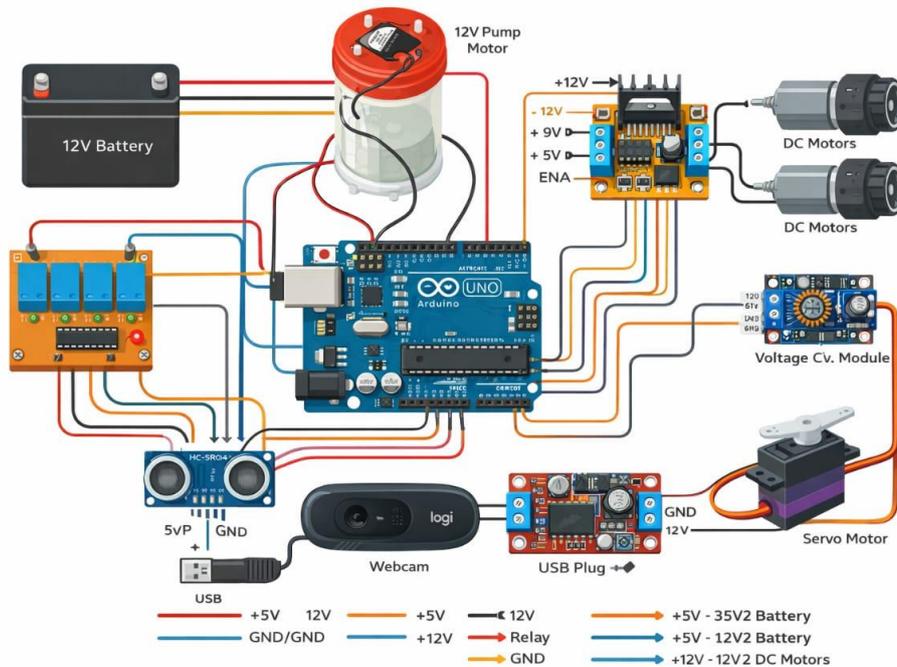
## II. II. SCHEMATIC DIAGRAM



Fig 2. Schematic Diagram of the Robotic Arm Integrated with Smart Cleaner

The **Fig 2** represents the schematic diagram the hardware architecture of the Robotic Arm Integrated with Smart Cleaner for Object Classification Using YOLO. The system consists of a microcontroller, sensors, actuators, power modules, and control circuits that work together to perform object detection and cleaning operations. At the center of the system is the

Arduino Uno, which acts as the main controller. It receives signals from sensors and sends control commands to motors, relays, and servo motors to perform the required actions.

The system is powered using a 12V battery, which supplies electrical energy to the entire circuit. Since different components require different voltage levels, a Buck Converter (voltage conversion module) is used to convert the 12V input supply into a regulated 5V output required for the Arduino board, sensors, and servo motors. A Relay Module is used to control high-power devices such as the suction pump motor. The relay acts as an electrically operated switch that allows the Arduino to turn the pump motor ON or OFF when required. For motion control, a Motor Driver Module is used to drive the DC motors. This motor driver receives control signals from the Arduino and provides the necessary current to operate the DC motors that may assist in mechanical movements of the system. The robotic arm movement is controlled using a Servo Motor, which enables precise angular positioning for picking and placing objects detected by the vision system.

Object detection is performed using a webcam connected to a computer system. The webcam captures real-time images, and the YOLO algorithm processes these images to identify and classify objects. Based on the detection results, the robotic arm is instructed to pick the object and move it to the appropriate location. Additionally, an Ultrasonic Sensor is used to measure the distance between the robotic arm and nearby objects. This helps improve positioning accuracy and avoid collisions. The smart cleaner unit includes a suction pump motor attached to a container through a pipe. When activated through the relay module, the pump creates suction to collect dust or small waste particles. Overall, the circuit integrates sensing, control, power management, and actuation modules to achieve automated object classification and cleaning using computer vision and robotics.

## III. COMPONENTS AND WORKING OF THE ROBOTIC ARM

### III.I COMPONENTS OF THE ROBOTIC ARM

**Arduino UNO (Microcontroller):** The Arduino UNO acts as the central controller of the system. It receives input signals from sensors such as the ultrasonic sensor and the object detection module. Based on the received data, the Arduino processes the information and sends control signals to the motor driver and servo motors. It coordinates the movements of the robotic arm and controls the operation of the smart cleaner unit, ensuring that objects are removed and the floor is cleaned efficiently.

**Servo Motors:** Servo motors are used to control the movement of the robotic arm joints. They allow precise positioning of the arm for picking up objects from the floor. Servo motors are used to control the joints of the robotic arm. These motors operate using PWM (Pulse Width Modulation) signals generated by the Arduino. The servo motors allow precise movement of the arm in different directions such as up, down, left, and right. This precise control enables the robotic arm to accurately position the gripper to pick up objects from the floor.

**Robotic Arm with Gripper:** The robotic arm consists of multiple joints and a gripper. The gripper is used to grasp objects such as small waste or obstacles present on the floor. The robotic arm is the mechanical structure responsible for picking and placing objects. It consists of multiple joints controlled by servo motors and an end effector called a gripper. When an object is detected, the robotic arm moves toward the object, the gripper closes to grasp it, and then the arm lifts and places the object into a designated location or collection bin.

**Ultrasonic sensors:** This sensor detects obstacles in front of the system. It helps the cleaner avoid collisions and assists the robotic arm in locating objects. The ultrasonic sensor is used for obstacle detection and distance measurement. It emits ultrasonic sound waves and measures the time taken for the echo to return after hitting an object. Using this time difference, the sensor calculates the distance between the cleaner and the obstacle. This helps the system identify objects present on the floor.

**Camera / Object detection & classification module (YOLO):** A camera is used for capturing images of the floor. Object detection algorithms such as YOLO can identify objects that need to be removed before cleaning. The camera captures images of the floor environment. These images are processed using an object detection algorithm such as **YOLO**, which identifies and classifies objects present on the floor. The detected object information is sent to the Arduino or control system to initiate the robotic arm movement.

**Smart Cleaner Unit:** The cleaner unit consists of a brush motor and a vacuum motor that sweep and collect dust from the floor.

**Motor Driver:** The motor driver controls the movement of the cleaner motors and wheels.

**DC Fan:** The DC fan is used in the smart cleaner unit to create suction for collecting dust and small particles from the floor. When power is supplied, the fan rotates at high speed and generates airflow. This airflow helps in pulling dust and debris into the cleaner compartment. The DC fan therefore supports the cleaning mechanism by assisting the brush system in removing dirt efficiently.

**Power supply:** The power supply provides the required electrical energy to all the components of the system. It converts the input voltage into a stable DC voltage suitable for the microcontroller, sensors, motors, and other electronic components. A regulated power supply ensures smooth operation of the robotic arm, camera module, and cleaning motors without fluctuations.

**USB Camera:** The USB camera is used to capture real-time images of the floor area. These images are processed using an object detection algorithm such as YOLO to identify objects present on the floor. Once the object is detected, the information is sent to the control unit which directs the robotic arm to pick up the object before the cleaning process begins.

**Jumper cables:** Jumper cables are used to connect different electronic components on the circuit. They establish electrical connections between the microcontroller, sensors, motor drivers, and other modules. These cables help in transmitting signals and power across the system for proper functioning.

**PCB Board:** The PCB (Printed Circuit Board) is used to mount and organize the electronic components in the system. It provides a stable platform for connecting circuits and reduces wiring complexity. The PCB ensures reliable connections between components such as voltage regulators, motor drivers, and the microcontroller.

**Voltage Regulators:** Voltage regulators are used to maintain a constant output voltage for sensitive components. They protect the microcontroller and sensors from voltage fluctuations by regulating the input voltage from the power supply. This ensures stable and safe operation of the entire robotic cleaning system.

**Relay:** The relay acts as an electronic switch used to control high-power devices in the system. In this project, the relay is used to turn the smart cleaner unit, such as the vacuum motor or fan, ON and OFF based on the commands from the Arduino Uno. When the controller sends a signal, the relay activates and allows power to flow to the cleaning motor, enabling the cleaning operation after objects are removed by the robotic arm.

**Buck Board:** The buck converter board is used to step down the voltage from the main power supply to a lower and stable voltage required by different components. For example, if the power source provides 12V, the buck board converts it to 5V or 6V for the Arduino, sensors, and servo motors. This helps protect the electronic components and ensures stable system operation.

**Gesture Wheel:** The gesture wheel helps in the movement and navigation of the smart cleaner unit. It allows smooth rolling of the robot across the floor while maintaining balance and stability. This wheel supports the cleaner as it moves to different positions during the cleaning process.

**Suction Tube:** The suction tube is connected to the vacuum motor or fan in the cleaning unit. When the cleaning system is activated, the suction tube pulls dust, dirt, and small particles from the floor surface and directs them into the dust collection chamber, helping maintain cleanliness.

**USB Port (TTL):** The USB TTL port is used for communication between the Arduino Uno and a computer or external device. It allows uploading of programs, debugging, and serial communication for monitoring the system. It also helps in sending and receiving control data between the controller and other modules in the system.

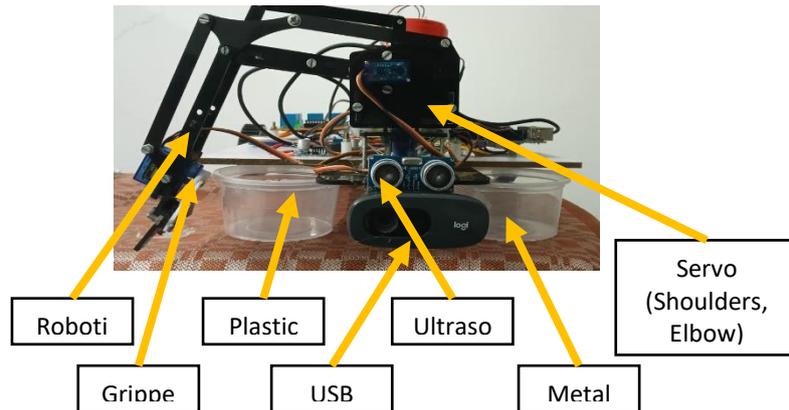The **Fig 3.1, 3.2, 3.3** represents the components used in the Robotic Arm.

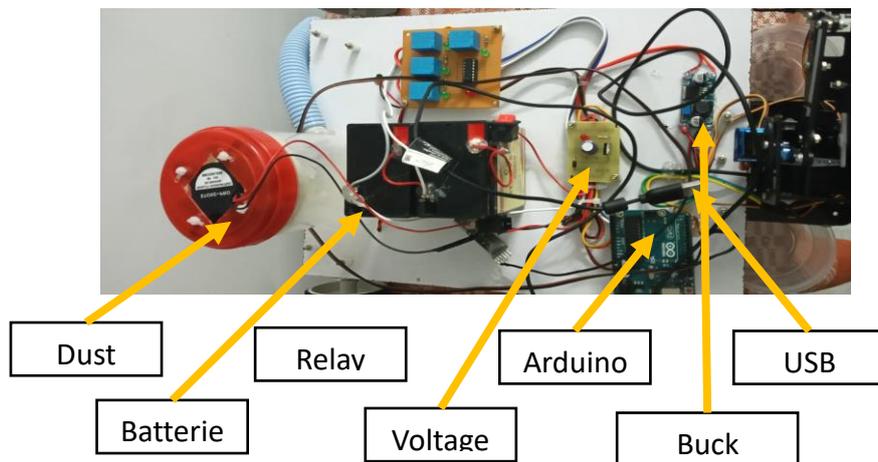Fig 3.1 Components of the Robotic Arm with Smart Cleaner



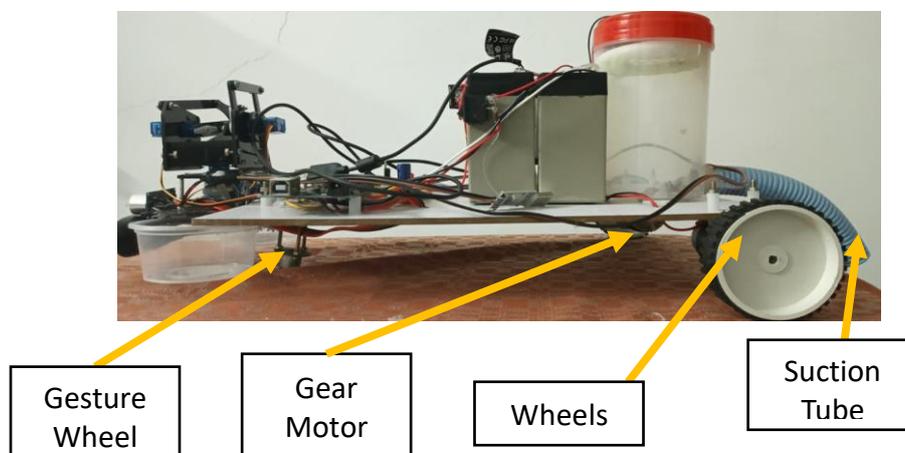Fig 3.2. Components of the Robotic Arm with Smart Cleaner



Fig 3.3. Components of the Robotic Arm with Smart Cleaner

## III.II WORKING OF THE ROBOTIC ARM

The system Robotic Arm Integrated with Smart Cleaner for Object Classification using YOLO operates by combining computer vision, microcontroller control, and mechanical actuation to identify objects and perform cleaning tasks automatically. The system is powered by a 12V battery which supplies energy to all the components. A Buck Converter is used to convert the 12V supply into a stable 5V output required for the control and sensing modules.

The central controller of the system is the Arduino Uno, which coordinates the operation of the robotic arm, sensors, and actuators. A webcam continuously captures real-time images of the surrounding objects. These images are processed using the YOLO algorithm on a connected computer. The YOLO model detects and classifies objects in the captured image and sends the identification results to the Arduino for further action.

Based on the detected object type and position, the Arduino controls the movement of the robotic arm using a Servo Motor. The servo motors enable precise angular movement so that the robotic arm can reach the object, grasp it, and move it to the designated container. To assist with distance measurement and positioning, an HC-SR04 Ultrasonic Sensor is used to measure the distance between the robotic arm and the object.

The cleaning mechanism is operated using a suction pump motor which is controlled through a Relay Module. The relay allows the Arduino to safely switch the high-power suction motor ON or OFF. When activated, the suction system collects dust or small debris into the container through a pipe. Thus, by integrating computer vision, sensing, and robotic actuation, the system can automatically detect objects, classify them, pick them using the robotic arm, and perform cleaning operations efficiently.

## IV. SOFTWARE USED IN THE ROBOTIC ARM

### IV.I. CODING IN ROBOTIC ARM

The Python program performs **real-time object detection using a webcam and sends signals to a microcontroller** for controlling the robotic arm. The system uses **computer vision and serial communication** to classify materials such as plastic and metal.

First, the required libraries are imported. The **OpenCV** library is used for accessing the webcam, capturing video frames, and displaying the detection results. The **YOLOv8** model from the **Ultralytics** library is used to detect objects present in the camera frame. The **PySerial** module enables communication with the **Arduino Uno** through USB UART. Next, the program initializes serial communication using **COM ports with a baud rate of 9600**, allowing data transmission between the computer and Arduino. After this, the pre trained YOLOv8 model **(yolov8n.pt)** is loaded for object detection. The code then defines two lists of objects: **plastic objects** such as bottle, cup, bowl, and toothbrush, and **metal objects** such as knife, fork, spoon, and scissors. These lists help the system categorize detected items into plastic or metal. The webcam is then activated using OpenCV. Inside the main loop, frames are continuously captured from the camera and passed to the YOLO model for detection. For every detected object, the program retrieves the class name, confidence score, and bounding box coordinates.

If the detected object belongs to either plastic or metal categories, the program draws a bounding box around it and displays the label with confidence value. When a plastic object is detected, the program sends **'1'** through UART, and when a metal object is detected, it sends **'2'**. A time delay of **30 seconds** is used to prevent repeated signals. Finally, the processed video is displayed on the screen. The program runs continuously until the **ESC key** is pressed, after which the camera and serial communication are safely closed.

### IV.II. FLOWCHART OF THE ROBOTIC ARM AND CLEANER

The flowchart in **Fig 4** explains the sequential operation of the robotic arm and smart cleaning system. The process begins with powering ON the system, where electrical power from the battery is supplied to all components. A Buck Converter regulates the voltage and provides a stable power supply to the control and sensing modules.

After initialization, the Arduino Uno activates and initializes all connected devices such as the servo motors, ultrasonic sensor, webcam, and relay module. The webcam then starts capturing real-time images of the working area. These images are processed using the YOLO, which detects and classifies objects present in the frame. If no object is detected, the system continues scanning the environment until an object appears. When an object is detected, the system measures the distance between the robotic arm and the object using the HC-SR04 Ultrasonic Sensor. Based on this information, the Arduino controls the movement of the robotic arm through Servo Motor to reach the object.

The robotic arm then picks up the detected object and places it in the designated container according to its classification. If dust or debris is present, the suction cleaner is activated using the Relay Module, which switches on the suction motor. Finally, the robotic arm returns to its initial position and the system continues scanning for the next object, repeating the process automatically.
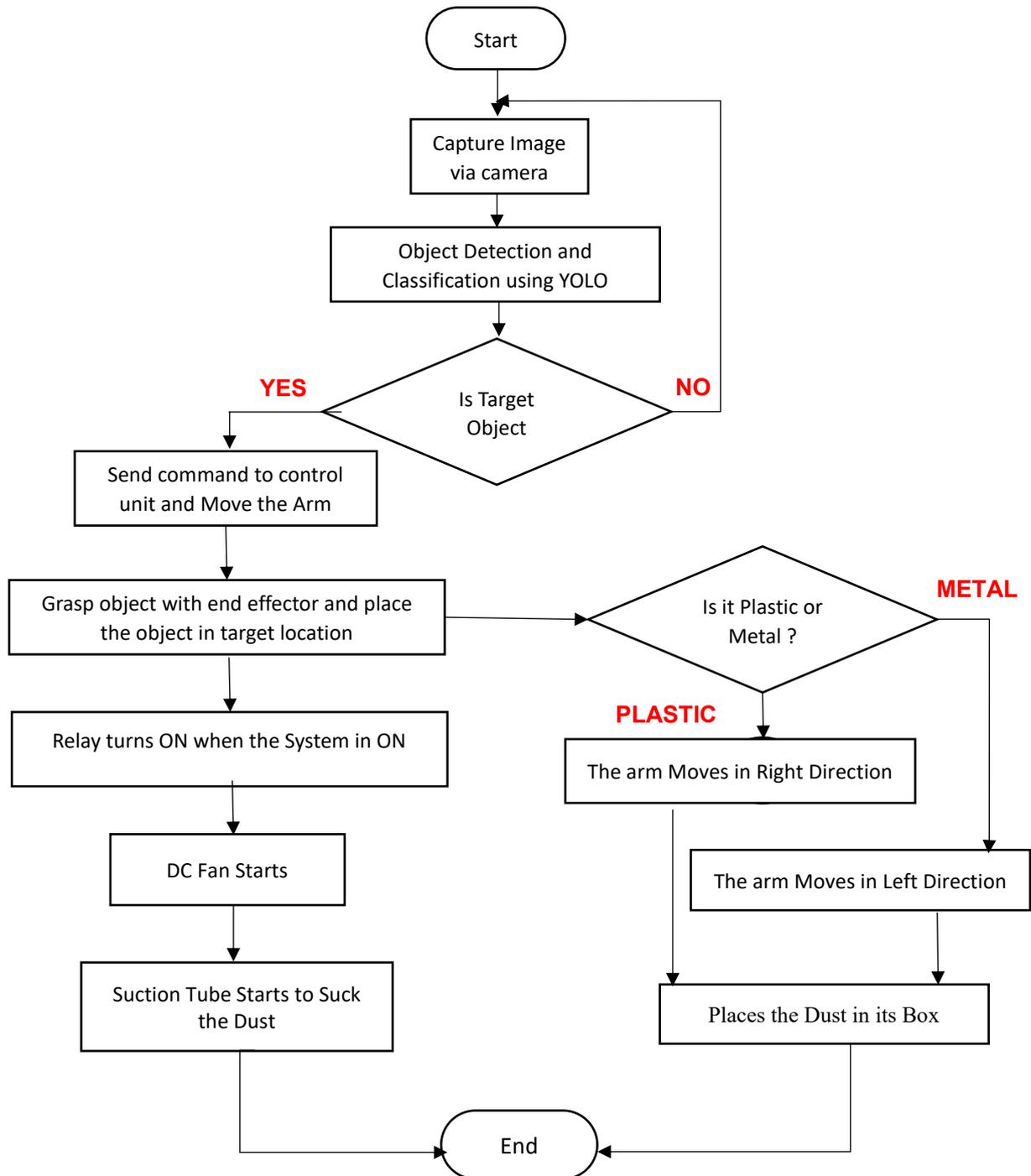
Fig 4. Flow Chart of the Robotic Arm with Cleaner

## V. RESULTS AND DISCUSSION

The robotic arm integrated with a smart cleaner system provides an innovative solution for automated floor cleaning and object handling. This project demonstrates the effective integration of robotics, embedded systems, and computer vision technologies to create a system capable of performing multiple tasks simultaneously. The robotic arm plays a crucial role in detecting and removing objects present on the floor, while the smart cleaner unit focuses on removing dust and debris, thereby ensuring a clean and obstacle-free surface.

The system uses key components such as Arduino UNO, servo motors, ultrasonic sensors, camera-based object detection modules, and motor drivers to achieve coordinated control and smooth operation. The camera captures real-time images of the floor environment, and the object detection algorithm identifies objects that need to be removed. Once an object is detected, the robotic arm moves toward it and uses the gripper mechanism to pick it up and place it in a designated location. After clearing the obstacles, the smart cleaner unit performs the cleaning process using its brush and suction mechanisms.

One of the major advantages of this system is its ability to reduce human effort and improve cleaning efficiency. The integration of automated object detection and robotic manipulation ensures that cleaning tasks can be carried out without continuous human supervision. This makes the system suitable for applications in homes, offices, hospitals, and industrial environments where maintaining cleanliness is essential.

Furthermore, the project highlights the potential of combining artificial intelligence with robotic systems for practical applications. With further improvements such as enhanced object detection accuracy, advanced navigation systems, and better power management, the system can become more efficient and reliable. Overall, the robotic arm integrated with a smart cleaner represents a promising step toward intelligent and automated cleaning solutions in modern environments.

## VI. CONCLUSION

The robotic arm integrated with the smart cleaner system was successfully designed and implemented to perform automated floor cleaning along with object detection and removal. The system was tested under different conditions to evaluate its performance in identifying objects, picking them up, and cleaning the floor effectively. The camera-based object detection module captured real-time images of the surrounding floor area and processed them to identify objects present on the surface. Using the object detection algorithm, the system was able to recognize and classify objects with reasonable accuracy.

Once an object was detected, the coordinates of the object were sent to the control system. The Arduino UNO processed the data and controlled the servo motors through PWM signals to move the robotic arm. The robotic arm successfully approached the detected object, and the gripper mechanism was able to grasp and lift the object from the floor. The object was then placed in a predefined location or collection area. This process ensured that obstacles or unwanted items were removed before the cleaning process began.

After the removal of objects, the smart cleaner unit started its cleaning operation. The brush and suction mechanisms effectively removed dust and small debris from the floor surface. The ultrasonic sensor helped in detecting nearby obstacles and assisted the system in avoiding collisions during operation. The motor driver ensured smooth control of the cleaner motors, allowing efficient movement and cleaning.

During testing, the system performed well in normal lighting conditions and was able to detect small and medium-sized objects accurately. However, slight variations in detection accuracy were observed under poor lighting conditions. Minor mechanical delays in servo motor movements and alignment adjustments were also noted.

Overall, the experimental results show that the integration of the robotic arm with the smart cleaner significantly improves the cleaning process by removing obstacles before cleaning. The system demonstrates good potential for automated cleaning applications in homes, offices, and industrial environments.

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