OPEN ACCESS
Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 05| Issue 06 | Nov.-Dec. | 2025
Journal homepage: https://gjrpublication.com/gjrecs/
Research Article

Artificial Intelligence-Powered Colour Recognition using Cobot Arms: Future Directions

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DOI: 10.5281/zenodo.18034327 **Submission Date:** 05 Nov. 2025 | **Published Date:** 23 Dec. 2025

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Abstract

The design and development of an automated pick-and-place Cobot system for sorting black colors is presented in this work. Additionally, it suggested a way for the cobots to identify an object's color by using an infrared sensor to identify black, then using an Arduino Nano and servo motors to direct the robotic arm to pick and position the object in a predetermined location. The detection of randomly colored objects has been used to test the suggested intelligent device's performance. However, it will only identify, select, and transport black-object objects to the specified location. It is anticipated that the suggested solution will save labor expenses while boosting industry production and efficiency. Future directions for pick and place cobots with color detection include enhanced sensor integration for more complex sorting, the use of machine learning for adaptive and adaptive picking, and improved human-robot collaboration for color-based tasks. These advancements will enable cobots to handle a wider variety of items, adapt to changing conditions, and work alongside humans more effectively. The introduction of artificial intelligence (AI) will make the cobot arm more efficient and accurate.

Keywords: *Artificial Intelligence (AI), Arduino, Color Sorting, Cobots Arm; Machine Learning; Pick and Place.*

I. INTRODUCTION

With the recent and continued improvement of science and technology nowadays, human living standards have been enhanced worldwide [19]. It has likewise improved economic growth and life anticipation [15]. Therefore, with such progress, human beings' work habits have changed considerably universally [16]. The use of robots in several fields, such as military combat, industrial production, and many other applications in recent years, has received extensive consideration [1, 20]. To minimize labor costs, production time, and possible dangers in different types of risky tasks, the use of robots is also encouraged [2]. For example, robotic arms are now often employed in many cases to execute jobs that humans cannot or will not undertake due to the high risk surrounding their environment [17]. Besides, to assist disabled or elderly people, computer vision-based robotic arms have been utilized in recent times [3]. Computer vision is a current improvement in the field of artificial intelligence (AI), and it is widely employed in industrial automation, detection, automated technology, and object identification [21, 22]. Picking and placing products faultlessly with unswerving motions is important in an industrial setting [4]. Additional control systems, such as joysticks or controllers, and even manual programming, are now used to maneuver the erudite robotic arm [5]. The robotic system may offer a range of devices (sensors) such as temperature, radiation, color, weight, and so on [23]. Nevertheless, there is a growing propensity to substitute all of these sensors with a single-lens camera and computer vision approaches to perform the responsibilities independently with enhanced precision [24]. In this method, an innovative control method is employed using computer vision to drive a robotic arm [25]. Thanks to artificial intelligence and computer vision methods, a cost-efficient, user-friendly, and highly efficient robotic arm can be built using such methods [26]. Artificial intelligence and computer vision have been brilliantly used to operate complex robotic systems in a variety of applications. For example, in a new paper [6], the authors designed an automated robotic arm-based assistance device by employing simple stereo matching and Q-learning optimization methods. This proposed device can perform five degrees of operation in a single instance and detect any object with the aid of stereo vision. The system likewise keeps track of an object's parameters. The stereo camera can recognize RGB color. In this work, the Q-learning framework [29] is employed to control the position of the robot's arm. Lastly, the paper presented experiments to detect an object's stereo vision and feature point. The downfall of this research is that it did not specify the precise distance between the objects. In [7], the authors present a new approach using a two-armed industrial robot for bimanual hybrid motion/force control and visual serving. This work aims to develop a telerobotic system that can manipulate a grabbed item with both arms. The experimental testbed is a dual-arm industrial robot with fifteen degrees of freedom, a camera, a torque/force sensor, and a rubber contact pad on each wrist. The operator's orders are sent by gestures using a Microsoft Kinect sensor. Seven processes are running on three PCs, and they are connected via a local hub using the protocol called TCP/IP. In addition, this author added global planning approaches to manage local equilibrium and more complex redundancy resolution. In this current research [8], the authors established a fusion-based manipulation of sensory-motor and a robotic bionic arm, a control strategy for grasping for an automated hand-eye system. This anticipated device was developed through vision serving, motion optimization, and a hybrid force approach. The arm of the robot was designed by joining various motors with an Arduino and was controlled with the aid of a Point Grey Bumblebee stereo camera. The hand was working from a matrix calculation using epi polar geometry [30]. In this research, various types of information like joint, relaxation, and grasping time graphs are collected with the help of 3 finger force and a 20 frame per second camera capturing the images. In [9], the authors explore the idea of building a robot that can track colored objects. The brightly colored object has a basic design. A wheeled robot has been designed by utilizing a motor and wheels. A Pixy-2-based wheeled robot with sensors is used to distinguish objects with dissimilar colors. This robot moves in the same direction as the thing it's attached to is moving. When it comes to movement, this robot has two wheels, one on each side (right and left). The Arduino microcontroller is in charge of controlling the movement of this robot. In this current research [10], the author designed a self-feeding assistive robotic arm with seven degrees of freedom (DOF) for people with severe incapacities. The system uses a robotic arm simulator to get the motion of the robotic arm. In the process, inverse kinematics equations [31] were used to control the robot's arm position. The research showed that the robot could efficaciously transfer the food to the appropriate location for its user. The author conducted further experiments by adding a web camera that is attached to the end-effector of the robotic arm to monitor whether food dropped from its edge was eaten or not. The research in [11] emphasizes employing a computer vision-based robotic arm that will perceive numerous objects by color sorting, grab that object, and place it in a specific place. The proposed system will likewise measure the width, length, and distance between objects and identify the objects' position with the help of the computer vision method. The arm will do the movement using a servo motor controlled by an Arduino microcontroller as the brain of the whole system. In this research, an automatic robotic arm has been built that can sort various items based on their shape, colors, and sizes [37]. This proposed device can pick a selected object and place it in a specific place according to the desired distance. The subsequent paragraphs discuss the software and hardware elements utilized to design the proposed robotic device. A. Computer Software Arduino is a cross-platform IDE that allows programmers to amend code and then upload the code to a board where it can be tested [27]. C++ and C are two major conformist languages for Arduino microcontrollers. As a result, the program primarily targets coders and developers who work in those two languages. In this research, we use this software to build the code, and with the aid of this software, we can control the robotic arm. Pixy Mon is a program that lets us specify the output port, set up the Pixy device, and control color signatures [28]. We can connect a universal serial bus (USB) connection to Pixy's back and run Pixy Mon to observe what Pixy sees when connected to the Arduino or other microcontrollers. With the aid of Pixy Cam, we use this software to perceive the colors of an object. Python is a programming language that enables connecting systems faster and more proficiently. We use this program to perceive the geometrical shape of an object. With the aid of easy Python language coding, we can load the image and calculate the geometrical shape of an object. The Anaconda is a Python and R programming language distribution that simplifies management systems to certify an installation in computer science. In this work, we use an Anaconda prompt to run the code and display the result for the shape detection of an object. The Arduino Mega 2560 R3 is a microcontroller board. It is based on the ATmega2560. It contains 54 digital input/output pins, 4 UARTs (hardware serial ports), 16 analog inputs, a USB connection, a power jack, a reset button, an ICSP header, and a 16 MHz crystal oscillator [12]. The use of this Arduino is to control the robotic arm through Arduino code. The Pixy CMUcam5 is a camera sensor that is compatible with the Arduino and Raspberry Pi [18]. This camera sensor successfully loads the image where many other image sensors have failed. It is often challenging to utilize this sensor with a simple Arduino board-type central processing unit without getting drenched. We use this component for the color detection of a specific object. The Tower Pro MG996R is a servo motor consisting of metal gear. It has a maximum stall torque of 11 kg/cm. It can rotate from zero to 180 degrees. This high-torque motor depends on the pulse width modulation (PWM) wave's duty cycle given to its signal pin, just like other RC servos. In this work, we used this motor to build the arm, grab the object, and place it in a destination folder [36].

II. MATERIALS AND METHOD

2.1. The Materials Used in This Research are Shown in Table 1.

Table 1. Materials used in the research

S/N	Names of Components	Number used
1	Arduino	1
2	Servo Motors	4
3	IR Sensor	1
4	Bluetooth Module	1
5	Voltage Regulator	1
6	Power Supply	1
7	Connections	14

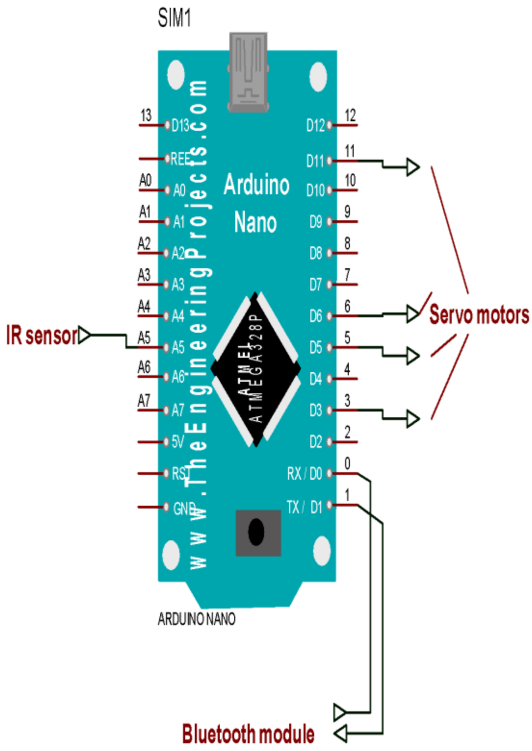

Fig. 1. Pin Assignment

2.1.1. Power Supply Unit

In this unit, the battery 12 volt serves to supply the direct current voltage to the regulator integrated circuit (IC 7809) and the output to the Arduino board.

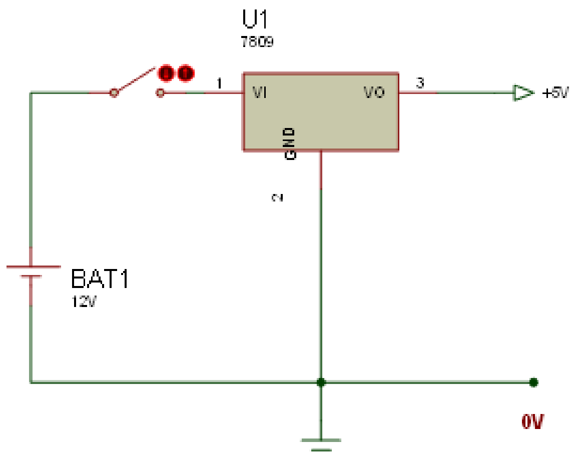

Fig. 2. Power Supply

2.1.2. Infrared Sensing Unit

This unit is used as an identification of black-colored items only. The infrared sensor is employed to sense the presence of dark color. When the robot is moving from the picking point to the placing point, if it senses the presence of black in the picking point, it will open its gripper and pick up the black item and take it to the placing point. This unit is used as an identification of black-colored items only. The infrared sensor is employed to sense the presence of dark color. When the robot is moving from the picking point to the placing point, if it senses the presence of black in the picking point, it will open its gripper and pick up the black item and take it to the placing point.

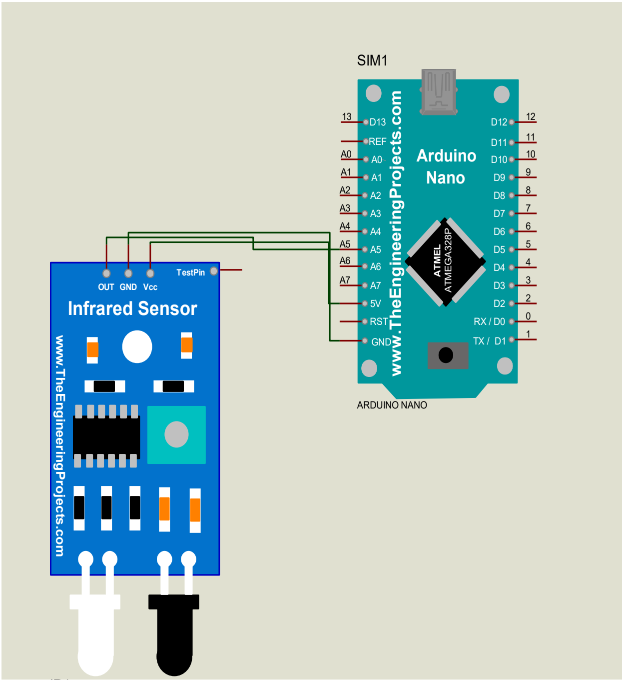

Fig. 3: The Interfacing of the IR Sensor to the Arduino

2.1.3. Robot Moving Control Unit (Servo motor)

This unit achieves positioning the robotic arm to rotate, bend down, and grip the items based on the black color recognized. The servomotor is tiny and lightweight with a high output power [38]. The servo can rotate approximately 180 degrees (90 in each direction) and works just like the standard kind but smaller. Position "0" (1.5 ms pulse) is in the middle, "90" (2 ms pulse) is in the middle, is all the way to the right, and "90" (1 ms pulse) is all the way to the left.

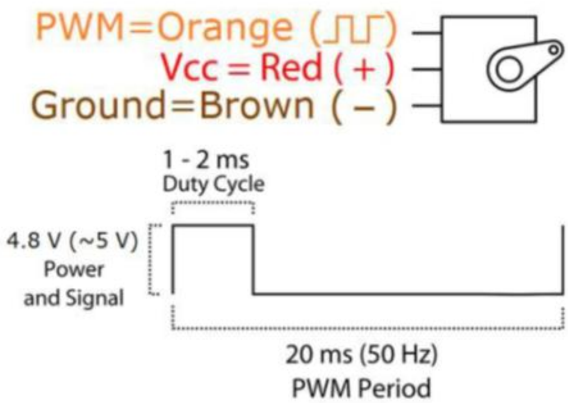

Fig. 4. Servo motor operation

2.1.4. Bluetooth module

The Bluetooth module is interfaced with the Arduino nano for serial communication between the Bluetooth module and the Android application installed to control and power on the Cobots arm and switch it off. The specifications for the Bluetooth module are: RX receiver output voltage: 5 volts
TX transmitter input

Fig. 5: Interfacing the Arduino to the Bluetooth Module

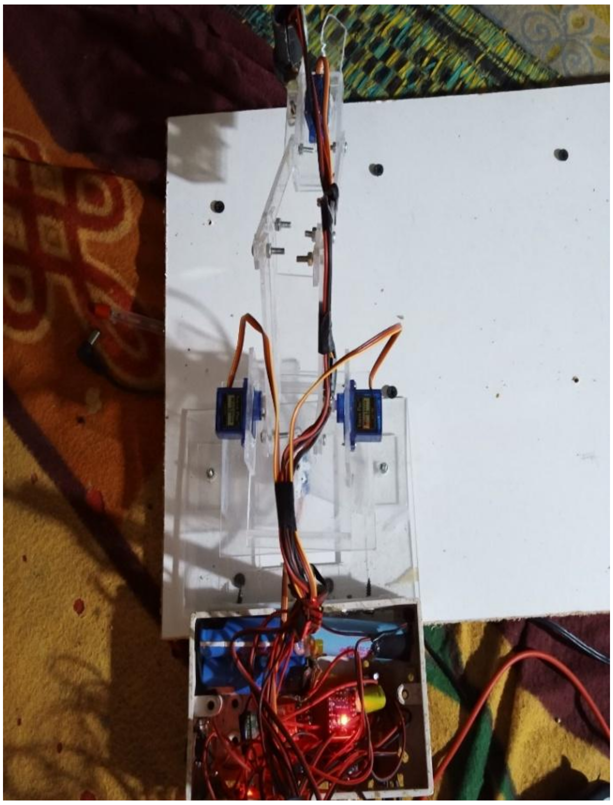

Fig. 7: Pick and place color detection circuit diagram in its entirety Implementation of Cobot Arms

III. RESULT

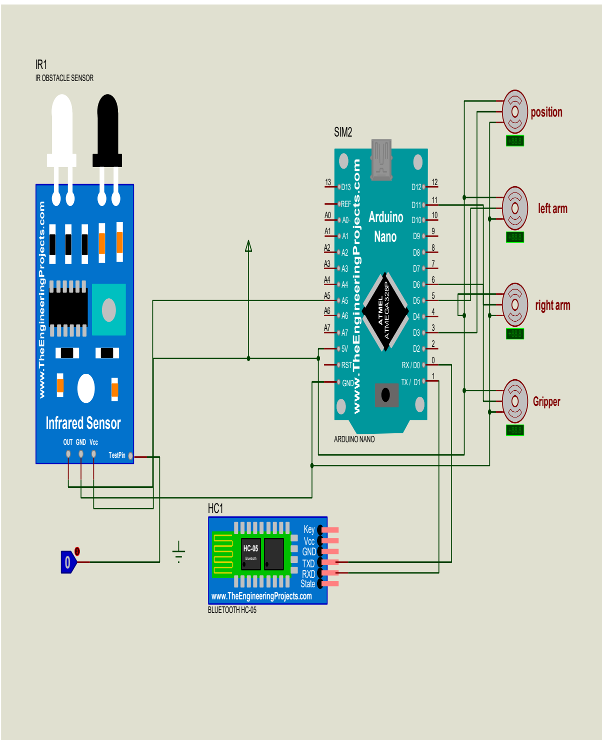

Fig. 6: Complete circuit diagram of the pick and place color detection Cobots' arms simulation

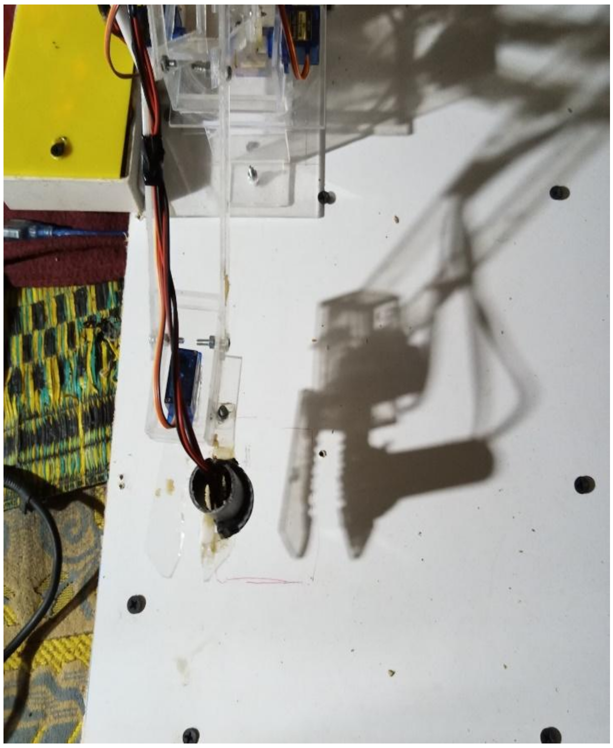

Fig. 8: The picking point of the black object

Fig. 9: Positioning the black object (destination)

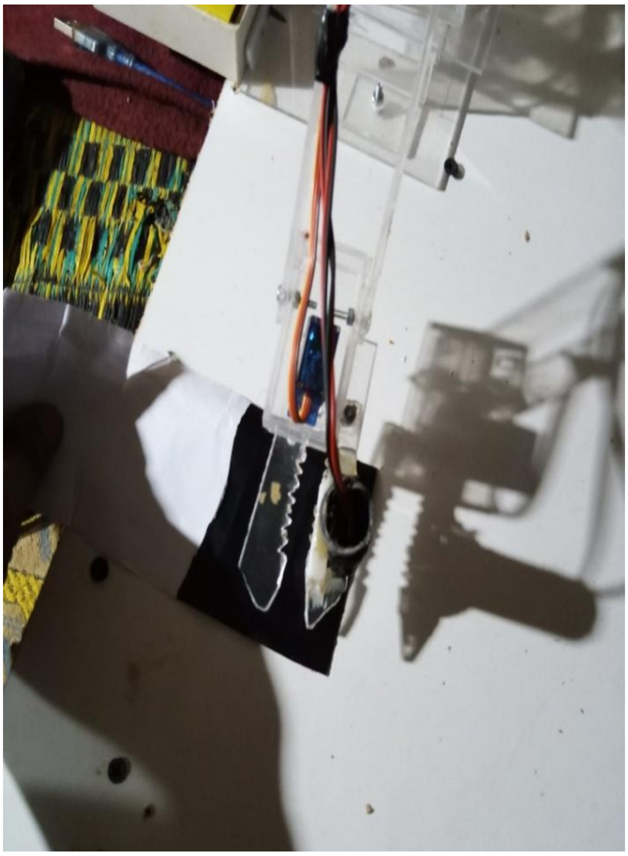

Fig. 11. Gripper close when it picks up the black object

Fig. 10: Gripper opens at the picking point when it senses a black object.

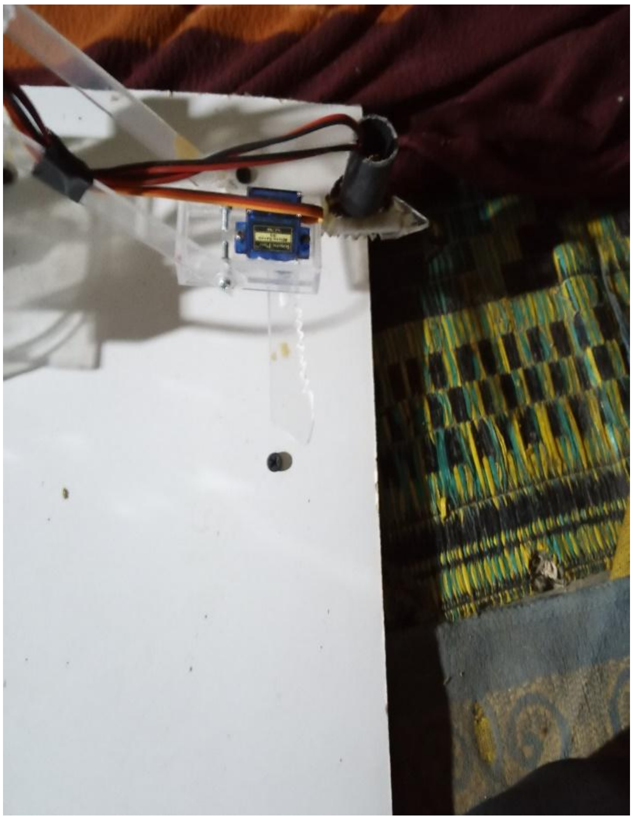

Fig. 12: The Gripper opens at the placing point to drop the black object it took from the picking point.

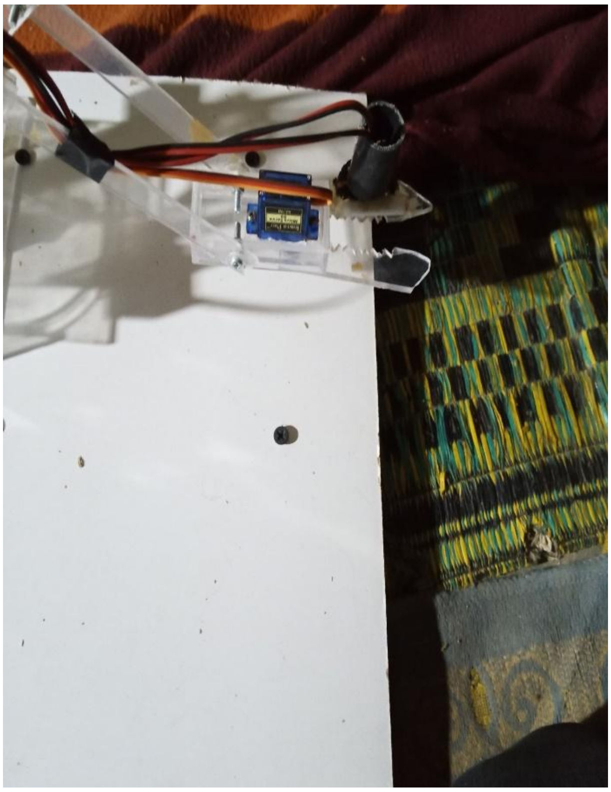

Fig. 13: The Gripper drops the black object it took from the picking point.

IV. CONCLUSION

The design and implementation of an automated pick-and-place system for classifying black colors is presented in this study. Additionally, it suggested a way for the Cobots to identify an object's color by using an infrared sensor to identify black, then using an Arduino nano and servo motors to operate the robotic arm to pick and position the object in a predetermined location. The detection of randomly colored objects has been used to test the suggested intelligent device's performance. However, it will only identify, select, and transport black-object objects to the specified location. The proposed system is expected to reduce labor costs and increase productivity and efficiency in industries [40-56].

Enhanced sensor integration

i. **Advanced color sensing:**
Integrating higher-resolution and more sensitive color sensors that can detect subtle variations, and even multiple colors at once, to identify and sort objects more precisely.

ii. **Multi-modal sensing:**
Combining color sensors with other sensors like depth cameras, 3D vision, or thermal cameras to improve object identification in challenging environments or to gather more comprehensive data for decision-making.
Advanced control and intelligence

iii. **Machine learning and AI:**
Using machine learning to train cobots to recognize and sort a vast range of items, even those with similar colors but different textures or shapes. This allows for greater adaptability and reduces the need for extensive manual programming for each new item [54-56].

iv. **Adaptive picking:**
Developing algorithms that allow the cobot to adjust its grip based on the object's color and material properties, ensuring a secure hold without damage.
Human-robot collaboration and interaction

v. **Collaborative color-based tasks:**
Designing applications where the cobot works with human operators on tasks that require color judgment. The cobot can handle the repetitive picking, while the human can oversee or perform more complex, color-dependent tasks, such as quality control or final assembly.

vi. **Intuitive interfaces:**
Creating more intuitive user interfaces for color detection applications, allowing human operators to easily teach the cobot new items or color rules.

Improved end-effector technology

i. **Smart grippers:**
Developing a new generation of end-effectors that not only grip but also have built-in sensors for color and other properties. This would reduce the complexity of the arm and streamline the integration of sensing and manipulation.

ii. **Flexible and adaptable grippers:**
Creating grippers that can change their form or color sensitivity on the fly to better handle a variety of items without needing to be physically swapped out, allowing for more efficient color-based sorting and handling [39].

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CITATION

Ahmad, M. A., Sumaila, J. L., Ado, K. K., Umar, M. A., Bari, A. S., Muhammad, S. A., & Baballe, M. A. (2025). Artificial Intelligence-Powered Colour Recognition using Cobot Arms: Future Directions. In Global Journal of Research in Engineering & Computer Sciences (Vol. 5, Number 6, pp. 50–59). https://doi.org/10.5281/zenodo.18034327