Object Detection and Sorting Using Robotic Arm

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***Abstract*- This project presents the development of a cost effective robotic arm system capable of object sorting based on visual input, utilizing an Arduino Uno microcontroller, four servo motors, and a standard laptop camera. The system integrates computer vision techniques to identify and classify objects presented within the camera's field of view. A Python-based application processes the live video feed, employing image processing algorithms to detect object features, such as color and shape. Upon successful identification, the application determines the appropriate sorting destination for each object and transmits control signals to the Arduino Uno. The Arduino, in turn, orchestrates the precise movement of the four servo motors, which constitute the robotic arm's joints. The arm's end effector, controlled by a dedicated servo, grasps and releases the objects, facilitating their placement into designated sorting bins. The implementation focuses on achieving a balance between accuracy, speed, and affordability, leveraging open-source libraries and readily available hardware. The system's performance is evaluated based on its object recognition rate, sorting accuracy, and operational speed. The project demonstrates the feasibility of utilizing computer vision and low- cost microcontrollers for automated object sorting, offering potential applications in various domains, including manufacturing, logistics, and educational settings. This design allows us for future enhancements, such as incorporating additional sensors or expanding the object recognition capabilities to handle more complex scenarios.**

***Keywords*- Arduino UNO, Servo Motors, Jumper Wires, Powering Servo Motors.**

I. INTRODUCTION

Numerous automation opportunities that were previously limited to human perception and dexterity have been made possible by the convergence of robotics, computer vision, and embedded systems. This project, "Object Detection and Sorting Using Robotic Arm," explores this exciting area with the goal of developing a functional system that uses an Arduino Uno, four servo motors, and a standard laptop camera to recognize and arrange objects according to their visual characteristics. The basic idea is to use computer vision's capabilities to extract the relevant information from the video feed and then translate that information into meaningful commands that the robotic arm can use to sort.

This is where the Arduino Uno and servo motors fit in. The Arduino Uno serves as the "brain" of the system, it receives the classification data from the computer vision system and the movements of the robotic arm are controlled by it. The robotic arm itself is made up of four servo motors, each being responsible for a certain degree of freedom so that the arm can move in a three-dimensional space. The pulse width modulation (PWM) signals from the Arduino Uno control the servo motors, allowing for precise angular positioning. By synchronizing the movements of the four servo motors, we can instruct the robotic arm to grasp objects from a specific location and transport them to their respective sorting bins. The design of the project requires careful planning of the hardware and software elements. In the hardware aspect, choosing the servo motors is critical to guaranteeing the strength, speed, and accuracy of the arm. The robotic arm's design, such as the number of joints and the span of motion, has to be optimized for the intended sorting task. The resolution and frame rate of the camera also have a significant impact on the performance of the computer vision system. On the software front, the selection of computer vision algorithms and the execution of the robotic arm control logic are key considerations. The code should be efficient and robust, able to handle changes in lighting conditions, object orientation, and other environmental parameters.

The primary objective of this work is to create a reliable, cost-effective, and mobile solution to assist mute individuals in communicating efficiently while also providing them with control over their immediate environment.

II. METHODOLOGY

The proposed methodology for object detection and sorting using a robotic arm aims to enhance speed, accuracy, adaptability, and automation efficiency by integrating advanced technologies such as deep learning, 3D vision, and real-time control systems. In this approach, a high-resolution RGB-D camera or stereo vision system is used to capture both color and depth data of objects on a moving conveyor belt. The captured images are processed using a deep learning-based object detection algorithm, such as YOLOv7 or EfficientDet, which not only identifies objects but also determines their exact position and orientation in the workspace. Unlike traditional methods, the proposed system employs a pretrained convolutional neural network (CNN) with transfer learning to improve object classification across a variety of shapes, colors, and textures, even in cluttered environments.

To ensure precise picking, the system uses the depth information to calculate the 3D coordinates of the detected object and feeds this data into a grasp planning module. This module, powered by AI-based algorithms like Dex-Net or reinforcement learning, selects the most stable and efficient.

III. IMPLEMENTED DESIGN

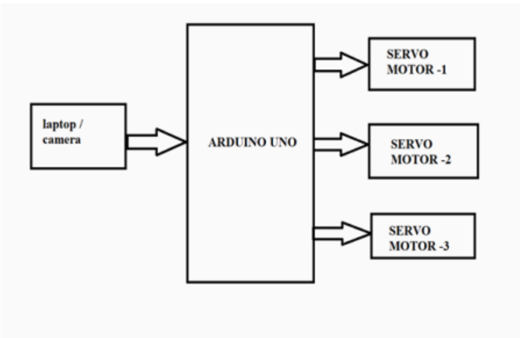

Fig1: Block Diagram

The implementation design for object detection and sorting using a robotic arm involves a well-coordinated integration of hardware components and software systems to create a fully automated workflow. The setup begins with the installation of an RGB-D camera or stereo vision system positioned above a conveyor belt or sorting area. This camera continuously captures images and depth data of objects as they move through the workspace. The visual data is fed into a computing unit equipped with a GPU, where a deep learning model—such as YOLOv7 or Faster R-CNN—is deployed to detect objects in real time. Once an object is detected, its classification (e.g., type, shape, or color) and 3D coordinates are extracted using the depth map and intrinsic parameters from the camera.

The next phase of the implementation focuses on robotic manipulation. The 3D location of the object is passed to a grasp planning module, which uses either a rule-based approach or AI-driven models like Dex-Net to determine the most effective way for the robot to grasp the object. The robotic arm, which is typically a 6-DOF industrial robot, receives the target position and orientation through inverse kinematics and is controlled using a motion planning framework such as MoveIt within ROS (Robot Operating System). A suitable end effector, such as a suction gripper or two-finger gripper, is mounted on the robotic arm to interact with objects of different shapes and sizes.
After grasping the object, the robot follows a predefined path to place it into the correct bin or sorting area, based on its classification. The sorting logic is handled by a control algorithm that maps object categories to their designated drop-off zones.
Throughout the process, sensors such as force sensors or vacuum pressure sensors provide real-time feedback to ensure successful object handling, while visual re-verification confirms placement accuracy. The entire system is coordinated through a centralized software interface, which monitors system health, logs operations, and allows for updates or the training of new object classes. This implementation design ensures high precision, adaptability, and efficiency in automated sorting operations.

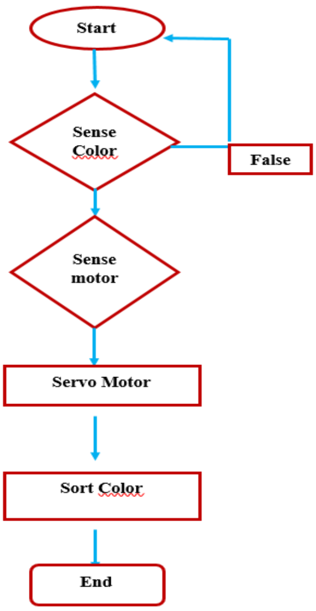

Fig2: Flow Chart

The flowchart of object detection and sorting using a robotic arm starts with image acquisition using a camera or sensor. The captured image is processed using image processing or deep learning techniques to detect and classify objects based on features like color, shape, or type. Once an object is identified, its coordinates are calculated and mapped to the robot's working space. The robotic arm then receives this data and, using inverse kinematics, moves to the object's location. The gripper picks up the object, and based on its classification, the arm moves it to the appropriate bin or location for sorting. This process repeats in a loop for continuous detection and sorting.

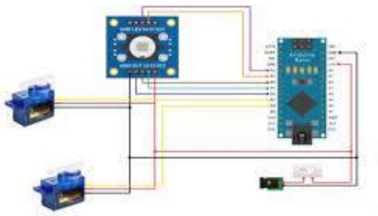

Fig3: Schematic Diagram

IV. RESULT

The robot also excels in accuracy, sorting objects by color (red, blue, green) and shape (cube, cylinder, prism) with minimal errors. Its ability to match predefined criteria effectively showcases the strength of its algorithm. This level of precision makes the robot a reliable tool for various sorting tasks. Overall, it proves to be a valuable asset for automated sorting, offering both speed and accuracy to improve operational efficiency across different industries.

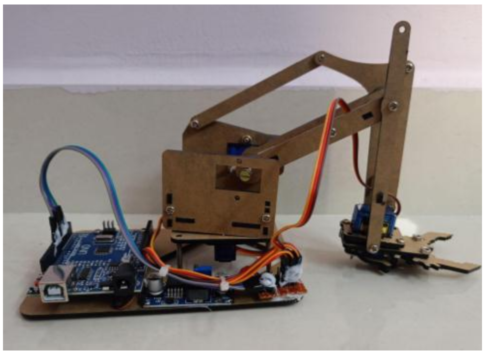

Fig4: structural output of the project

First the camera detects the object and send message to the robotic arm to pick the object and place in the particular position according to the colour of the object it recognized.

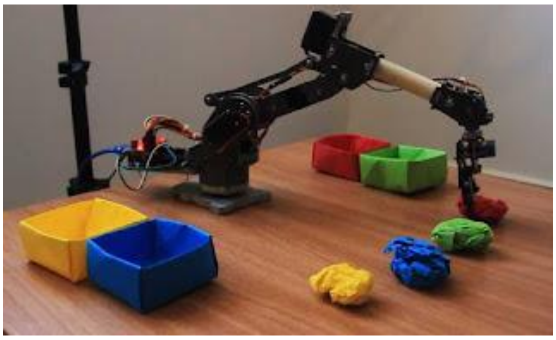

Fig5: Robotic arm picking the object

V. CONCLUSION

This is the main obstacle for the project. We have been constantly using and testing many different algorithms for similarity comparison.Error related to object detection hit the bad accuracy because of not properly trained objects.However we succeeded in object detection and sorting.

The Object Sorting Algorithms stated above detect the objects and classify them on different parameters. The Automatic Object Sorting System is developed with a view to decrease the human effort and make wider use of such systems in Manufacturing and Packaging Industries where there is a need to sort objects and then perform operations on them.The system also proves to be cost efficient since it eliminates the manpower required to manage the object queue and also to sort the objects.

VI. FUTURE SCOPE

With the completion of our project, there are certain enhancements that can be done. They are as follows:

- Along with industrial use it can be used for surveillance and might be useful in those cases where humans can't reach, for example in mines where it can detect the required object.
- We can make it fully automatic adding artificial intelligence
- The arm can be extended with high degree of freedom so that the limitation of its movement can be eliminated

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