International Journal of Advanced Multidisciplinary Research and Educational Development ISSN: **3107-6513**
Volume 2, Issue 3 | May - June 2026 | www.ijamred.com

ARM Based Pick and Place Robotic Vehicle Using IoT

Mrs. Ambika K[1], Aishwarya H H[2], Monika S P[3] , Moulya S L[4], Swathi V R[5]

[1]*Assistant Professor, Dept. of Electronics and communication Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India*

[2345] *Students, Dept. of Electronics and communication Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India*

[1]ambika.hsn@rithassan.ac.in [3]spmonika939@gmail.com

***Abstract*—The proposed system presents an intelligent color sorting pick and place robotic arm designed to automate the sorting of objects based on their color. The system uses a laptop camera integrated with Python and OpenCV to capture and process images in real time. The system works by using a camera to capture the image of objects and detect their colors using image processing techniques. It checks the RGB or HSV color values to identify colors like red, green, and blue. After detecting the color, the information is sent wirelessly through Zigbee to the ESP32 microcontroller. The ESP32 controls the robotic arm with the help of motor drivers. The robotic arm automatically picks the object and places it in the correct position based on its color. The system also provides a Bluetooth manual control mode, which allows the user to operate the robotic arm manually whenever needed. This project helps to reduce human effort, improve sorting accuracy, and increase efficiency in industrial automation applications.**

Keywords*—*IoT, Robotic Arm, Color Sorting, OpenCV, ESP32, Zigbee Communication, Bluetooth Control, Industrial Automation, Image Processing.

I. INTRODUCTION

In recent years, the automation and robotics have become an integral part of modern industrial systems, where significantly this project Arm based pick and place robotic vehicle as improving productivity, accuracy, and efficiency. One of the key applications of this robotics in industries is object sorting and handling, where as robots are used to identify, classify, and place objects based on specific attributes such as size, shape, or color. The project titled "Arm based pick and place robotic vehicle using Iot" focuses on designing and developing an intelligent robotic system capable of detecting objects based on their color (Red, Green, Blue) and placing them in designated locations automatically. This system integrates embedded systems, computer vision, wireless communication, and robotics into a unified solution.

The robot uses a laptop camera to capture real-time images of objects and materials. These images are processed to detect the color using image processing techniques by using python and opencv. Based on the detected color, commands are sent wirelessly using Zigbee communication to the robotic arm controlled by an ESP32 microcontroller. The robotic arm then picks up the object and places it in a predefined location. Additionally, Bluetooth communication is incorporated for manual control, allowing the user to operate the robot when required. Motivation and Need for the System Manual sorting of objects in industries is time-consuming, error-prone, and inefficient, especially when dealing with a large volume of products. Industries such as manufacturing, packaging, recycling, and agriculture require accurate and fast sorting mechanisms to maintain quality and reduce operational costs.
This project is motivated by the need to reduce human effort and dependency in repetitive tasks, while improving sorting accuracy and speed. It also aims to enable cost-effective automation using affordable components and to demonstrate the integration of artificial intelligence, particularly computer vision, with embedded systems. Traditional sorting systems often rely on expensive sensors and complex machinery, making them less accessible for small-scale applications. In contrast, this project uses a low-cost camera-based vision system along with simple robotic mechanisms, making it highly suitable for small-scale industries as well as educational purposes.

The proposed system is designed to operate in two modes: automatic mode and manual mode. In automatic mode, the system follows a predefined workflow to perform sorting tasks without any human intervention. A laptop camera captures the image of the object placed in front of it, and image processing algorithms are used to identify the color of the object, such as red, green, or blue. This detected color information is then transmitted through Zigbee communication. The ESP32 microcontroller receives the signal and controls the robotic arm accordingly. The robotic arm then follows a predefined path to pick and place the object into the corresponding bin, ensuring efficient and accurate sorting.

In manual mode, the system allows the user to control the robotic arm using Bluetooth communication where this can be used through mobile application. This mode is particularly useful for testing and debugging the our Arm based pick and place robotic system, handling special cases, and demonstrating the robot's arm movement. It provides flexibility and ease of operation during development and working of the arm maintenance. This project integrates several modern technologies to achieve its functionality. The ESP32 microcontroller acts as the central processing unit,

controlling motors and communication modules. Computer vision techniques are used for color detection by analyzing RGB values from the captured images. Zigbee communication enables reliable and low-power wireless data transmission between the laptop and the robotic system. Additionally, a Bluetooth module is included for manual control. The H-bridge motor driver is used to control the direction and speed of the DC motors, while the robotic arm mechanism performs precise pick-and-place operations. The developed system has a wide range of practical applications. It can be used in industrial product sorting and packaging, waste segregation based on color-coded materials, agricultural product grading, and warehouse automation. Furthermore, it serves as an excellent platform for educational and research purposes in the fields of robotics and artificial intelligence. The system can also be extended in the future to detect shapes, sizes, or specific objects using advanced machine learning techniques.

II. LITERATURE REVIEW

To carry out any project work, it is very essential to understand the current scenario and the technology merits and demerits. In this context thorough literature survey has been carried out to formulate and to choose the objectives of the project work. Following are some of its literature that has contributed in the area choose for the study.

1.R. S. Patel, K. Mehta, and J. Shah, "Color Based Object Sorting Robot using Image Processing," presented at the 2022 International Conference on Smart Systems and Inventive Technology (ICSSIT). This paper presents a robotic system capable of sorting objects based on color using image processing techniques. The system uses a camera to capture images and processes them using RGB color5 space to classify objects. The robot arm then picks and places the objects into designated bins. The study highlights the importance of automation in reducing manual labor and improving sorting accuracy. However, the system faces challenges in varying lighting conditions, which can affect color detection accuracy.

2.S. Kumar and P. Singh, "Automated Pick and Place Robotic Arm using Arduino and Computer Vision," presented at the 2021 International Conference on Robotics and Automation (ICRA).

This work focuses on the development of a robotic arm controlled by a microcontroller and integrated with computer vision for object detection. The system uses a camera to identify objects and sends commands to the robotic arm for pick-and-place operations. The study emphasizes the use of low-cost components for building efficient robotic systems. However, the system has limited flexibility and requires predefined object positions for accurate operation.

3.M. Rahman, A. Khan, and T. Ahmed, "Wireless Controlled Robotic Arm for Industrial Automation using Zigbee," presented at the 2023 IEEE International Conference on Communication Systems (ICCS). This paper discusses the implementation of a robotic arm controlled wirelessly using Zigbee communication. The system enables reliable data transmission between a control unit and the robot over long distances with low power consumption. It demonstrates improved efficiency in industrial automation tasks. However, the system does not include vision-based object detection, limiting its ability to perform intelligent sorting operations.

4.P. Verma, N. Gupta, and R. Sharma, "Bluetooth Controlled Robotic Arm for Pick and Place Applications," presented at the 2020 International Conference on Embedded Systems (ICES).

This research focuses on a robotic arm controlled via Bluetooth for manual pick-and-place operations. The system allows users to control the robot using a mobile application, providing flexibility and ease of use. While the system is effective for manual control, it lacks automation and intelligent decision-making capabilities, making it unsuitable for large-scale industrial applications.

5.K. Lee and H. Park, "Vision-Based Color Detection and Sorting System using OpenCV," published in IEEE Transactions on Industrial Electronics, 2022.
This study presents a vision-based system that uses OpenCV for detecting object colors and sorting them accordingly. The system demonstrates high accuracy in controlled environments and showcases the effectiveness of computer vision in automation. However, it requires high computational resources and is sensitive to environmental factors such as lighting and background noise.

This paper highlights the use of ESP32 microcontroller for controlling robotic arms in industrial applications. The ESP32 provides advantages such as built-in Wi-Fi and Bluetooth, making it suitable for wireless communication. The system is efficient and cost-effective but lacks integration with advanced vision systems for intelligent automation.

6.G. Bradski and A. Kaehler, Learning OpenCV: Computer Vision with the OpenCV Library. O'Reilly Media, 2008.. This project provides book is widely used by students, researchers, and engineers who are beginning to work with image processing and vision-based systems. The book provides a comprehensive introduction to computer vision by combining theory with hands-on programming. It explains how digital images are formed, processed, and analyzed, and then demonstrates how to implement these concepts using OpenCV functions in C/C++. The authors focus on making complex vision techniques accessible, guiding readers step-by-step through real-world examples and practical applications. One of the key strengths of this book is its coverage of fundamental computer vision techniques such as image filtering, edge detection, thresholding, color space conversion, and object detection. It also introduces important algorithms used in motion tracking, feature extraction, and pattern recognition.

These concepts are essential for building systems like color detection and object sorting, which are directly relevant to your project

7.Khin Moe Myint, Zaw Min Min Htun, Hla Myo Tun ,"Position Control Method For Pick And Place Robot Arm For Object Sorting System" . International journal of scientific & technology research volume 5, issue 06, June 2016 .which is designed to Vision-based Sorting: Computer vision systems can be used to detect and recognize objects, enabling accurate sorting and handling.Sensor-based Sorting: Sensors, such as proximity sensors and weight sensors, can be used to detect and sort objects based on their properties.

8.Ashly Baby , Chinnu Augustine, Chinnu Thampi , "Pick and Place Robotic Arm Implementation Using Arduino". IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 12, Issue 2 Ver. III (Mar. – Apr. 2017). For cost effectiveness and reducing harm to the objects, we introduced a robotic arm with better wireless communication technology and soft catching gripper. The robot is controlled remotely using android based smart phone or tablets, so there is no need of complex hardwires to operate this system. This increases the easiness of user.

9.Kaustubh Ghadge, Saurabh More, Pravin Gaikwad ,"Robotic Arm for pick and place Application"., International Journal of Mechanical Engineering and Technology (IJMET) Volume 9, Issue 1, January 2018, pp. 125–133.Which focuses on the Kinematics and Dynamics: Researchers have studied the kinematics and dynamics of robotic arms to optimize their design and control for pick and place tasks. Actuation Systems: Various actuation systems, including servo motors, stepper motors, and pneumatic actuators, have been used in robotic arms for pick and place applications.

Control Algorithms: Control algorithms, such as PID, MPC, and fuzzy logic control, have been developed to improve the accuracy and precision of robotic arms.

III. OVERVIEW OF STUDIES

Automation is becoming important in industries such as industries, manufacturing, warehouses, agriculture, and recycling systems. Manual sorting and also object handling require more time and human effort, and may lead to human errors. To solve these problems, robotic systems are used to improve speed, accuracy, and efficiency in industrialand manufacturing ,warehouse applications. The Arm Based Pick and Place and Color Sorting Robotic Vehicle using IoT is developed to automate the process of detecting, picking, placing and sorting objects based on their colors. The system combines robotics, wireless communication, image processing, and embedded technology into a single platform. A camera is used to identify the color of objects, and the robotic arm places them in the correct position automatically. One of the main challenges in such systems is achieving smooth real-time operation. Delays in object detection, communication, or robotic movement can reduce performance. This project uses OpenCV for color detection and the ESP32 for controlling the robotic vehicle and arm movements efficiently. IoT technology also helps in wireless monitoring and control, making the system more flexible and suitable for automation applications.

IV. METHODOLOGY

When the system is powered ON, all the main components such as the ESP32, laptop camera, Zigbee module, and Bluetooth module are initialized and made ready for pick and place operation. After initialization, the system checks the selected operating mode. The robot can work in two different modes which is Automatic Mode and in Manual Mode. Automatic Mode is mainly used for intelligent object detection and sorting, while Manual Mode allows the user to control the robot directly for testing and monitoring purposes. In Automatic Mode, the laptop camera continuously captures images of the objects placed in front of the robotic vehicle. The captured images are processed using python OpenCV to identify the color of the object. The system is programmed to recognize colors such as red, green, and blue. If the object color is detected correctly, the process continues further. If the color is not detected properly, the system waits and captures the image again until successful detection occurs. After detecting the color, the information is transmitted wirelessly to the robotic vehicle through Zigbee communication. The ESP32 controller receives this data and processes the signal to control the robotic arm. The robotic arm then moves towards the detected object, activates the gripper mechanism, and picks up the object carefully. Based on the detected color, the system decides the correct sorting location. For example, red objects are placed in the red bin, green objects in the green bin, and blue objects in the blue bin. After placing the object in the appropriate bin, the robotic arm automatically returns to its initial position, ready to handle the next object.In Manual Mode, the system connects to a user device through Bluetooth communication. The user can manually control the robotic arm and vehicle movements, including picking, placing, and directional movement. This mode is mainly useful for testing, debugging, and monitoring the system performance. The complete process runs continuously in a loop until the power supply is turned OFF.

 ISSN: 3107-6513

The system consists of several integrated components working together to perform automated color-based object sorting. The power supply unit provides the necessary electrical energy to all components such as the ESP32, motor drivers, and LCD display, ensuring stable voltage (typically 5V/12V) for proper operation, as any instability may cause system failure or resets. The ESP32 microcontroller acts as the central controller, receiving color data from the Zigbee module in automatic mode and commands from Bluetooth in manual mode, processing this information, controlling the H-Bridge motor drivers, and updating the LCD display, thereby managing overall decision-making and movement. The Zigbee modules enable wireless communication between the laptop and the robot, where the laptop-side Zigbee transmits detected RGB color data and the robot-side Zigbee receives it, offering low-power and reliable medium-range communication. The laptop equipped with OpenCV serves as the vision system, capturing images through a camera, processing them to detect object colors (red, green, blue), and sending the results to the ESP32, thus replacing costly sensors with an intelligent vision-based approach. Additionally, a Bluetooth module connected to the ESP32 allows manual control of the robot through a mobile device or laptop, which is useful for testing, debugging, and manual pick-and-place operations, providing operational flexibility. The H-Bridge motor driver acts as an interface between the ESP32 and DC motors, enabling control of motor direction and speed, since the microcontroller cannot directly drive motors.

A. Hardware and Software Components:

Component / Software	**Version / Type**	**Purpose**
ESP32	ESP32 Development Board	Main controller used for robotic arm and vehicle control.
Zigbee Module	Transmitter & Receiver	Enables wireless communication between laptop and robot.
Bluetooth Module	HC-05 / HC-06	Used for manual wireless control of the robot.
H-Bridge Motor Driver	L298N Motor Driver	Controls the direction and speed of DC motors.
DC Motors	Geared DC Motors	Provides movement for the robotic vehicle.
Servo Motors	SG90 / MG995	Controls robotic arm movement and gripper actions.
Robotic Arm Structure	Mechanical Arm Setup	Used for pick and place operations.
Laptop with Camera	Webcam Enabled System	Captures object images for color detection.
Power Supply Unit	12V / Battery Supply	Provides power to all hardware components.
Arduino IDE	2.x	Used for programming and uploading code to ESP32.
Embedded C	Programming Language	Used for microcontroller programming and hardware control.
Python	3.x	Used for image processing and communication tasks.
OpenCV	4.x	Used for color detection and image processing.
Zigbee Communication Protocol	Wireless Technology	Transfers color detection data to the robot.
Bluetooth Communication	Wireless Connectivity	Enables manual control and debugging operations.

V. RESULTS AND DISCUSSION

Hardware Implementation:

The hardware implementation consists of assembling all electronic and mechanical components to form a functional robotic system. The ESP32 is connected to Zigbee, Bluetooth, motor drivers, and LCD display. The Zigbee module ensures wireless communication between the laptop and robot, while the Bluetooth module enables manual control. The H-Bridge motor driver controls multiple DC motors used in the robotic arm. The robotic arm is constructed with joints and a gripper mechanism to perform pick-and-place tasks. Proper wiring and power supply connections are ensured for stable operation.

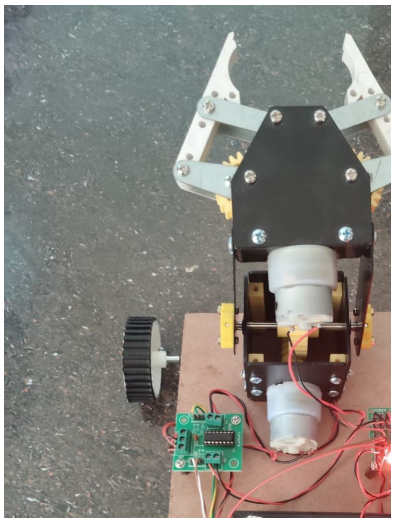


Fig 1: Hardware Implementation

ISSN: **3107-6513**

The software part of the system is divided into two main sections: image processing on the laptop and control logic on the ESP32. OpenCV is used to process camera input and detect object colors. Based on the detected color, a command is generated and transmitted via Zigbee. The ESP32 program receives this data and executes corresponding motor control instructions. The Arduino IDE is used to write and upload code to the ESP32, ensuring smooth communication and control.

Image Processing

The image processing module uses OpenCV to detect colors in real time. The captured image is converted into HSV color space, which is more robust to lighting variations. Color thresholds are defined for Red, Green, and Blue, and masks are created to isolate these colors. Contour detection is then used to identify objects of interest. Once the color is determined, the system sends a corresponding signal (e.g., 'R', 'G', 'B') to the ESP32 via Zigbee communication.

Capture image using camera

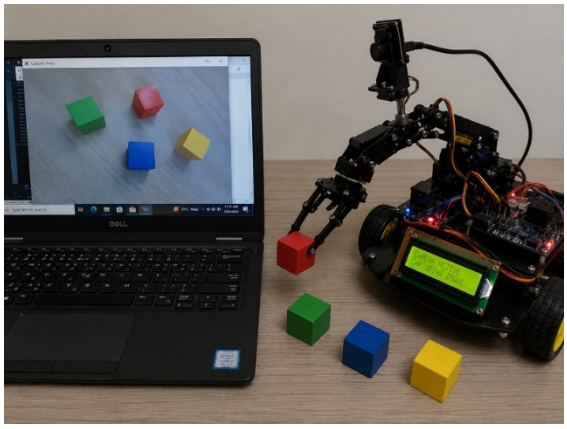
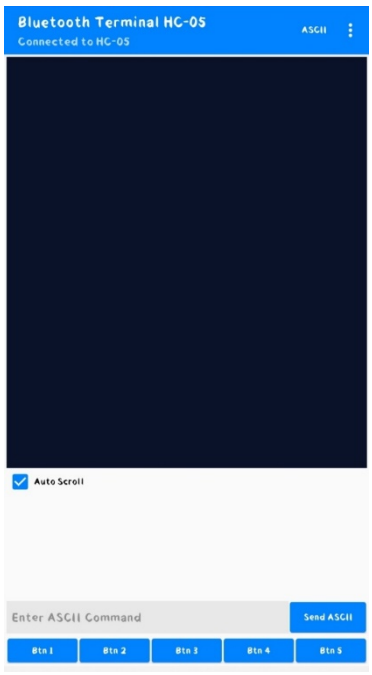


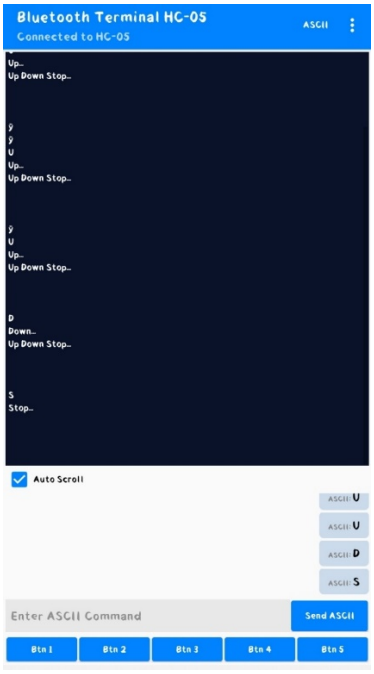
Fig 2: Image Processing

Bluetooth Communication

Used for manual control :

Bluetooth communication is used in the project to provide wireless manual control of the robotic vehicle and robotic arm. A Bluetooth module is connected to the ESP32 microcontroller, allowing communication between the robot and a smartphone or other Bluetooth-enabled device.





The send movement commands process is responsible for controlling the motion of the robotic arm in the proposed color sorting system. After detecting the object color using the laptop camera and OpenCV, the system generates specific movement instructions for the robotic arm. These commands are transmitted wirelessly through Zigbee communication from the laptop to the ESP32 microcontroller.The movement commands include instructions such as moving the robotic arm forward, backward, upward, downward, rotating the arm, opening the gripper, and closing the gripper.

ISSN: **3107-6513**

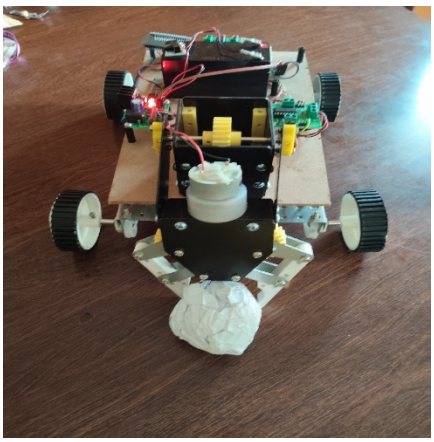


Fig 3: Pick object

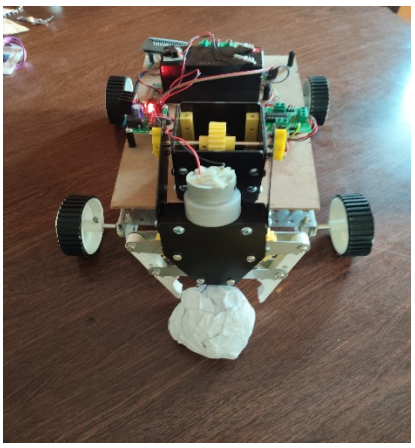


Fig 4: Release object

The pick object operation is one of the most important functions in the color sorting robotic arm project. In this process, the robotic arm identifies the object position and automatically picks it using the gripper mechanism. After the laptop camera detects the object and identifies its color using computer vision, the color information and object location are transmitted wirelessly to the robot through Zigbee communication.The robotic arm then moves towards the detected object with the help of servo motors. The gripper attached at the end of the robotic arm opens and positions itself around the object. Once the object is properly aligned, the gripper closes and firmly holds the object. This process is controlled by the ESP32 microcontroller programmed using Embedded C in the Arduino IDE.The pick object mechanism helps in reducing manual work and increases the accuracy and speed of industrial sorting operations. It is widely useful in automation industries, packaging systems, warehouses, and manufacturing units where objects need to be handled automatically without human intervention.

The release object operation is the final step in the pick and place robotic arm system. After the robotic arm picks the object and moves it to the required location based on its detected color, the gripper releases the object into the specified container or sorting area.Once the ESP32 microcontroller receives the color information from the laptop through Zigbee communication, it controls the servo motors to move the robotic arm to the correct destination. When the robotic arm reaches the target position, the gripper slowly opens to release the object safely and accurately. After releasing the object, the robotic arm returns to its initial position and waits for the next object detection process.This operation is very important in automated color sorting applications because it ensures that objects are placed in the correct location without human involvement. The release mechanism improves the efficiency, speed, and accuracy of industrial automation systems.

VI. CONCLUSION

The implementation of the system highlights the importance of automation in modern industrial applications. By replacing manual sorting with an intelligent robotic solution, the system significantly reduces human effort, minimizes errors, and improves operational efficiency. The use of computer vision enables accurate color detection in real time, making the system more flexible and adaptable compared to traditional sensor-based approaches. Furthermore, the integration of wireless communication ensures seamless data transfer between the vision system and the robotic unit, enhancing system reliability and mobility.

One of the key strengths of this project is its dual-mode operation. The automatic mode allows the system to function independently by detecting colors and performing sorting actions without human intervention. On the other hand, the manual mode using Bluetooth provides flexibility for testing, debugging, and special operations. This combination of automation and manual control makes the system versatile and user-friendly. The use of cost-effective components such as ESP32 and DC motors also ensures that the system remains affordable while maintaining good performance.

During the implementation phase, various challenges were encountered, such as maintaining accurate color detection under different lighting conditions and ensuring smooth coordination between hardware and software components. These challenges were addressed by optimizing image processing techniques and carefully calibrating the system. The successful operation of the robotic arm in performing precise pick-and-place tasks demonstrates the effectiveness of the control system and mechanical design.

VII. REFERENCES

[1]. R. S. Patel, K. Mehta, and J. Shah, "Color Based Object Sorting Robot using Image Processing," in Proceedings of the International Conference on Smart Systems and Inventive Technology (ICSSIT), 2022, pp. 1123–1128.

[2]. S. Kumar and P. Singh, "Automated Pick and Place Robotic Arm using Arduino and Computer Vision," in Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), 2021, pp. 245–250.

[3]. M. Rahman, A. Khan, and T. Ahmed, "Wireless Controlled Robotic Arm for Industrial Automation using Zigbee," in Proceedings of the IEEE International Conference on Communication Systems (ICCS), 2023, pp. 89–94.

[4]. P. Verma, N. Gupta, and R. Sharma, "Bluetooth Controlled Robotic Arm for Pick and Place Applications," in Proceedings of the International Conference on Embedded Systems (ICES), 2020, pp. 134–139.

[5]. K. Lee and H. Park, "Vision-Based Color Detection and Sorting System using OpenCV," IEEE Transactions on Industrial Electronics, vol. 69, no. 4, pp. 3567–3575, 2022.

[6]. A. N. Reddy, V. Prakash, and S. Rao, "ESP32 Based Smart Robotic Arm for Industrial Applications," in Proceedings of the International Conference on IoT and Smart Systems (ICISS), 2023, pp. 210–215.

[7]. G. Bradski and A. Kaehler, Learning OpenCV: Computer Vision with the OpenCV Library. O'Reilly Media, 2008.

[8]. Dr.R.Senthil Kumar, Dr.S.Perumal, Bagavathi T, Karthikeyan M, Ranjith R, Vasanthamohan "Arm Based Pick and Place Robot Vehicle using Iot" International Journal of Advances in Engineering and Management (IJAEM) Volume 6, Issue 04 Apr. 2024, pp: 185-194 www.ijaem.net ISSN: 2395-5252.

[9]. B.O.Omijeh and R.Uhunmwangho. Design Analysis of a Remote Controlled "Pick and Place" Robotic Vehicle ,International Journal of Engineering Research and Development ,Volume 10, Issue 5 (May 2014), PP.57-68.

[10]. Ashly Baby , Chinnu Augustine, Chinnu Thampi, Maria George. "Pick and Place Robotic Arm Implementation Using Arduino" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 12, Issue 2 Ver. III (Mar. – Apr. 2017).

[11]. Momena M. Mohammed, Mohanned M. H. Al-Khafaji, "Smart Robot Vision for a Pick and Place Robotic System", Engineering and Technology Journal 41 (06) (2023).

[12]. Ademola Abdulkareem, O. Ladenegan, A.F. Agbetuyi and C. O. A. Awosope "Design and implementation of a prototype remote-controlled pick and place robot" International Journal of Mechanical Engineering and Technology (IJMET) Volume 10, Issue 02, February 2019,

[13]. Manjula VS and Karamagi, "Automatic Pick and Place Robot Manipulation Using a Microcontroller", Journal of Applied & Computational Mathematics, J Appl Computat Math, an open access journal Volume 7 • Issue 3 • 1000408 ISSN: 2168-9679.