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Robotic Arm Vision Systems: Advances and Applications in Manufacturing Automation

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Abstract

Robotics might be defined more practically as the study, development, and use of robot systems for industry. The first industrial robot was made by George Charles Devol, who is commonly regarded to as the father of robotics. Their absolute precision can range from several mms (±5–10 mm, ±0.5–1.8 mm) due to mechanical tolerances, elasticities, temperature, and other factors. Historically, their position can be altered frequently with a modest repeatability error in the submillimeter range of ±0.3 mm. The goal of the Intelligent Industrial Robotic Arm project is to create, develop, and deploy an advanced robotic arm system that will improve and automate a range of industrial manufacturing processes. This project creates a flexible and effective solution for the contemporary production environment by integrating state-of-the-art technologies including sophisticated robotics, computer vision, and artificial intelligence. The goal of the Intelligent Industrial Robotic Arm project is to further automation in production, which will eventually result in more productivity, better-quality products, and safer working conditions. Intelligent technology integration guarantees scalability and adaptability, which makes it a valuable asset in the dynamic field of industrial automation.

Keywords: Robotics, automation, ESP32, microprocessor, artificial intelligence.

INTRODUCTION

An industrial robot is described as "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes" [1] by the International Standards Organization (ISO).

A more practical definition of robotics would be the study, creation, and application of robot systems for industry. George Charles Devol, who is frequently referred to be the pioneer of robotics, created the first industrial robot [2]. Historically, their position can be changed repeatedly with a small repeatability error in the submillimeter range of ±0.3 mm; however, due to mechanical tolerances, elasticities, temperature, etc., their absolute accuracy can be in the order of several mms (±5–10 mm, ±0.5–1.8 mm) [3-5]. The robot end-effector may experience a considerable offset as a result of these error sources. As a result, measuring the end-effector's position and orientation in Cartesian space is crucial for applications that need to be precise [6]. The flexibility with which articulated robots can move around their surroundings and their capacity to carry out duties without being physically confined to one place make them advantageous to use in the business.

In reality, there is a great need to use mobile robots in hazardous or hard-to-reach places as well as unprepared situations [7]. Robots are frequently controlled in these situations from a safe distance.

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Monitoring systems must be established to maintain track of the motion parameters programmed within mobile robots in order to guarantee an error-free performance. By using input from implanted sensors, which may assist robots in doing complicated tasks by gathering information like the robot location, the performance of mobile robots can be further improved. A thorough review of the principles of inertial and visual sensors was followed by a thorough examination of the sensor systems that can be employed in a particular type of robot (flexible manipulators) in previous research, which highlighted the sensory techniques used for robots [8, 9]. In scientific and instructional contexts, robotic arms are employed. They can be used to teach students programming, engineering, and robotics. They can be used by researchers to create new robotic applications and technologies.Robotic arms can be effectively controlled using the inexpensive, potent ESP32 microprocessor. Because of its integrated Wi-Fi and Bluetooth connectivity, it can talk to other gadgets like PCs and cellphones. Additionally, a significant number of GPIO pins are available for connecting to actuators, sensors, and other devices.Robotic arms' joints are frequently controlled by servo motors. Servo motors turn to a predetermined angle and maintain it there. As a result, the robotic arm's joints can move precisely.The robotic arm can be equipped with color and infrared sensors to sense its surroundings. For instance, a color sensor can be used to determine an object's color, while an infrared sensor can detect an object's existence. The robotic arm can use this feedback to precisely pick and place things, among other duties.The robotic arm has a gripping mechanism that allows it to grasp and release items. It is possible to create gripping devices that can hold a wide range of objects, including spheres, cylinders, and cubes [10–18].

EASE OF USE

The Industrial Robotic Arm's design places a high priority on user-friendliness, making it simple to operate for operators of all skill levels. Users can easily program and modify the robotic arm to meet specific industrial requirements because to its user-friendly programming interface, which makes task customization and control simpler [19, 20]. Operators with little technical experience may operate the system thanks to its intuitive graphical user interface, which simplifies both basic and complicated procedures [21]. The Industrial Robotic Arm enables smooth communication and cooperation between human workers and the robotic system with features including intuitive controls, fast reconfiguration choices, and real-time monitoring feedback. The focus on simplicity and user-centric design of the Industrial Robotic Arm guarantees a seamless integration into current manufacturing workflows, improving productivity and offering a flexible and intuitive solution for automating a range of industrial operations [22].

ESP32 Microcontroller

- The system's brain is the microcontroller. It is in charge of managing every other part, including the LCD display, servo motor, stepper motor, pharmaceutical carousel, RTC module, and LDR sensor. Additionally, in order to notify the patient's caregiver in the event that the medication is not taken, the microcontroller connects with the IoT connectivity module. Specifications has been shown in Table 1. with rating.
- A powerful and versatile microcontroller with built-in Wi-Fi and Bluetooth connectivity.

Table 1. Specifications with rating

S.N.	Specification	Rating
1	Operating Voltage	2.3V–3.6V
2	Frequency	2.4GHz
3	Memory	4 MB
4	Operating current	80 mA

IR Sensor

- 5VDC Operating voltage
- I/O pins are 5V and 3.3V compliant.
- Range: Up to 20 cm

- Adjustable Sensing range
- Built-in Ambient Light Sensor
- 20 mA supply current.
- Mounting hole

Servo Motor

- One well-liked servo motor that works with the ESP32 microcontroller board is the MG996R. It is a high-torque servo motor with a torque output of 9.4 kg/cm at 4.8 V and 11 kg/cm at 6 V [23]. Specifications for good servo motor required has been shown in Table 2.with rating.
- The rapid operating speed of the MG996R servo motor is 0.20 seconds/60° at 4.8 V and 0.16 seconds/60° at 6 V.

Table 2. Specifications with rating requires for well servo motor.

S.N.	Specification	Rating
1	Operating Voltage	4.8V–6V
2	Frequency	50–400 Hz
3	Operating Speed	0.20 sec/60° (4.8V), 0.16 sec/60° (6V)
4	Rotation Angle	180°

Moto Driver

- Since a stepper motor can be used to accurately regulate the position of the pill tray, it is the best choice for this project. This is significant because it guarantees that the right medication is administered at the appropriate time.
- Moreover, stepper motors may be operated with relative ease by utilizing an ESP32 microcontroller board in conjunction with a stepper motor driver. They are therefore a suitable fit for this project, which is meant for novices [24]. Specifications for well moto driver required has been shown in Table 3.with rating.

Table 3. Specifications with rating requires for well moto driver.

S.N.	Specification	Rating
1	Operating Voltage	12V
2	Steps per Revolution	200
3	Holding Torque	3.2 kg-cm (44 oz.-in)
4	Operating current	400 mA

Colour Sensor

- Input voltage: (2.7V to 5.5V)
- Interface: Digital TTL
- High-resolution conversion of light intensity to frequency
- Programmable colour and full-scale output frequency
- No need of ADC (Can be directly connected to the digital pins of the microcontroller)
- Power down feature
- Working temperature: -40°C to 85°C
- Size: 28.4 × 28.4 mm (1.12 × 1.12”)

Switch

- For this project, a momentary push button switch is the best option because it is easy to operate and can be installed in a number of locations. This facilitates the user’s ability to manually administer medication in the event that it is required. • Momentary push button switches are reasonably priced. They are therefore a suitable fit for this project, which is meant for novices. Specifications for well switches required has been shown in Table 4.with rating.

Table 4. Specifications with rating requires for well switches

S.N.	Specification	Rating
1	Operating Voltage	3–6V
2	Switch Type	Momentary Push Button Switch
3	Current Resistance	<100 mΩ
4	Current Rating	10 mA

Battery

- The ideal option for this project is a battery, which enables the medication dispenser to function even when it is not plugged into a power source. This is crucial because it guarantees that the patient will always have access to their prescription drugs, even in the event of a power outage.
- Batteries are simple to replace and reasonably priced. They are therefore a suitable fit for this project, which is meant for novices. Specifications for good batteries required has been shown in Table 5. with rating

Table 5. Specifications with rating requires for good quality batteries.

S.N.	Specification	Rating
1	Operating Voltage	9V
2	Capacity	600 mAh
3	Current	50 mA

Industrial Robotic Arm

This block diagram as shown in Figure 1 illustrates the components we will be using for this project and explains how it works. The block diagram displays a number of the components that are being utilized in this project, including the ESP32, IR Sensor, Color Sensor, Motor Driver, Servo motor, Switch, and others. The circuit is powered by the power source.

Complete Design Concept: Complete Flowchart of the Industrial Robotic Arm working is shown in Figure 2.

LITERATURE REVIEW

1. The robotic arm's brain is the ESP32. It is in charge of interpreting sensor data and directing the servo motors with orders.
2. The robotic arm's movement is managed by the servo motors. They are accurate and have controllable movement at certain angles.
3. The environment's objects are detected by the infrared sensor. It may be used to locate and pick up objects as well as to avoid obstacles.
4. Objects can be recognized by their color thanks to the color sensor. It can be used to pick up particular objects or to sort objects.
5. Objects can be moved and picked up using the grasping mechanism. It could be as basic as a gripper or as sophisticated as a system that can hold many kinds of things.
6. The servo motors' direction and speed are managed by the motor driver. It also guards against damage to the servo motors [25].
7. *Industrial automation:* In factories, repetitive operations like product assembly and palletizing can be carried out by robotic arms [26].
8. *Education:* By utilizing robotic arms in the classroom, students can learn about programming, robotics, and engineering.

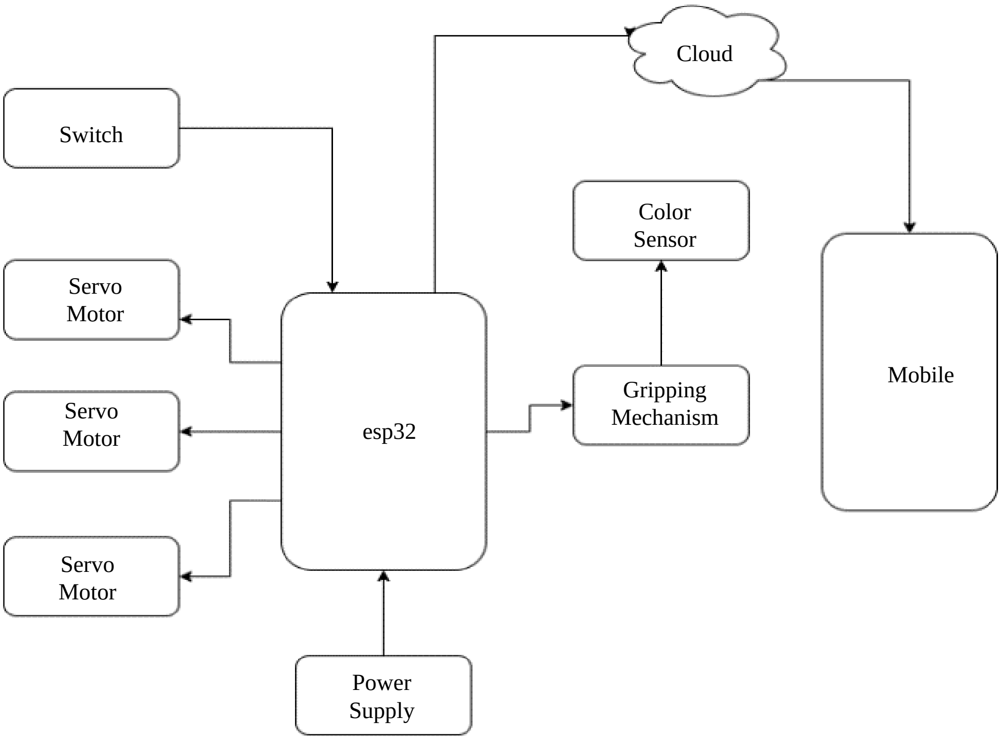

Figure 1. Block diagram of the Industrial Robotic Arm.

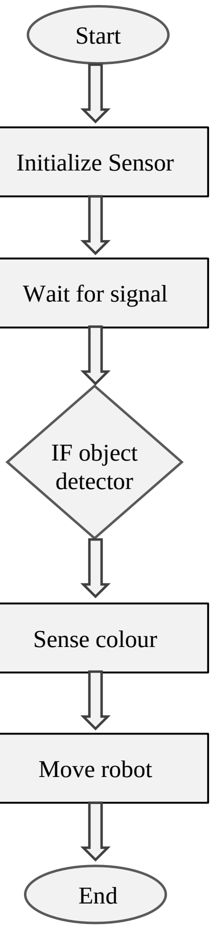

Figure 2. Flowchart of the Industrial Robotic Arm.

9. *Research:* Experiments and the development of new technologies can be carried out in research environments using robotic arms.
10. *Hobbyists:* Those who like constructing and coding robots are another group of people who are fond of robotic arms.

As human requirements grow faster than ever, technology is evolving in the same way today. Every day, life is made easier by the work being done to address these needs; the focus of these studies is robotic arm research. Robot arm operates by following preset commands or in conjunction with an external user. These days, the industrial and medical sectors have the most advanced robotic arm technology. With the help of five servomotors, the robot arm that was designed and implemented for the project can move in four directions. The holder allows you to mix the material it receives with the necessary substance that you can transport from one location to another. Robot control is achieved throughout this process by attaching the Arduino Nano microcontroller Bluetooth module to the Android application.

Advantages

- *Cost-effective:* The construction of this kind of robotic arm is reasonably priced. The parts are reasonably priced and easily obtainable.
- *Versatile:* This kind of robotic arm can be employed for a number of jobs, including assembling, sorting, inspection, and pick and place.
- *Easily expandable:* By adding extra grippers, sensors, and servo motors, this kind of robotic arm may be made larger.
- *Programmable:* A robotic arm of this kind can be made to carry out a wide range of functions. It is therefore perfect for use in research and education.
- Here are a few particular applications for this kind of robotic arm:
- *Pick and place:* In a range of environments, including warehouses, laboratories, and factories, this kind of robotic arm can be used to pick up and position goods.
- *Sorting:* You can use this kind of robotic arm to arrange items according to their size, shape, or color. Applications like product sorting and recycling may benefit from this.
- Ins*pection:* Using this kind of robotic arm, one can look for flaws in objects. Applications like product testing and quality control may benefit from this [27].
- *Assembling:* Products can be assembled with this kind of robotic arm. Applications like manufacturing and packing may find this helpful.
- *Research and education:* This kind of robotic arm is perfect for these endeavors. It can be applied to the development of novel robotic applications as well as robotics education.

All things considered, a robotic arm is a flexible and reasonably priced option for a range of robotic applications.

CONCLUSION

An ESP32-powered robotic arm is a strong and adaptable platform with a wide range of uses. It is a fantastic option for both novices and seasoned enthusiasts because it is reasonably priced and simple to construct. A growing number of sectors, including manufacturing, logistics, retail, healthcare, agriculture, and education, are using this kind of robotic arm. Additionally, it’s being utilized for development and research.

REFERENCES

1. Industrial Robotic Arm” International Research Journal of Engineering and Technology (IRJET) e-
2. ISSN: 2395 -0056 Volume: 04 Issue: 03 | Mar -2017 www.irjet.net p-ISSN: 2395-0072).
3. S. S. Pujari, M. S. Patil, and S. S. Ingleshwar, “Remotely controlled autonomous robot using Android

4. application", 2017 IEEE on I-SMAC (IoT in Social, Mobile, Analytics, and Cloud) (I-SMAC), 2017.
5. M. R. Mishi, R. Bibi, and T. Ahsan, "Multiple motion control systems of the robotic car based on IoT
6. to produce cloud service," 2017 IEEE Electrical, Computer and Communication Engineering
7. (ECCE), 2017.
8. E. Amareswar, G. S. S. K. Goud, K. R. Maheshwari, E. Akhil, S. Aashraya, and
9. T.Naveen,"Multipurpose military service robot," 2017 IEEE,Communication, and Aerospace
10. Technology (ICECA), 2017.
11. R. Nageswara Rao, B.Sridhar, "Iot Based Smart Crop-Field Monitoring And Automation Irrigation
12. System", (ICISC 2018) IEEE Xplore Compliant.
13. Abhilash V, P.K.Mani, "IOT Based Wheeled Robotic Arm" International Journal of Engineering &
14. Technology, (2.24) (2018) 16-19.
15. .yothsnadevi1,K.Chandisivapriya,B.Saikrishnateja,L.Nagajyothi,U.Dushyanthkumar "IOT
16. Controlled Robotic Arm", International. Journal of Scientific & Engineering Research Volume 10,
17. Issue 3, March-2019.
18. Aparna Ajith, Niraj Mohan Nambiar, etc "Saksha-Self Automated Kinematic Smart Haptic Arm"
19. International Conference on Robotics and Smart Manufacturing (RoSMa2018).
20. Standard, I. Manipulating industrial robots–vocabulary (1994).
21. Reinhart, G., Gräser, R.-G., Klingel, R. Qualification of standard industrial robots to cope with sophisticated assembly tasks. CIRP Annals-Manufacturing Technology (1998) 47(1): 1-4.
22. Young, K., Pickin, C.G. Accuracy assessment of the modern industrial robot. Industrial Robot: An International Journal (2000) 27(6): 427-436
23. Pérez, L., et al. Robot guidance using machine vision techniques in industrial environments: a comparative review. Sensors (2016) 16(3): 335.
24. Yuan, J., Yu, S. End-effector position-orientation measurement. IEEE Transactions on Robotics and Automation (1999) 15(3): 592-595.
25. Zhang, L., et al. Tracking mobile robot in indoor wireless sensor networks. Mathematical Problems in Engineering (2014).
26. Corke, P., Lobo, J., Dias, J. An introduction to inertial and visual sensing. The International Journal of Robotics Research (2007) 26(6): 519-535.
27. Kiang, C.T., Spowage, A., Yoong, C.K. Review of control and sensor system of flexible manipulator. Journal of Intelligent & Robotic Systems (2015) 77(1): 187-213.

