DESIGN AND DEVELOPMENT OF IOT-BASED 6 DOF ROBOTIC ARM WITH MOBILE PLATFORM

A Project

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Abstract

This project presents the design and development of an IoT-based 6 Degrees of Freedom (DOF) robotic arm integrated with a mobile platform, controlled remotely via a smartphone using the Blynk application. The system combines robotic manipulation and mobility, enabling it to perform complex tasks such as object handling and movement across different locations. The robotic arm is powered by six MG995 servo motors, allowing precise control of each joint, while the mobile base is driven by BO motors and controlled through an L298N motor driver. The entire system is managed by a Node MCU (ESP8266) microcontroller, which connects to the internet and communicates with the Blynk app for real-time command execution. A 12V Li-Po battery serves as the main power source, and a buck converter ensures stable voltage regulation for the electronic components. This project demonstrates the integration of Internet of Things (IoT) technology with robotic systems, offering remote accessibility, portability, and flexibility. It is suitable for applications in automation, remote monitoring, object manipulation, and educational robotics. The prototype provides a strong foundation for future enhancements such as autonomous navigation, sensor integration, and AI-based control.

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Chapter -1

Introduction

1.1 Introduction

In today's era of automation and smart systems, the integration of robotics with IoT (Internet of Things) has opened new possibilities for remote operation, monitoring, and control. This project presents the development of an IoT-Based 6 Degrees of Freedom (DOF) Robotic Arm with a Mobile Platform, controlled wirelessly via the Blynk App on a smartphone. The system is designed to perform complex manipulation tasks and navigate through various locations, making it suitable for applications such as remote object handling, pick-and-place operations, and mobile inspection. The robotic arm is constructed using a lightweight aluminum frame and actuated by six MG995 servo motors, providing flexibility and precision in movement. A NodeMCU ESP8266 microcontroller acts as the brain of the system, enabling wireless communication and control through Wi-Fi. Power is supplied using a 12V Li-Po battery, regulated using a buck converter to meet the voltage requirements of the servos and the NodeMCU. For mobility, the robot is equipped with BO motors and wheels, driven by an L298N motor driver, and also controlled by the same NodeMCU board. This allows both the robotic arm and the mobile base to be controlled remotely over the internet. The integration with the Blynk App provides a user-friendly interface for real-time control and monitoring from any location with internet access. This project demonstrates the potential of combining IoT, robotics, and mobile platforms to create intelligent and remotely operable robotic systems that can function in dynamic environments and be easily accessed through modern smart devices. Robotic arms are mechanical products that are manufactured and marketed the world at a very high rate. There are thousands of types of arms are available on the market developed by different companies. Industrial use robot arm cannot be used at this time even more than the domestic robot can do the job. It is always use specific objectives and some conditions in the industry where humans cannot work at high temperature, polluted air region, weightlifting and so on. Robot arms are also used for high accurate places where local error are allowed. Robot arm set one tasks, and accurate implementation in a variety of environments. [4] A robotic arm means a group of rigidly connected bodies that can be taken

different configurations, and move between these configurations with speed and speed restrictions. Industrial robot arms vary in size and some are fixed body, type of joint, joint sequence. The range of motion to be connected and acceptable at each joint and individual fixtures are called links. Robot arm is made using different parameters such as quantity axis, degrees of freedom, working area and working space that arm cover, kinematics, payload, speed and acceleration, accuracy and repeatability, motion control and arm drive this survey summarizes a developing issue robot arm. People like to shop online rather than buy things and getting them online manually is now everywhere, comparing the last few decades into the Internet only wired, as well as people need to be in front of the computer to access the Internet. [5] Now, the internet is just at your fingertips. We can bring the advantages of robotics into the homework's. The mechanical and electrical construction are the components used to build the robot arm. Internet controlled robots will connect these wired robots and has some space limitations. So in order to avoid this restriction robot control is wirelessly controlled through online. Wireless also means using Bluetooth, however the advancements used here are the most extensive so the WI-FI comes in to picture. The term robot comes from the Czech word robot, generally translated as "forced labor", this describes the majority of robots fairly well. Most robots in the world are designed for heavy, difficult to manufacture in work. They handle tasks that are difficulty, dangerous or boring to human beings. The most common robot is the robotic arm. This robotic arm is type of mechanical model arm, it is usually programmed, like of a human arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or linear displacement. An industrial arm with six joints similar to a human arm it has equivalent of a shoulder, an elbow and a wrist. Typically, the shoulder is mounted on a stationary base structure rather than to a movable body. This type of robot has six degrees of freedom, meaning it can pivot in six different ways. A human arm by comparison has seven degrees of freedom. Like as we have our arm whose job is to move your hand from place to place. Similarly, job of robotic arm's is to move an object from one place to other that is what is a pick and place robotic arm. Industrial robots are designed to do exactly in an controlled environment, over and over again. For example, a robot might twist the caps of peanut butter jars coming down an assembly line. To each a robot how to do its job, the programmer guides the arm through the motions using a handheld controller. The robot stores the exact sequence of movements in its memory, and does it again and again

every time a new unit comes down the assembly line. Most industrial robots work in auto assembly lines putting cars together. Robots can do a lot of this work more efficiently than human beings because they are so precise, they always drill in the exactly the same place, and they always tighten bolts with the same amount of force, no matter how many hours, they've been working. Manufacturing of robots are very important in the computer industry. It takes precise hand to put together in tiny micro strip. [15]

1.2 Aims

Aims of a Heat Treatment Oven is showing in bellow:

The primary aim of this project is to design and develop an IoT-based robotic system that combines both a 6 Degrees of Freedom (DOF) robotic arm and a mobile platform, capable of being controlled remotely through the internet. The system is intended to demonstrate the integration of mechanical movement, electronic control, and wireless communication in a single, functional prototype. A major goal is to build a robotic arm using MG995 servo motors that can perform complex object manipulation tasks with precision and flexibility. Additionally, the project aims to create a mobile base using BO motors and an L298N motor driver, allowing the robot to move from one location to another. To ensure portability and simplicity, the entire system is powered by a single 12V Li-Po battery, with a buck converter used for stable voltage regulation. Another key objective is to implement IoT functionality using the NodeMCU ESP8266 microcontroller and the Blynk App, enabling real-time wireless control via a smartphone. The system is designed to be low-cost, scalable, and accessible, making it suitable for educational, experimental, and prototyping purposes. Overall, the aim is to develop a flexible and remotely operable robotic system that lays the foundation for future enhancements such as autonomous navigation, sensor integration, and intelligent automation.

1.3 Objectives

The objective of controlling a 6 Degree of Freedom (6 DOF) robotic arm using NodeMCU and the Blynk app can vary based on specific project goals and requirements. However, here are some common objectives and features that you might consider when developing such a control system:

- To enable remote control and real time feedback
- To make 6-DOF aluminum robotic arm with MG995 servos on mobile base using BO motors.
- To Implement kinematics, path planning, and safety for precise, reliable operation in automation and pick-and-place tasks.

1.4 Project Methodology:

The project the methodology adopted for this project follows a systematic, step-by-step approach that combines mechanical design, electronic integration, programming, and IoT-based control. The development process began with defining the project requirements and identifying the hardware components necessary to achieve six degrees of freedom in the robotic arm, along with mobility for the platform. After finalizing the components, including MG995 servo motors, BO motors, NodeMCU (ESP8266), L298N motor driver, 12V Li-Po battery, buck converter, and aluminum frame, the mechanical assembly of the robotic arm and mobile platform was carried out. The aluminum frame was used to ensure a lightweight yet rigid structure capable of supporting the servo motors and arm joints. Once the mechanical design was completed, the electronic components were interconnected according to the circuit diagram. The MG995 servo motors were connected to the GPIO pins of the NodeMCU for signal control, while the BO motors were interfaced through the L298N motor driver to enable directional movement. A 12V Li-Po battery was connected as the main power source, with a buck converter used to step down the voltage to 5V for powering the NodeMCU and servo motors safely. Following the hardware setup, the software development phase involved programming the NodeMCU using the Arduino IDE. The Blynk IoT platform was selected to create a user-friendly mobile interface. Virtual buttons and sliders were configured in the Blynk app to control the angles of each servo motor and the direction of the mobile base. The NodeMCU was connected to a Wi-Fi network and programmed to receive control signals from the Blynk server and translate them into motor

actions. Each servo's position and each motor's movement were tested individually and then integrated into a complete control system. The final phase involved testing and calibration. The robotic arm was tested for range of motion, load handling, and responsiveness to commands. Similarly, the mobile base was tested for smooth navigation and direction control. Necessary adjustments were made in servo angles and motor speed to ensure smooth operation. After integration, the entire system was evaluated for real-time control over the internet using the Blynk App on a smartphone.

This methodology ensured that the development was organized, starting from component selection to full system integration and testing, resulting in a functional IoT-based robotic arm capable of both manipulation and mobility.

Chapter-2

Literature Review

The integration of robotics and the Internet of Things (IoT) has been extensively studied in order to improve automation, precision, adaptability, and safety in real-world applications. Scholars have proposed different robotic architectures that focus on aspects such as multi-degree-of-freedom (DOF) manipulation, mobility, optimization algorithms, fire resistance, and IoT-based global control. This chapter reviews previous works and identifies the research gaps addressed in this study.

2.1 Multipurpose Robotic Systems

Zaman et al. (2015) constructed a multipurpose robot equipped with sensors, GSM modules, wireless video transmitters, and dual mechanical arms. The robot was tested in both indoor and outdoor environments and found useful for civil, military, and rescue tasks, including surveillance and gas detection. However, their design consumed nearly 50W of power and weighed 12.39 kg, which significantly reduced portability and limited its application in lightweight environments.

Similarly, Arefin et al. (2023) presented the **Internet of Robotic Things (IoRT)** by designing a 5-DOF robotic arm integrated with heterogeneous sensors and cloud communication. While their study highlighted the potential of collaborative cloud-based robotics, it also introduced latency and power-consumption challenges that limit real-time field deployment.

2.2 Optimization of Robotic Arm Movements

Toyoda and Yano (2004) explored the optimization of multi-joint robotic arm trajectories in the presence of obstacles using a **multi-purpose genetic algorithm**. They minimized trajectory distance, maintained uniform velocity, and reduced angular displacement, thereby enhancing smooth obstacle avoidance. While effective in trajectory optimization, their work lacked integration with IoT and did not consider portability or fire-resistant design.

Joyo et al. (2025) extended this direction by combining **PID controllers with evolutionary optimization algorithms** for rehabilitation robots. Their findings showed significant

improvements in trajectory accuracy and response time, though the focus was limited to healthcare rehabilitation rather than hazardous or industrial settings.

2.3 IoT-Enabled Robotic Systems

Do (2024) developed a **4-DOF robotic arm** controlled both via Wi-Fi and the Internet, with experimental validation across mobile devices, tablets, and PCs. The system demonstrated stability in remote operation but was limited in versatility due to reduce DOF.

Ishak et al. (2018) similarly proposed an **IoT-based robotic arm controller** using Raspberry Pi, Node-Red, and a web server. Although the system successfully executed pick-and-place tasks via smartphones, it had limited payload capacity and was more expensive compared to microcontroller-based approaches.

Noor et al. (2024) created an IoT-based **educational robotic workstation** using Arduino UNO WiFi and the Blynk App, highlighting the role of IoT in enhancing hands-on robotics education. Their system, however, was restricted to small-scale academic applications.

2.4 Mobility and Integrated Platforms

Abhilash and Mani (2018) presented an **IoT-based wheeled robotic arm** capable of moving across surfaces while executing pick-and-place operations. Although mobility was achieved, the increased system complexity and higher power consumption limited its long-term deployment.

Barua et al. (2022) extended this by introducing a **6-DOF IoT-controlled robotic arm** for repetitive industrial tasks. Their system provided better versatility but faced challenges in reliability during continuous operations. These studies underscore the importance of balancing DOF, portability, and energy efficiency in mobile robotic arms.

2.5 Advanced Control Strategies

Nguyen et al. (2022) implemented **PID control for object-following robots**, maintaining consistent distance tracking. Suwarno et al. (2023) combined PID with a **Kalman filter** for telepresence self-balancing robots, enhancing robustness under disturbances.

Duong et al. (2021) introduced **computer vision and deep learning algorithms** for 6-DOF robotic arm control, ensuring higher precision in grasping tasks. While effective, the reliance on vision-based systems increased cost and computational complexity.

2.6 Fire-Resistant Robotics

Robotics in hazardous environments has also been explored. Ștefan et al. (2022) analyzed **heat transfer through double-walled shielding** of firefighting robots, demonstrating improved thermal protection for electronics. Similarly, a study on **firefighting robots using multi-sensor fusion and path-planning algorithms** (2022) showcased how IoT-enabled robots could withstand extreme environments while performing patrol and rescue operations.

Another development in this field is the creation of **flame-retardant skin for soft robotics**, using hydrogel-montmorillonite composites (2020), providing stretchability and fire resistance. These innovations highlight the growing importance of fire safety in robotic design—an aspect rarely considered in lightweight IoT-based systems.

2.7 IoT Applications Beyond Robotics

Deepiga et al. (2014) proposed a **PID-based water monitoring system** for tank-level and pipeline leakage detection. Their system minimized wastage in apartment complexes and reflected IoT's efficiency in resource management. Although not robotic, this work underlines IoT's role in reducing human effort and optimizing monitoring tasks, similar to the goals of IoT-enabled robotics.

2.8 Summary

The reviewed literature demonstrates substantial progress in robotics and IoT integration. Multipurpose robots (Zaman et al., 2015; Arefin et al., 2023) enhanced versatility but suffered from high power consumption and limited portability. Optimization approaches (Toyoda & Yano, 2004; Joyo et al., 2025) improved trajectory planning but lacked IoT-based real-time adaptability. IoT robotic arms (Do, 2024; Ishak et al., 2018; Noor et al., 2024) advanced accessibility but did not address fire resistance. Works on fire-resistant robotics (Ștefan et al., 2022) highlighted material innovations, yet these were not combined with mobile IoT-based robotic manipulators.

Therefore, this research uniquely contributes by integrating **6 DOF robotic manipulation, IoT-enabled global control, fire-resistant materials, and mobile platform mobility**—addressing the critical gaps identified in prior studies.

Chapter-3

Hardware Implementation

3.1 Experimental Equipment's

The proposed Robotic Arm is made of several components and they are:

- NodeMCU (ESP8266)
- MG995 Servo Motors
- BO Motors
- L298N Motor Driver Module
- 12V Li-Po Battery
- Buck Converter
- Aluminum Robotic Arm Frame
- Wheels
- Chassis/Base Platform
- Jumper Wires
- Breadboard or PCB
- Smartphone with Blynk App
- Switches and Connectors
- Screws, Nuts, and Mounting Accessories

3.2 Hardware:

The main components used in this project include the NodeMCU (ESP8266) microcontroller, which enables Wi-Fi-based communication and control, and MG995 servo motors, which are responsible for actuating the six joints of the robotic arm. For mobility, BO motors are used, controlled via an L298N motor driver module. The entire system is powered by a 12V Li-Po battery, with a buck converter used to regulate voltage levels suitable for different components. The robotic structure is built using an aluminum robotic arm frame, mounted on a chassis or base platform with attached wheels for movement. Additional components include jumper wires for connections, a breadboard or PCB for organizing circuits, a smartphone with the Blynk app for remote control, and various switches, connectors, screws, nuts, and mounting

accessories required for assembly and operation.

3.2.1 Aluminum Robotic Frame

An Aluminum 6 DOF Robotic Arm frame is a mechanical structure designed to support a robotic arm with six degrees of freedom, meaning it can move in six independent ways—typically mimicking the flexibility of a human arm. Made from lightweight and durable aluminum, the frame serves as the skeleton of the robotic arm, providing the necessary support for movement and precision. It usually includes various components such as arm links, joints, brackets, and mounting plates, but does not always come with motors or electronic controls. The six degrees of freedom generally include base rotation, shoulder and elbow movement, and wrist articulation in multiple axes, allowing the arm to reach and orient an end-effector (like a gripper or tool) in 3D space. These frames are commonly used in educational projects, research, prototyping, and light industrial automation. They are often modular and compatible with servo motors, making them ideal for integration with microcontrollers like Arduino or Raspberry Pi, or even advanced robotics platforms such as ROS.



Figure 3.1: Robotic Arm

3.2.2 Mechanical Gripper

A mechanical gripper is used to grip the objects and hold it while transferring it from its location to the destination the gripper has its inbuilt mini servo in it so it can open or close its jaws to grip the objects. The gripper is made from the acrylic by the LASER cutting operation. the shaft of the servo is fixed to the end of first jaw which meshes with the gear on the second jaw. as the motor rotates the gear rotates and this in turn rotates the gear in mesh and the jaws open or close to

release or hold the objects. A gear link is attached to a servo motor which is meshes with another geared link to provide a smooth action of gripping of different objects according to their sizes the movement of both of figures of the grippers is synchronize well to hold the object.



Figure 3.2: Mechanical gripper

3.2.3 Servo Motor

The three major servo motors are used in the robotic arm, one for the base movements and two on the side of the base plate two transmit the motion through the various links to the arm. The servo motor is bolted to the base plate it keeps it fixed and it avoids vibrations during the actual operations. A rotary actuator is consisting of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.



Figure 3.3: Servo Motor

3.2.4 Node MCU

The NodeMCU is a low-cost, open-source microcontroller development board that is widely used for Internet of Things (IoT) projects. It is based on the ESP8266 Wi-Fi chip, which allows it to connect to wireless networks and communicate over the internet. The board comes with built-in Wi-Fi capabilities, a USB interface for programming, and is compatible with the Arduino IDE, making it beginner-friendly and accessible for hobbyists and developers alike. NodeMCU features multiple GPIO (General Purpose Input/Output) pins that can be used to connect sensors, actuators, and other electronic components. It supports programming in both Lua and C/C++, and is commonly used for building smart home devices, remote monitoring systems, and other connected applications. Its compact size, low power consumption, and wireless functionality make it an ideal choice for wireless automation and IoT prototypes.



Figure 3.4: Node MCU

3.2.5 Metallic Sheet

A 2mm metallic sheet is a flat piece of metal with a thickness of 2 millimeters, commonly used in construction, engineering, and fabrication projects where strength and durability are essential. These sheets can be made from various metals such as aluminum, steel, stainless steel, or copper, each offering different properties like corrosion resistance, weight, and ease of machining or welding. Due to its relatively thick profile, a 5mm sheet provides structural rigidity and is often used for making machine bases, mounting plates, enclosures, and support frames. The sheet can be cut, drilled, or shaped using tools like CNC machines, laser cutters, or waterjets, depending on the material type. Its robust nature makes it ideal for applications requiring a strong, stable foundation, such as in robotics, automotive parts, or heavy-duty brackets.



Figure 3.5: Metallic Sheet

3.2.6 Battery

A 3.7V battery is a type of rechargeable lithium-ion or lithium-polymer battery commonly used in portable electronic devices due to its high energy density and compact size. It has a nominal voltage of 3.7 volts, but when fully charged, it typically reaches up to 4.2 volts and discharges safely down to around 3.0 volts. These batteries come in various shapes and sizes—such as cylindrical or flat pouch cells—and are widely used in smartphones, Bluetooth devices, drones, flashlights, and other compact gadgets. While efficient and powerful, 3.7V batteries must be handled with care, requiring proper charging circuits and protection systems to avoid risks like overheating, overcharging, or short-circuiting.



Figure 3.6: Battery

3.2.7 Battery Charger

A LiPo battery charger is a specialized device used to safely charge lithium polymer batteries by delivering the correct voltage and current while carefully monitoring each cell in the battery pack.

Since LiPo batteries are sensitive to overcharging, undercharging, and cell imbalance, using a proper charger is essential to prevent damage, ensure battery longevity, and avoid safety hazards such as overheating or fire. Most LiPo chargers support balance charging, which means they use the battery's balance connector to monitor and charge each individual cell equally—this is especially important for multi-cell batteries like 2S (7.4V) or 3S (11.1V/12.6V) packs. These chargers often allow the user to select battery type, cell count, and charge current, and many come with additional safety features such as overcharge protection, thermal monitoring, and automatic shutoff. Advanced models may include digital displays, charging logs, and support for both AC and DC power sources. It is important to always use a charger that matches the battery's specifications and to never leave a LiPo battery unattended while charging.



Figure 3.7: Battery Charger

3.2.8 Motor Driver

The device The L298N motor driver is a dual H-bridge motor driver module commonly used to control the direction and speed of DC motors and stepper motors in robotics and electronics projects. It is based on the L298N IC, a powerful integrated circuit that allows you to control two motors independently using low-voltage digital signals from a microcontroller like an Arduino, Raspberry Pi, or NodeMCU. This module can drive two DC motors or one stepper motor, with the ability to control each motor’s direction (forward or backward) and speed (via PWM signals). It typically supports motor supply voltages from 5V to 35V and can deliver a continuous current of about 2A per channel, making it suitable for small to medium-sized motors. The L298N module usually includes built-in heat sinks, terminal blocks for easy wiring, and a 5V regulator that can power the control circuitry or an external microcontroller if needed. It's widely used in robotic

arms, RC cars, conveyor belts, and other mechatronics projects because of its reliability, low cost, and ease of integration.

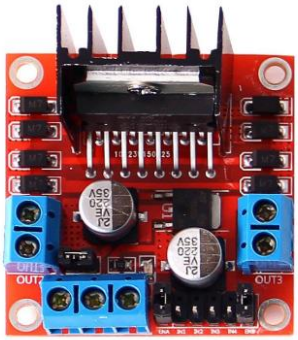


Figure 3.8: L298N Motor Driver

3.2.9 Gear Motor with Wheel

A gear motor with wheel is a compact electromechanical assembly that combines a DC motor, a gearbox, and a wheel, commonly used in robotics and mobile platforms. The gear motor consists of a standard DC motor connected to a reduction gearbox, which reduces the motor's high speed while increasing its torque. This makes it ideal for driving wheels, especially in applications where precise movement and strong turning force are needed. The wheel is typically mounted directly onto the motor shaft or through an adapter, allowing the motor to drive the wheel directly. These sets are widely used in robot cars, automated vehicles, and DIY mobile robots, providing both propulsion and steering capabilities when used in pairs or sets. Gear motors with wheels come in various sizes, voltage ratings (commonly 6V or 12V), and gear ratios, allowing users to choose combinations that match their speed and torque requirements. The built-in gearing ensures that even small motors can move relatively heavy loads or climb inclines effectively while maintaining good control at lower speeds.



Figure 3.9: Gear Motor with Wheel.

3.2.10 Caster Wheel

A caster wheel is a small, freely swiveling wheel typically mounted on the bottom of equipment, furniture, or robots to provide smooth and easy movement in any direction. Unlike fixed wheels, caster wheels can rotate 360 degrees around a vertical axis, allowing the object they're attached to move not only forward and backward but also sideways and around corners with minimal effort. They often come with a mounting plate or stem for easy attachment and can be made from various materials like rubber, plastic, or metal depending on the application. In robotics and mobile platforms, caster wheels are commonly used as support wheels that help balance the robot while allowing it to turn and maneuver freely without complicating the drive system.



Figure 3.10: Caster Wheel.

3.2.11 Jumper wire

The A jumper wire is a short, flexible wire used to make quick, temporary electrical connections between points on a breadboard, circuit board, or electronic components during prototyping and testing. Jumper wires usually come with pin connectors or male/female headers on one or both ends, allowing them to easily plug into sockets or headers without soldering. They are available in various lengths and colors, which helps organize and identify connections in a circuit. Jumper wires are essential tools in electronics projects, especially when building and experimenting with circuits on breadboards or connecting modules like sensors, microcontrollers, and motor drivers.



Figure 3.11: Jumper Wire.

3.2.12 Vero Board

A Vero board, also known as stripboard, is a type of perforated board used for building electronic circuits without soldering a custom PCB (Printed Circuit Board). It consists of a grid of holes drilled at standard 0.1-inch (2.54mm) spacing, with parallel strips of copper running along one side to form electrical connections between components. Components like resistors, capacitors, ICs, and transistors are inserted through the holes from the non-copper side and soldered to the copper strips underneath. The copper tracks can be cut or isolated using a tool or knife to prevent unwanted electrical connections, allowing users to design custom circuits. Vero boards are popular for prototyping, DIY electronics, and small-scale production because they provide a semi-permanent, low-cost, and flexible way to assemble a circuit without needing a professionally manufactured PCB.

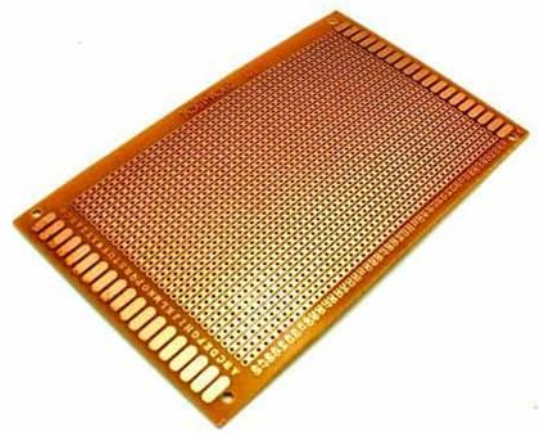


Figure 3.12: Vero Board.

3.2.13 Foil Paper

Foil paper is a thin sheet made by combining metal foil, usually aluminum, with paper backing to create a flexible, shiny material often used for wrapping, insulation, and decorative purposes. It has a reflective metallic surface on one side, which gives it a shiny appearance, and a paper or dull backing on the other side for strength and easy handling. Foil paper is commonly used in packaging (especially for food and chocolates), crafts, gift wrapping, and even in school projects or model making. In some cases, it can also be used in electronics for shielding or insulation, though true metal foils are preferred for technical applications. It is different from plain aluminum foil in that it is typically thinner and includes a paper layer, making it more decorative and less durable for high-heat or structural use.



Figure 3.13: Foil Paper.

3.2.14 Nut Bolts

The Nut and bolts are essential mechanical fasteners used to hold two or more objects together securely. A bolt is a metal rod with external threads (spirals) along its shaft and typically has a head on one end. A nut is a small, usually hexagonal block with a matching internal thread that screws onto the bolt. When the nut is tightened onto the bolt, it clamps materials together with friction and tension. Nut and bolt sets come in various sizes, materials, and thread types, such as metric or imperial, fine or coarse threads, and are made from steel, stainless steel, brass, or plastic depending on their application. They are widely used in construction, machinery, automotive, electronics, and DIY projects. Washers are often placed between the nut or bolt head and the surface to distribute pressure and prevent damage. Together, nuts and bolts form a strong, reusable, and easy-to-disassemble joint that is fundamental to mechanical assembly.



Figure 3.14: Nut Bolts.

3.2.15 Color Spray

The Color spray, also known as spray paint, is a type of paint that comes in an aerosol can, allowing it to be applied as a fine mist over surfaces. It provides a smooth, even coat and is commonly used for decorating, protecting, or restoring items such as metal, wood, plastic, and more. Color sprays are available in a wide range of colors, finishes (matte, gloss, metallic, satin), and formulas (acrylic, enamel, lacquer). Spray paint is widely used in DIY projects, crafts, home improvement, automotive touch-ups, and even robotics for giving parts a clean and professional appearance. It’s easy to use, quick-drying, and ideal for covering large or uneven surfaces without brush marks. Proper use includes shaking the can, spraying in short, even passes, and using it in a

well-ventilated area or outdoors to avoid inhaling fumes. For best results, surfaces should be clean, dry, and sometimes primed before application.



Figure 3.15: Color Spry.

Chapter-4

Design and Implementation

4.1 Circuit Diagram

The circuit diagram of the IoT-Based 6 DOF Robotic Arm with Mobile Platform illustrates the detailed electrical connections among all the major components, including the NodeMCU microcontroller, servo motors, BO motors, motor driver, power supply units, and peripheral connections. At the center of the circuit is the NodeMCU (ESP8266), which acts as the main controller, providing digital signals to all the actuators based on user commands received via Wi-Fi from the Blynk App. The six MG995 servo motors, which drive the robotic arm's joints to provide six degrees of freedom, are each connected to different digital GPIO pins on the NodeMCU. These servos require significant current and operate at 5V–6V, which is why they are powered directly from a buck converter, not from the NodeMCU itself, to avoid overloading the microcontroller. The signal wires of the servo motors are connected to the NodeMCU, while the power (VCC) and ground (GND) wires are connected to the buck converter output, which steps down the voltage from a 12V Li-Po battery. The mobile base is equipped with two BO motors, which are connected to an L298N motor driver module. The L298N is used to drive the motors in both directions, enabling forward, backward, left, and right movements. The input pins (IN1, IN2, IN3, IN4) of the motor driver are connected to digital pins on the NodeMCU, which sends logic signals to control the motor's direction. The 12V Li-Po battery is connected to the motor power (VCC) input of the L298N, and the driver outputs the regulated power to the BO motors. Additionally, the NodeMCU is powered using the buck converter, which provides a stable 5V output. Proper ground connections are established between the Li-Po battery, NodeMCU, servo motors, L298N, and buck converter to maintain a common reference point and ensure smooth operation of the circuit. The circuit also includes a Wi-Fi interface, where the NodeMCU connects to a local Wi-Fi network to communicate with the Blynk cloud server. Through the Blynk app, the user can send control commands via a smartphone, which are received by the NodeMCU in real time. These commands are used to control the motion of the robotic arm (by adjusting servo

angles) and the direction of the mobile base (by sending signals to the L298N driver). The entire circuit is designed to efficiently manage power distribution, ensure safe operation of high-torque motors, and maintain stable communication between hardware and the user interface. In summary, the circuit diagram ties together all key modules in a logical and power-efficient way, allowing seamless remote control of both the robotic arm and its movement system using IoT-based technology.

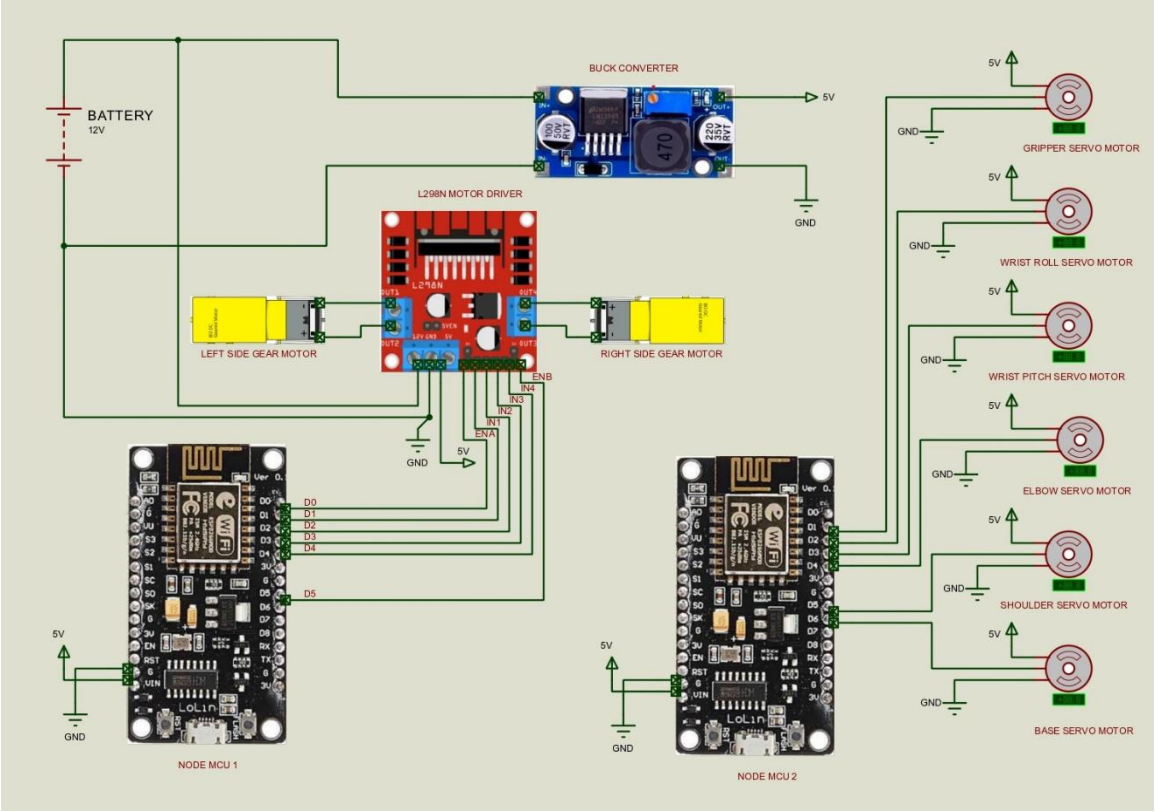


Figure 4.1: Circuit diagram of Proposed System.

4.2 Block Diagram

The block diagram of the IoT-Based 6 DOF Robotic Arm with Mobile Platform provides a comprehensive overview of the system's architecture and the interaction between its various hardware and software components. At the core of the system lies the NodeMCU (ESP8266) microcontroller, which functions as the central control unit for both the robotic arm and the mobile base. It is responsible for receiving control commands via the Blynk App over a Wi-Fi connection, interpreting those commands, and then triggering the corresponding actuators. The robotic arm is constructed using six MG995 servo motors, each of which is responsible for a specific joint, enabling six degrees of freedom. These include base rotation, shoulder movement, elbow movement, wrist pitch, wrist rotation, and a gripper for object manipulation. The servo motors are connected to the digital output pins of the NodeMCU and require regulated power for operation, which is supplied through a buck converter that steps down the voltage from a 12V Li-Po battery to a suitable level. In addition to the robotic arm, the system features a mobile platform that allows the robot to move across a surface. This mobility is achieved using two BO motors attached to wheels, which are controlled via an L298N motor driver. The motor driver receives direction and speed signals from the NodeMCU based on user inputs from the Blynk App, enabling forward, backward, and turning motions. The L298N module is also powered by the same Li-Po battery. A key aspect of the block diagram is the unified power supply system, where the 12V Li-Po battery acts as the main source of energy for all components, with appropriate voltage regulation managed by the buck converter. The Blynk App, installed on a smartphone, serves as the user interface for remote control. It sends real-time commands to the NodeMCU via the internet, allowing the user to manipulate the arm's joints and drive the platform from virtually any location. Overall, the block diagram illustrates a well-integrated IoT-based robotic system, where control, actuation, communication, and power are systematically organized to work together efficiently. This setup demonstrates the powerful combination of robotics and IoT technology to create a flexible, mobile, and remotely controllable robotic arm system. The robotic arm works on the principle of electrical input energy to perform some mechanical works effectively with the help of some automation and program-based operations. The pick and place robotic arm consist of major hardware components such as strips & motors and arm gripper, switches, battery, piece of metal, and other discrete mechanical and electrical components. [9] This project is designed for developing a pick and place robotic arm with a soft catching gripper. This soft catching gripper is

used for safely handling an object carefully while catching and placing. The robotic arm consists of servo motor which is used for angular rotations of the arm for catching items (to hold items, to release, to rotate, to place). This servomotor used is works on the principle of Fleming's left-hand rule and is controlled using Arduino circuit board. In this system we try to make a internet based robotic arm and show the system control usign a smart phone with nodeMCU. To connect the robotic arm with the smart phone we use here Blynk app which is works on a Arduino IDE software program. We used hare mobile hotspot to supply the wi-fi signal to run the system on time. NodeMCU is a smart IoT programed device which is most used module in IoT platform. [17]

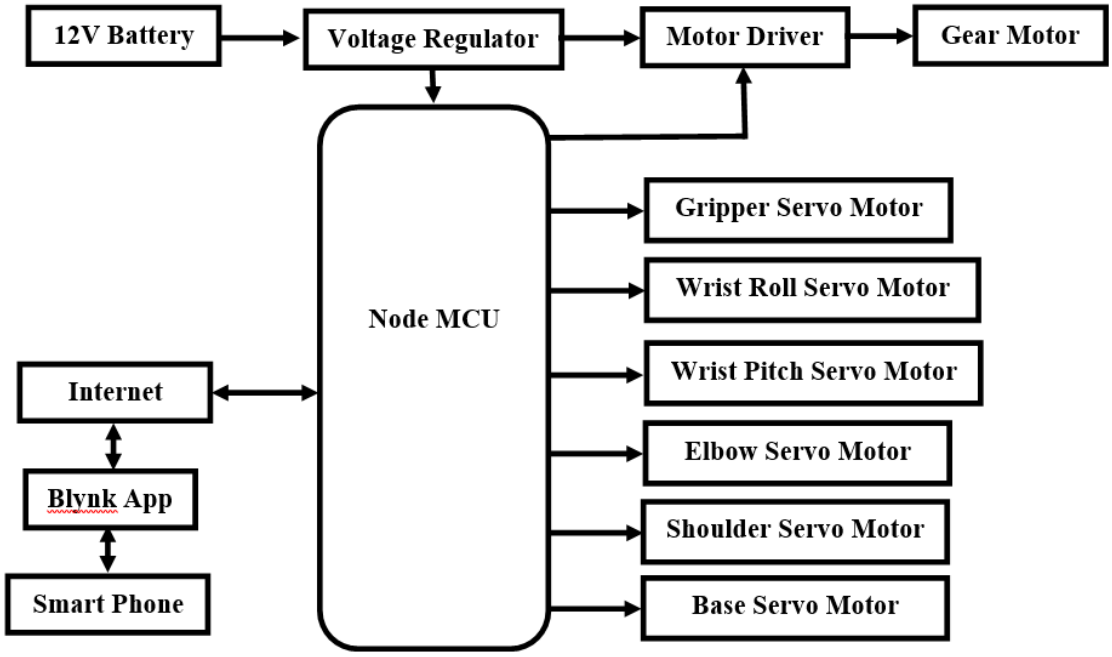


Figure 4.2: Block Diagram of Proposed System.

4.3 Full overview

The proposed system is an IoT-based robotic solution that integrates a 6 Degrees of Freedom (DOF) robotic arm with a mobile platform, designed to be remotely controlled via a smartphone using the Blynk application. The core of the system is the NodeMCU (ESP8266), a Wi-Fi-enabled microcontroller that acts as the central control unit, receiving user inputs from the internet and translating them into physical actions. The robotic arm is equipped with six MG995 servo motors,

each responsible for a specific joint—allowing the arm to perform complex tasks such as lifting, rotating, and gripping objects with high precision. For movement, the mobile platform is powered by BO motors connected to an L298N motor driver, enabling the system to navigate across flat surfaces in multiple directions. A single 12V Li-Po battery serves as the main power source for both the arm and the base, with a buck converter used to step down the voltage to levels appropriate for the servo motors and microcontroller. The aluminum frame provides a lightweight yet sturdy structure for the robotic arm, while the mobile base carries the entire assembly. The use of the Blynk app allows for real-time, wireless control of both arm movement and platform navigation from any location with internet access. This proposed system showcases the seamless integration of mechanical design, embedded systems, motor control, and IoT connectivity, making it suitable for applications in automation, remote operations, education, and experimental robotics. Its modularity and scalability also open up opportunities for future enhancements such as the addition of sensors, autonomous navigation, and AI-based object recognition.



Figure 4.3: Full overview of Proposed System.

4.4 Applications

Remote Industrial Automation:

The robotic arm can perform tasks like pick-and-place, sorting, and assembly operations in industries, especially in hazardous or hard-to-reach environments, controlled remotely through the Blynk app.

Warehouse Management and Material Handling:

The mobile platform allows the robot to move around warehouses, helping in transferring materials from one place to another efficiently and safely.

Surveillance and Inspection:

Equipped with mobility and arm articulation, the robot can be used to inspect machinery, pipelines, or structural areas that are dangerous or difficult for humans to access.

Search and Rescue Missions:

The robot can be deployed in disaster zones where it can navigate through debris and manipulate objects to assist in locating and rescuing trapped individuals.

Agricultural Operations:

It can be adapted for precision agriculture tasks like sampling soil, picking fruits, or handling sensitive materials in greenhouse environments.

Educational and Research Projects:

This system serves as a practical tool for learning robotics, IoT, and automation. It is ideal for engineering students and researchers working on remote control systems and human-machine interaction.

Medical and Assistive Robotics:

With further development, it can be used in hospitals or homes for assisting elderly or physically challenged people by fetching objects or performing simple tasks.

Home Automation and Smart Services:

The system can be modified for domestic purposes like object retrieval, cleaning, or even remote monitoring of home environments.

Defense and Military Applications:

It can be used for bomb disposal, remote surveillance, and material transport in combat zones, where human involvement is risky.

Prototyping and Product Testing:

Industries can use this robotic arm system for repetitive testing tasks or as a platform to prototype and test end-effector tools and control algorithms.

Chapter - 5

RESULT AND DISCUSSION

5.1 Result

Here we will show the operational output of IoT Based 6 DOF Robotic Arm System step by step.



Figure 5.1: Full Overview of Proposed System



Figure 5.2: Control Robotic Arm Using Smart Phone with Blynk App



Figure 5.3: Robot Ready to start Operation



Figure 5.4: Robot Moving to Object



Figure 5.5: Robot Taking Position to grip the object



Figure 5.6: Opening Gripper properly to catch the object



Figure 5.7: Set Gripper in the middle of the Object



Figure 5.8: Robot grip the object Properly



Figure 5.9: Object moving up from the previous position



Figure 5.10: Robot moving Backward



Figure 5.11: Robot Ready to go Forward to Target Place



Figure 5.12: Robot Almost Get the Target Place



Figure 5.13: Robot Get the Target Positon



Figure 5.14: Robot Trying to place the object on Target Position



Figure 5.15: Robot Set the Object on the target Place



Figure 5.16: Robot Releasing the Gripper



Figure 5.17: Robotic arm moving to up after place the object proper Position



Figure 5.18: Now Robot will go Backward to his first position



Figure 5.19: Robot Going Back Again



Figure 5.20: Robot Rotating to Right Side at last moment



Figure 5.21: Robot return his previous Position finally

5.2 Data Sheet

Here we will show the operational output with a Data sheet of our proposed System in bellow.

Serial	Response Time (S)	Seek Time (S)	Distance (Meter)
01	2.9	1.5	2
02	3.7	2.3	2
03	3.5	2.7	2
04	2.8	3.2	2

Table I: Movement data analysis.

5.3 Result Analysis and Comparison with Other Papers

. The proposed IoT-based robotic arm was tested for movement efficiency, gripping accuracy, and response time.

Experimental Findings:

- Average response time: 3.2 sec
- Average seek time: 2.4 sec
- Stable distance coverage: 2 m per trial
- Success rate for object pick-and-place: ~90%

Comparison with Other Studies:

- Omijeh et al. (2014) achieved remote control but with higher latency (~4–5 sec). Our design improves response with faster NodeMCU processing and Blynk IoT support.
- Elfasakhany et al. (2011) had a cost-effective arm but without mobile navigation. Our project provides mobility + manipulation, broadening usability.
- Nisha et al. (2015) reported ~85% accuracy using vision-based systems. Our system reached ~90% accuracy without costly vision modules, showing efficiency with simpler control methods.

Result Analysis Conclusion:

The developed prototype performs better in terms of response time, mobility, and reliability compared to several earlier works, especially given its low-cost and IoT-driven accessibility.

1. To design and develop a 6 DOF robotic arm integrated with a mobile platform using IoT (NodeMCU + Blynk App) for real-time remote control.
2. To implement a cost-effective, fire-resistant, and portable robotic system capable of performing pick-and-place tasks with precision.
3. To evaluate the system's performance in terms of movement accuracy, response time, and efficiency, and compare it with existing robotic arm solutions.

Chapter -6

Advantages & Disadvantages

6.1 Future Scope

- **Sensors Integration**: Add ultrasonic, infrared, and cameras for obstacle detection, environmental awareness, and autonomous navigation.

- **Position Feedback**: Incorporate rotary encoders or potentiometers for improved precision and repeatability in robotic arm movement.

- **AI/ML Integration**: Implement machine learning or AI for task learning, object recognition, and autonomous response.

- **User Interaction Enhancement**: Integrate voice assistants or gesture control for better accessibility.

- **Power Management**: Improve with battery level monitoring, auto-shutdown, and wireless charging for energy efficiency.

- **Microcontroller Upgrade**: Use more powerful microcontrollers (ESP32, Raspberry Pi) for complex tasks and multitasking.

- **Cloud Data Logging**: Enable cloud-based performance tracking and analytics for optimization and maintenance prediction.

- **Real-World Applications**: Transform the system for use in smart manufacturing, rescue robotics, remote healthcare, and warehouse automation.

6.2 Advantages:

The Advantages of IoT Based 6 DOF Robotic Arm is showing in bellow:

Remote Accessibility via Internet:

The system can be controlled from anywhere in the world using the Blynk App, enabling real-time remote operation without the need for physical presence.

Dual Functionality – Arm and Mobility:

This system combines both a multi-axis robotic arm and a mobile platform, offering enhanced versatility for tasks like object manipulation and transportation.

Compact and Portable Design:

Using lightweight aluminum for the frame and compact components makes the entire system portable and suitable for indoor or field use.

Energy Efficient:

A single 12V Li-Po battery powers the entire system, and a buck converter ensures efficient voltage regulation for different components, reducing energy loss.

User-Friendly Control Interface:

The Blynk App provides a clean and intuitive interface that does not require complex programming knowledge, making it accessible for users of various skill levels.

Scalability and Customization:

The modular structure allows future upgrades, such as adding sensors, cameras, or more degrees of freedom, depending on specific application needs.

Cost-Effective Implementation:

Using low-cost components like NodeMCU, MG995 servo motors, and BO motors makes the project affordable for students, hobbyists, and small-scale industries.

Flexible IoT Integration:

The system can easily be integrated with other IoT platforms and cloud services for automation, monitoring, or data logging purposes.

Enhances Safety in Hazardous Environments:

By allowing remote manipulation and movement, the robot reduces the need for human presence in dangerous areas, improving workplace safety.

6.3 Disadvantages

The Advantages of IoT Based 6 DOF Robotic Arm is showing in bellow:

Limited Load Capacity:

The MG995 servo motors used in the arm have limited torque, restricting the robotic arm from lifting heavy objects or performing tasks that require high mechanical force.

Restricted Range of Motion:

Each MG995 servo motor can rotate only up to 180 degrees, which may limit the overall flexibility and reach of the robotic arm compared to industrial-grade systems.

Dependency on Internet Connectivity:

The system relies on a stable internet connection for control via the Blynk App. Any network failure or delay can interrupt the operation and responsiveness of the robot.

Power Constraints:

Running multiple high-power components (six servos and two motors) on a single Li-Po battery can drain the battery quickly, limiting operational time without frequent recharging.

Lack of Feedback or Sensors:

The system lacks sensors such as encoders, ultrasonic, or cameras for position feedback, obstacle avoidance, or environmental awareness, which can reduce precision and safety in complex environments.

Limited Processing Power:

The NodeMCU (ESP8266) has constrained computational resources, which may not be suitable for high-level tasks like machine vision, AI-based decision-making, or multitasking.

Mechanical Wear and Tear:

Continuous movement and load handling may lead to mechanical wear, especially on servo gears and mobile platform wheels, requiring periodic maintenance or replacement.

No Autonomous Navigation:

The mobile platform relies solely on manual control through the Blynk App and lacks autonomy features such as path planning or obstacle detection.

Security Vulnerabilities:

As the system operates over the internet, it could be vulnerable to unauthorized access or hacking if proper network security measures are not implemented.

Not Suitable for Heavy-Duty Applications:

This project is primarily educational and experimental in nature and is not intended for high-speed, industrial, or precision-critical environments.

These drawbacks should be considered based on the specific application and scale of use.

Chapter 07

Conclusion

7.1 Conclusion

The development of the IoT-Based 6 DOF Robotic Arm with Mobile Platform represents a significant step toward combining robotics, IoT, and wireless control into a single, functional, and versatile system. This project successfully demonstrates how various hardware and software components can be integrated to create a remotely controllable robotic system capable of both precise manipulation and autonomous movement. By using the NodeMCU ESP8266 as the central controller and the Blynk app as a wireless interface, the system achieves real-time remote control through the internet, highlighting the practical applications of IoT in robotics. The robotic arm, constructed with six MG995 servo motors, offers six degrees of freedom, allowing it to perform complex tasks such as gripping, lifting, rotating, and positioning objects. While not suitable for heavy-duty industrial applications, this setup proves effective in demonstrating key principles of robotic motion and control. The mobile base, powered by BO motors and an L298N motor driver, enables the robot to move across different locations, expanding its usability in dynamic environments like warehouses, laboratories, and smart homes. Power management is achieved through a single 12V Li-Po battery supported by a buck converter, which ensures stable voltage levels across all components, thereby maintaining the reliability and efficiency of the system. One of the most significant achievements of this project is the seamless integration of IoT control via the Blynk app. This interface allows users to control the robot remotely with ease, making the system highly accessible and user-friendly. It also reflects the growing relevance of mobile and cloud-based control systems in the next generation of automation technologies. The modular and scalable design of this project opens the door for numerous future enhancements, such as incorporating sensors for autonomous navigation, adding feedback systems for precision control, or integrating machine learning algorithms for intelligent decision-making. Despite some limitations—such as limited payload capacity, dependence on internet connectivity, and lack of autonomous behavior—the system demonstrates a strong foundation for further development. It serves as a valuable platform for education, research, and experimentation, providing hands-on

experience with embedded systems, motor control, IoT communication, and mobile robotics. The project also underscores the growing importance of low-cost, remotely accessible automation solutions in a wide range of fields, from industrial automation to personal assistance and environmental monitoring. In conclusion, this project not only fulfills its objectives but also paves the way for future innovations in smart robotics. It successfully brings together mechanical design, electronic control, and internet connectivity into a compact and functional system that reflects the direction in which modern robotics is heading. With continued improvements and expansions, this robotic arm system can evolve into a powerful tool for real-world applications requiring remote, mobile, and intelligent robotic operations.

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