*IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)*
*e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 19, Issue 2, Ser. I (Mar. – Apr. 2024), PP 38-43*
*www.iosrjournals.org*

# Monitoring And Controlling 5 Dof Robotic Arm Using Iot

Mr. Premkumar Chauragade [*1], Mr. Yash Chandel [*2], Mr. Pranay Neware[*3], Mr. Gaurav Wankar [*4], Mr. Akash Gawai[*5] Prof. Ashwini Waghale[*6]

[*1,2,3,4]*student, Department Electronics And Telecommunication Engineering, Govindrao Wanjari College Of Engineering And Technology, Nagpur, Maharashtra, India.*
[5]*asst. Prof., Department Electronics And Telecommunication Engineering, Govindrao Wanjari College Of Engineering And Technology, Nagpur, Maharashtra, India.*

***Abstract***
*This research project introduces a 5 Degree of Freedom (DOF) robotic arm designed for pick-and-place tasks, integrating advanced object and shape detection technology to meet the growing demand for precise and efficient automation solutions in the industrial sector. The robotic arm incorporates IoT technology, providing a web-based portal for remote monitoring and control, granting real-time access to crucial data. With meticulous design involving servo motors and sensors, the arm adapts to diverse objects effectively. The implementation of object and shape detection algorithms enhances its capabilities, enabling seamless interaction and efficient management of industrial processes. Overall, this research contributes to enhancing industrial automation by presenting a versatile robotic arm with IoT-enabled functionalities, ensuring improved efficiency and adaptability in various industrial applications.*
***Keywords:*** *Robotic arm, 5 DOF, Internet of Things (IoT), automation.*

---

Date of Submission: 22-03-2024 Date of Acceptance: 02-04-2024

---

## I. Introduction

The industrial landscape is experiencing a profound transformation, driven by rapid advancements in automation technologies. Robotic systems, in particular, are at the forefront of this revolution, offering unparalleled efficiency and precision in a wide range of industrial applications. Among these innovations, the development of a 5 Degree of Freedom (DOF) robotic arm equipped with IoT-enabled monitoring and control capabilities represents a significant stride towards enhancing industrial automation processes.

Unlike traditional robotic systems, this 5 DOF robotic arm is designed to provide tailored solutions for industries seeking adaptable and connected automation solutions. Its versatility and flexibility make it suitable for various applications across sectors such as manufacturing, logistics, and healthcare.

At the heart of this project lies the integration of IoT technology, enabling seamless remote monitoring and control of the robotic arm through a web-based portable application. Leveraging wireless connectivity, the application provides real-time access to critical data and functionalities, thereby enhancing operational efficiency and decision-making processes. The development process encompasses meticulous mechanical design considerations, including the incorporation of servo motors and sensors for precise motion control and feedback mechanisms. Coupled with a sophisticated control system interfaced with a microprocessor, the robotic arm offers an intuitive user experience through a console or web interface.

Furthermore, the robotic arm's adaptability extends beyond traditional industrial settings, enabling it to operate seamlessly in various environments, including human-centered spaces. By collaborating with human operators and sharing workspace, the robotic arm enhances productivity and safety standards, further underscoring its relevance in modern industrial settings.

In the integration of robotics and IoT technologies represents a significant milestone in advancing industrial automation capabilities. This research paper aims to contribute to this paradigm shift by presenting a novel approach to designing and implementing a 5 DOF robotic arm with IoT integration, thereby enhancing operational efficiency and connectivity in industrial processes.

## II. Literature Review

A robotic arm, akin to a human arm in functionality, can be programmed to execute various tasks such as moving objects from one location to another. With the ongoing IoT revolution and increased integration of robots into daily operations, the concept of Internet of Robotics Things (IoRT) is swiftly becoming a reality. (IoRT) enhances robotic systems by facilitating connectivity, exchange, and transmission of distributed computation resources, contextual information, business activities, and environmental data. By connecting the robot to the internet, users can remotely assign tasks, eliminating the necessity for physical presence onsite as the robot can autonomously complete the assigned tasks. Leveraging IoT technology, an HMI interface implemented in a smartphone via wireless Wi-Fi connectivity using an ESP32 microcontroller enhances the capabilities of the robotic system. The aim of the robotic arm project is to develop a cost-effective and reproducible robot that aids in understanding robotics design through project-based learning, encompassing theoretical concepts, practical coding, and prototype fabrication. The Raspberry Pi functions as both the robotic arm's controller and web server. A web server hosted on the Raspberry Pi enables users to control the robot arm remotely by accessing a web page from any computer on the same network. Several studies, including those by Ankur Bhargava and Rahul Gautam, have proposed robotic arm designs for specific applications, showcasing the importance of precise control in tasks such as object manipulation. Vaibhav Pawar et al. further refined the robotic arm's design, incorporating features for analyzing hazardous areas and performing material handling tasks. Additionally, Shuangquan Fu et al. proposed a method for controlling robotic arms using IoT technology, specifically through web-based control systems utilizing MQTT protocol and ESP8266 microcontroller, allowing for platform-independent, real-time manipulator control from remote locations.

**Problem Statement**

In the emerging landscape of smart manufacturing, the integration of IoT technologies with robotic systems has become essential. The goal is to improve the efficiency, adaptability and real-time monitoring capabilities of industrial processes In this context, there is a need to develop an advanced robotic arm system with IoT functionality.

1.The advent of emphasizes the essential role of the Internet of Things (IoT) in the field of robotics, highlighting the importance of control and monitoring facilitated by embedded devices.

2.The insufficient emphasis on resource-constrained nodes, particularly within the realm of robotic arms, impedes the complete realization of IoT's potential in optimizing and advancing robotic applications.

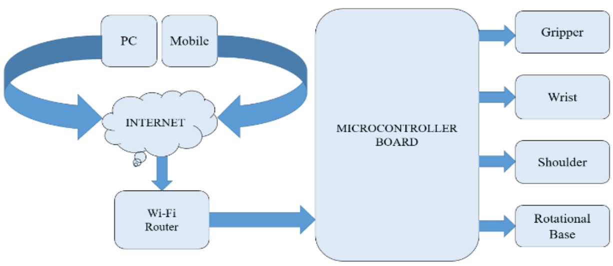
3.The convergence of IoT and robotics has transformed the landscape of automation; however, the exploration of its application in resource-constrained nodes, such as sensor network nodes for robotic arms, remains limited.

**Objectives**

Enhance automation and efficiency across diverse sectors like manufacturing, logistics, and healthcare by enabling precise, rapid, and accurate task execution. Boost safety, cut expenses, and offer operational adaptability. Equip businesses with a versatile and flexible tool to amplify productivity, safety, and efficiency, all while streamlining costs and optimizing operations.

## III. Methodology

The core of the project centers on the robotic arm's ability to manipulate objects between different locations. Control over the arm's movements is achieved through specific commands, utilizing servo motors for precise directional adjustments. A microcontroller facilitates motor control, interpreting commands received via a web page or app interface. Commands are transmitted over the internet to a Wi-Fi module acting as a receiver, which then relays signals to the microcontroller. The microcontroller executes instructions accordingly and provides feedback through an LCD display. Access to control the robotic arm remotely is secured by requiring a login ID and password through the web page or app interface. The arm's movements can be recorded and stored, enabling it to replicate tasks consistently as needed.




The Internet of Things (IoT) encompasses the interlinking of physical devices, vehicles, buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity. This connectivity enables seamless data exchange among these objects. IoT transcends traditional machine-to-machine (M2M) communications, offering advanced connectivity across diverse protocols, domains, and applications. This interconnected network of devices is poised to revolutionize automation across various sectors, fostering innovations such as smart grids and extending to the realms of smart cities. Within the IoT framework, "Things" can denote a wide array of devices, spanning from medical implants and animal biochip transponders to vehicle sensors and tools utilized for environmental monitoring or aiding in search and rescue missions.

Robotic Arms While the Industrial Revolution introduced mechanization and mass production, it was industrial automation that truly revolutionized industries. Multi-degree-of-freedom robotic arms have transformed industrial operations, particularly with the emergence of IoT. These arms enhance efficiency, accuracy, and effectiveness by replacing manual labor. Automation has evolved significantly, impacting the digital landscape and enabling global-scale production. Whether through machinery executing repetitive tasks or intelligent systems analyzing and responding to their environment, automation is crucial for increasing production and achieving optimal outcomes across industries.


## IV. Design And Development

Developing synchronized robotic arms for industrial automation entails addressing numerous aspects to guarantee optimal performance and accuracy. Critical factors taken into account include Payload Capacity, Reach and Workspace, Degrees of Freedom of the arm, Kinematics, Actuators and Drivers, Control Systems, End-effector tooling, Integration, and Safety measures.

A. Dimensions and CAD Design

Utilizing CAD models for 3D printing offers numerous advantages. Firstly, it enables the creation of intricate geometries that may be challenging to achieve through traditional manufacturing methods. CAD software's flexibility empowers designers to explore complex shapes, organic forms, and fine details. Secondly, CAD models allow for customization and personalization, with designs easily adaptable to specific requirements or preferences. This versatility facilitates rapid prototyping, product iteration, and on-demand manufacturing. Additionally, CAD models streamline the design validation process, allowing for virtual simulations and analysis before printing to identify and address potential issues. This approach ensures functionality, performance, and structural integrity optimization.

3D printing using CAD models spans various industries, including aerospace, automotive, healthcare, architecture, consumer products, and more. It caters to diverse needs, from prototyping and functional parts creation to artistic sculptures and architectural models. The combination of 3D printing and CAD Modelling Presents endless opportunities for innovation and creativity.

In additive manufacturing, 3D printing employs a range of materials to build objects layer by layer. Material selection depends on specific object requirements, including application, properties, and functionality. Common materials in 3D printing include thermoplastics like polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS). PLA offers biodegradability, ease of printing, and minimal warping, while ABS boasts strength, durability, and heat resistance. Other popular plastics include polyethylene terephthalate (PETG), polypropylene (PP), and nylon.

Dimensions and CAD Design

3D printing, enabled by CAD models, offers numerous benefits, particularly in its ability to fabricate intricate geometries that may be challenging or impossible with traditional manufacturing methods. CAD software's adaptability empowers designers to explore complex shapes, organic forms, and detailed features. Additionally, personalization, facilitating rapid prototyping, product iteration, and on-demand manufacturing. Furthermore, they streamline the design validation process by enabling virtual simulations and analysis to identify and address potential issues before printing, thereby optimizing functionality, performance, and structural integrity.

The application of 3D printing using CAD models spans various industries, including aerospace, automotive, healthcare, architecture, consumer products, and beyond. Whether creating prototypes, functional parts, artistic sculptures, or architectural models, the combination of 3D printing and CAD modeling presents boundless opportunities for innovation and creativity.

Control System

The control system for the project involves integrating servo motors with microcontrollers, utilizing components such as the Arduino Nano, Servo Driver PCA9685, and Servo Motors (MG90S and MG996r). Multiple such components have been utilized to successfully complete the project.

The protocol employed is the I2C (Inter-Integrated Circuit), offering several advantages in Arduino-based projects. A significant benefit of utilizing the I2C protocol is the simplified wiring requirement of only two wires: a data line (SDA) and a clock line (SCL), reducing complexity and the number of required pins on the Arduino board. This simplicity makes I2C a cost-effective and accessible option, particularly for hobbyists and prototyping.

Additionally, the I2C protocol incorporates an addressing scheme allowing multiple devices to coexist on the same bus. Each device is assigned a unique address, enabling individual communication with specific devices, simplifying the integration and control of multiple peripheral devices in Arduino projects.

Efficient data transfer is another advantage of I2C. It employs a master-slave architecture and a synchronized clock signal for reliable communication, ensuring efficient and error-free data exchange. I2C also supports various data transfer modes, providing flexibility in configuring data rates. Moreover, the I2C protocol is widely supported by peripheral devices such as sensors, displays, and motor controllers, with many manufacturers providing I2C-compatible devices with libraries and documentation, simplifying the integration process and expediting the development of Arduino projects.

Regarding the dashboard development, Python is utilized, divided into two main sections: task creation and management, and data transfer between the control system and the GUI. These tasks are then integrated into the main code to seamlessly merge the complete GUI with the control system.

Dashboard

The project's dashboard is built using Python, divided into two main sections: task creation and management, and data transfer between the control system and the GUI. These sections handle the activities related to creating, managing tasks, and ensuring smooth communication between the control system and the graphical user interface (GUI). These functionalities are then seamlessly integrated into the main code to provide a comprehensive GUI experience.

**Component**

Microprocessors and Raspberry Pi

Two widely used examples of microprocessors and mini computers are the Arduino Uno and the Raspberry Pi 4B. The Arduino Uno is a microcontroller featuring an ATMEGA328 processor capable of reading inputs and generating outputs through its digital and analogue pins. Connected components can be controlled using the Arduino programming language and IDE compiler, making it ideal for rapid prototyping across a variety of projects. Microcontrollers, such as the Arduino Uno, are specialized central processing units designed with fixed hardware to manage analogue and digital functions.

On the other hand, the Raspberry Pi 4B is a compact computer board running Raspberry Pi OS, equipped with multiple USB, Mini HDMI, and LAN ports, as well as Wi-Fi compatibility and GPIO header PINs. In this project, the GPIO PINs are utilized to control the servo motors of the robotic arm, among other features. Python serves as the programming language for implementing functionalities on the Raspberry Pi.

Arduino

Arduino boards are extensively employed across the robotics industry and various computational aspects of robots. Their usage spans from facilitating path planning and safety protocols in autonomous vehicles to enabling vibration analysis through sensors in industrial setups. With a capacity for high performance while conserving power, Arduino boards are integral components in drones utilized by emergency response services. This adaptability has prompted a paradigm shift in technological development approaches. The ATmega 328P microcontroller, frequently integrated into Arduino boards, has gained prominence, particularly in machine learning applications, which significantly influence contemporary robotics. Arduino's emphasis remains on matching the most suitable computing solution with the specific workload requirements.

Servo Motor Controller

A motor controller is a system of electronic components designed to manage the operation of an electric motor according to predefined parameters. Its functions include initiating and halting motor operation, determining the direction of rotation, adjusting speed, restricting torque, and safeguarding against overloads and faults. Depending on their application, motor controllers may feature either manual or automated control mechanisms.

Bluetooth Module

This specific module is designed to function with a 3.3V power source, although it can also accommodate a 5V supply voltage thanks to an onboard 5 to 3.3V regulator. The HC-05 Bluetooth module communicates using a 3.3V level for RX/TX, which is compatible with most microcontrollers without requiring additional voltage shifting. However, it's crucial to ensure proper voltage level matching when transmitting data from the microcontroller to the RX input of the HC-05 module. Capable of data transfer rates up to 1Mbps, the HC-05 module has a range of approximately 10 meters.

Power Supply

In this specific scenario, there are two types of power supply units available: the PS 307 with a 5A capacity and the PS 307 with a 2A capacity. Motor controllers are employed to drive the motors, with a starting current requirement of around 3A and a nominal motor current of approximately 1A. Since the motor controller necessitates a higher power supply, the 5A capacity power unit (PS 307) is connected to the motor controller. Meanwhile, the 2A capacity power unit (also PS 307) is connected to the control units.

Voltage Regulator

To power potentiometers serving as input devices for an analog. signal module, a steady voltage supply is essential. The HB7809 voltage regulator is employed to stabilize this voltage, providing a fixed output voltage of 9V. To establish the voltage range for the analog signal module, adjustments can be tailored according to specific requirements. Presently, the processing range for analog signals has been set to span from 0 to 10V.

**Advantages**

1.Facilitating the lifting and transportation of heavy objects.
2.Enhancing productivity, safety, efficiency, and product quality.
3.Achieving higher levels of accuracy compared to human capabilities.
4.Simplifying monitoring and control processes.

**Appliction**

1.Timely product delivery is crucial for a company's financial success; IoT technology leveraging new sensor data can aid in cost-saving measures, especially in industrial pick-and-place applications.
2.A third arm can securely hold objects while operators perform tasks.
3.Small drills play a significant role in manufacturing processes.
4.IoT applications in the medical field are beneficial for minor surgical procedures.
5. Retrieving suspicious objects without risking human safety is made possible through advanced technology.

## V. Conclusions

The integration of Internet of Things (IoT) technology with robotic arm systems is a promising advancement in automation, spanning industries like manufacturing, healthcare, and agriculture. This approach involves combining sensors, actuators, and communication protocols to enable robotic arms to interact with their environment and perform tasks effectively. Real-time monitoring and control are central to IoT-based arm robots, enhancing operational precision. Predictive maintenance reduces downtime by addressing potential breakdowns before they occur. Remote operability enables collaborative efforts, enhancing flexibility in operations. While still in early stages, this technology shows great potential for future development. Future efforts may focus on improving sensor accuracy, optimizing communication protocols, and discovering new applications. The integration of IoT technology with robotic arm systems offers a promising path for advancing robotics and automation. This synergy can improve efficiency, autonomy, and adaptability in robotic operations, leading to increased productivity and cost savings. Adopting IoT-based arm robots is emphasized as a significant step forward, with opportunities for ongoing exploration and refinement.

**Output**

The utilization of IoT (Internet of Things) technology for monitoring and controlling a 5 Degree of Freedom (DOF) Robotic Arm represents a significant advancement in the realm of automation. This integration intertwines the physical world of robotics with the digital realm, offering a comprehensive solution for efficient and precise management.

At its core, this system enables real-time monitoring of various parameters critical to the operation of the robotic arm. Through sensors strategically placed on the arm, data such as position, velocity, acceleration, and torque can be continuously collected and transmitted to a central IoT platform. This wealth of information provides operators with invaluable insights into the performance and health of the robotic arm, allowing for proactive maintenance and optimization of operations.


Moreover, the IoT connectivity facilitates seamless control of the robotic arm from remote locations. By leveraging cloud-based platforms or dedicated control interfaces, operators can manipulate the arm's movements, adjust parameters, and initiate tasks with unparalleled flexibility and convenience. This capability not only streamlines operations but also enables the integration of the robotic arm into larger IoT ecosystems, facilitating collaboration with other connected devices and systems.

One of the key advantages of monitoring and controlling a 5 DOF robotic arm using IoT lies in its potential for automation and optimization. By implementing advanced algorithms and machine learning techniques, the system can adapt and learn from past performance data, continuously improving efficiency, accuracy, and reliability. This adaptive intelligence empowers the robotic arm to autonomously optimize its movements, adapt to changing environments, and even anticipate maintenance needs, ultimately enhancing overall productivity and reducing downtime.
facilitate compliance reporting and auditing, ensuring adherence to industry regulations and standards.

## VI. Future Scope

Integration of robotic arms with IoT technology holds promise for advancing healthcare, particularly in aiding with minor surgeries. Security applications benefit from the integration of robotic arms, allowing for safe retrieval of objects. Advancements in sensors contribute to improved perception capabilities in robotic arms. AI enables autonomous operation of robotic arms, leading to enhanced workflow efficiency. Collaboration between humans and robots promotes safer work environments. Robotic arms support environmental monitoring and disaster response efforts, capable of navigating challenging terrain. Integration of augmented reality enhances remote operation and training capabilities for robotic arms.

## Acknowledgment

The authors wish to thank the University Grant Malaysia for generously providing Author 1 with a scholarship. Furthermore, appreciation is extended to the University Grant Teknologi, Malaysia for their support via the Research University Grant Scheme, particularly under GUP Vote No. 13H86 and Vote No. 17H42.

## References

[1] M. E. Moran, 2007 Evolution Of Robotic Arms, J. Robot. Surg., Vol 1 Pp 103–111
[2] P. P. Ray 2017 Internet Of Robotic Things: Concept, Technologies, And Challenges, Ieee Acesss Vol 4 P 1–1
[3] Victor H. Benitez, Rodrigo Symonds, David E. Elguezabal, 2020 Design Of An Affordable Iot Open-Source Robot Arm For Online Teaching Of Robotics Courses During The Pandemic Contingency, Hardware X, Elsevier Vol 8 P1 E00158
[4] Ankur Bhargava And Anjani Kumar, 2017 Arduino Controlled Robotic Arm", Ieee Of International Conference Of Electronics, Communication And Aerospace Technology (Iceca).
[5] Rahul Gautam, Ankush Gedam, Ashish Zade And Ajay Mahawadiwar , 2017 Review On Development Of Industrial Robotic Arm, Journal Of Industrial Research & Development Vol 4 P3
[6] Vaibhav Pawar, Sneha Bire, Komal More, Reshma Mule Shubham More, 2018 Review On Design And Development Of Robotic Arm Generation-1, International Journal Of Innovative Science And Research Technology, Vol 3
[7] Shuang Quan Fu And P. Bhavsar, 2019 Robotic Arm Control Based On Internet Of Things, Ieee Of Long Island Systems, Applications And Technology Conference (Lisat).