Implementation of a Human Hand Gesture Controlled Robotic Arm

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ABSTRACT - This project aims to develop a robotic arm controlled by human hand gestures using remote sensing technology and server-based communication. The system consists of a transmitter module that detects hand gestures, which are processed using IoT technology on a server. The server then transmits the interpreted motion data to the receiver module, where an Arduino Mega is responsible for controlling the robotic arm. The robotic arm is a 6- axis system equipped with servo motors that respond to the received gesture commands in real time, ensuring precise and smooth movement. By utilizing remote sensing, this system effectively captures hand movements and translates them into robotic actions, allowing for intuitive and seamless control. The server-based communication facilitates efficient data transfer between the hand gesture detection module and the robotic arm, making the system reliable and scalable for various applications. This prototype highlights the potential of integrating IoT and robotics for gesture-based control systems, which can be applied in industries such as healthcare, manufacturing, and assistive technology. The use of Arduino Mega for processing and controlling the robotic arm ensures flexibility and ease of programming, while the IoT-based server enhances connectivity and remote operation capabilities. With further improvements, this technology can be extended for advanced robotic automation, prosthetics, and remote-controlled machinery. The project effectively demonstrates thesynergy between remote sensing, IoT, and robotic systems, paving the way for future innovations in human- machine interaction.

Keywords: Arduino Uno, Arduino Mega, Server, Robotic Arm, IoT.

I.INTRODUCTION

A robotic arm is a technology that can be programmed in a way that it works like a human hand by performing tasks rapidly and accurately. [1] From basic picking and dropping activities to more intricate ones like welding, packing, and even assembling products, robotic arms can carry out a variety of tasks. [2] Robotic arms are used extensively in different industries like research, healthcare, medicine, industrial automation, and even entertainment. [3] Earlier, the use of robotic arms was restricted to a specific range of activities because the operations could only be performed on-site PCs or manual input systems. [4] However, robotic arms can now be used with servers that automate the movement of the robotic arm based on specified commands. [5] Sending these commands through a network on web applications, mobile devices or even IoT devices enables remote control and automation. [6] WIFI allows remote monitoring and operation which increases productivity, accuracy, and safety of robotic arms.[7] The fact that helps us understand this better overshadows the important rest: thanks to this invention, modern automated warehouses, smart manufacturing, and even robotic surgeries are possible, and, as such, this invention is as important as the rest of advanced technology. [8] Robotic salts simplify the conduction of many industrial operations. [9] Multi-purpose robotic arms can be used in different types of industries because they are able to perform simple tasks such as picking and placing items, as well as more sophisticated operations like assembling, welding, or even mechanical packing. [10]

II. LITERATURE SURVEY

Yang et al. (2019) performed a study on a cloud-based robotic control systems and their benefits in remote controlling, multi-robot systems, and industrial automation. This research showed that cloud computing offers greater flexible and scalable control while minimizing reliance on human power [1].Li and Wang (2018) studied a number of low- latency communication protocols, such as MQTT and Web Sockets, arguing their usefulness in realization of instructions to a robotic system in real time. These protocols permit efficient virtual command execution and minimal lag in industrial settings [2]. Zhang et al. (2020) developed a sensor based feedback system, that can analyze the real- time data from only robotic joints & actuators on central server in order to increase the accuracy of movement at robotic platform. Error correction and automatic motion planning [3] error minimization feedback loop help. Gao et al (2016) prediction analytics on robotic arms AI and Machine Learning tasks completion rate increase fault detection self-learning industrial automation [4].Singh et al (2022), in server controlled robotic systems 5G, it was found that With high speed and low-latency communication, real-time control can be accelerated drastically, thus minimizing the operation iteration time for complex tasks up to orders of magnitude compared with traditional down-streams [5].Chen et al.(2023) Edge- Computing in the Robotics Control Systems, decrease the dependency of factory peripheral devices on clouds servers and gain of agility with bettered wide-area energy in industrial automation [6] In 2023, Patel and team checked out using blockchain with robots [7]. The idea is to let robots make choices and share info more safely and automatically. This helps robots keep their actions secure, which is useful for stuff like military surveillance and managing money [8]. Kim et al. (2023) looked into using digital twins to control robot arms. It's like having a virtual copy of the robot working with the real one. You can test things out, spot problems early, and repair things before they break, which is helpful for aerospace, cars, and factories [9].Huang et al. (2023) checked out how brain-like computing can control robots. This helps robots make fast choices while saving power. It's helpful for robots that drive themselves and learn as they go [10].

III.METHODOLOGY

This robotic arm uses WIFI so you can boss it around from far away. [1]When you send a command, it goes straight to the Arduino uno think of it as the arm's little brain. [2]The Arduino then tells the servo motors what to do via PWM signals. This makes the arm move nice and smooth. [3]The arm can do simple jobs lifting, lowering, grabbing, and releasing stuff.[4] Tell it to go up, and the Arduino gets the motors to raise it. Down, and it lowers.[5] Pick makes the gripper grab, and place lets go of whatever it’s holding. [6]An LCD screen shows you what’s going on so you can watch. [7] This setup makes automation easier, cutting down on manual work and being more exact.[8] Because it uses WIFI, you can control it from any spot.[9] This makes it super handy for factory automation, warehouse jobs, and handling hazardous stuff.[10]The servo motors make sure everything moves just right.[11]This robotic arm uses WIFI so you can boss it around from far away. [12]When you send a command, it goes straight to the Arduino uno think of it as the arm's little brain.[13] The Arduino then tells the servo motors what to do via PWM signals. [14]This makes the arm move nice and smooth. The arm can do simple jobs lifting, lowering, grabbing, and releasing stuff. [15]Tell it to go up, and the Arduino gets the motors to raise it. Down, and it lowers.[16] Pick makes the gripper grab, and place lets go of whatever it's holding. An LCD screen shows you what's going on so you can watch. [17]

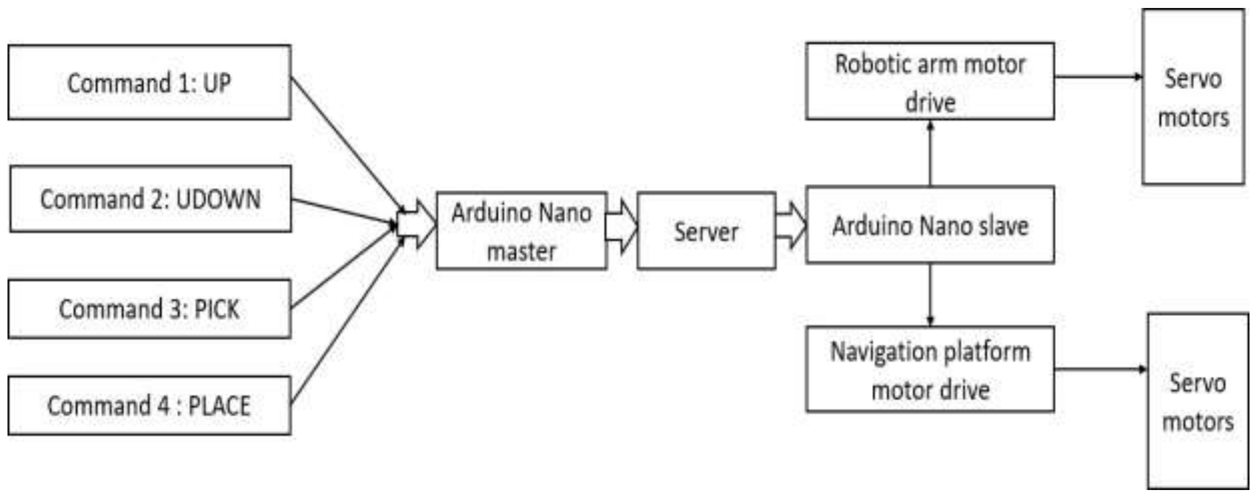

Figure 1:Proposed Model

ARDUINO UNO:

The Arduino Uno is a versatile microcontroller board based on the ATmega328P chip. This board is widely used in most embedded systems, robotics, and automation because of its ease of use, robustness, and compatibility with various sensors and modules. The robotic arm is regulated by Arduino Uno, the central processing unit, to synchronize communication between power supply, Wi-Fi module, LCD display, and servo motors. The power supply provides power to the Arduino and other peripherals connected. The commands were transmitted by the server through the Wi-Fi module, which are then translated into signals for the robotic arm with the help of Arduino. So, the Arduino can operate properly, reading the inputs and making the right movements of the robotic arm according to the commands provided.

Figure 2 : Arduino

WIFI MODULE :

In this project, the WIFI Module enables a remote control through acting as a communication interface between the user and the Arduino Uno. The module is connected to the network and remains idle for control commands from an server, mobile application, or web interface.

Figure 3 : Wifi Module

The user can insert control commands that involve moving the arm up and down and picking and placing an object. The data, upon receiving by the WIFI module, is transmitted to Arduino using serial communication (UART). The WIFI enabled module provides remote control of the robotic arm so that it increases convenience and utilization of the robotic arm in automation applications. The Arduino interprets the control commands sent from the WIFI module. It then sends the correct Pulse Width Modulation (PWM) drive signals to the servo motors in order for the robotic arm to make accurate moves, doing all the tasks involved. The Arduino would, on its part, update the LCD providing real-time feedback of executed commands for proper monitoring and controlling of the automatic system.

LCD (Liquid Crystal Display) :

In this project, the robotic arm's operations and status are monitored at real time using an LCD that is connected to the Arduino Uno. The LCD receives information to be displayed from the Arduino Uno based on the commands and actions that are executed. When a command is sent via the Wi-Fi module to control the robotic arm— whether it's lifting, lowering, picking, or placing an object—the Arduino will carry out the command and update the LCD with relevant messages such as "Arm Moving Up," "Object Picked," or "Task Completed." These notifications assist users in monitoring the actions being performed by the system. The LCD uses digital communication protocols through either direct pins or an I2C module for easier wiring. With the ability to display pertinent information, the LCD further encourages interaction while ensuring that the robotic arm is operating effectively and efficiently.

Figure 4: LCD display

SERVO MOTORS :

The robotic arm is shifted by the servo motors, while this movement is controlled from the Arduino Uno in PWM format to determine the positioning of every servo. Each servo corresponds to an action-a case of lifting, rotation, gripping, or putting something down. The Arduino translates WIFI commands received and sends out a control signal that determines the angles for every one of the servos. Once a command to grasp an object is executed, coordinated movements for the arm joints and the gripper move in to reach, grasp, and lift the object. For smooth and accurate performance of automation work, fine control over the servo motors offers the right mechanism to execute this work.

Figure 5: Servo Motor

POWER SUPPLY :

A proper power supply is critical as the voltage and current necessary for every unit, such as an Arduino Uno, WiFi module, LCD display, and servo motors, must be provided. A step-down transformer eases the high voltage AC electricity from the primary power source into low voltage AC electricity. This form of AC electricity is then transformed into a direct current with a bridge rectifier. Afterwards a voltage regulator is used to bring the voltage to a desired level. The power supplied for the Arduino Uno is a regulated 7-12V DC which allows it to later distribute 5V and 3.3V to the other components. A user friendly operating experience is given as power for the servo motors, which require higher current, is supplied separately through a dedicated power source. The robotic arm's performance can be affected by constant fluctuation but an inherent power supply design has been implemented which guarantees reliable and consistent performance from the robotic arm.

Figure 6 : Transformer

IV . IMPLEMENTATION :

Once the robotic arm is put together, it's made of sections linked by motors that let it move accurately in lots of ways. It even has parts that work like a human arm – a shoulder, elbow, and wrist – so it can move smoothly. There's a gripper (or claw) at the end that can grab stuff. The whole thing runs on a transformer and is managed by a microcontroller (like an Arduino Uno). This microcontroller takes commands sent by WiFi or some other connection. Wires keep everything hooked up right for power and data. You might even see an LCD screen showing what's going on. This robotic arm is built to do automated jobs, and it's great for factories, labs, or dangerous places.

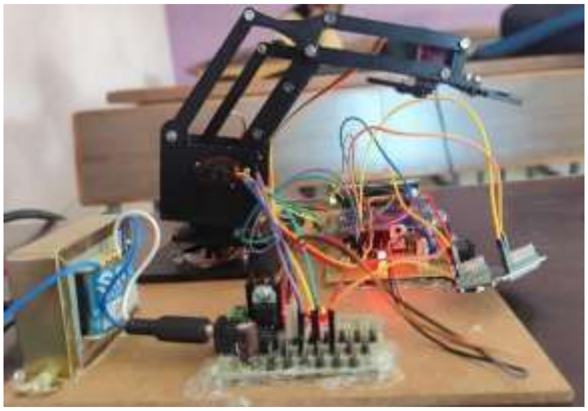

Figure 7 : Robotic arm after assembling.

WORKING PRINICIPLE :

This robotic arm uses WiFi. The Arduino gets commands through WiFi and tells the motors what to do. It can move stuff up and down, pick things up, and drop them off pretty well.

Command 1 – Move Up :

- When the Arduino gets Command 1 over WiFi, it turns on the motors to lift the arm up.
- The arm goes up nice and smooth because the motors are controlled by PWM (Pulse Width Modulation).
- This puts the arm in the right spot to grab or drop something.

Command 2 – Move Down :

- When Command 2 is sent, the Arduino tells the motors to spin the other way, which lowers the arm.
- The arm lowers carefully so it can drop things where they need to go or reach down to grab.
- The LCD screen tells you what's going on.

Command 3 – Pick (Grab Something) :

- When Command 3 is sent, the gripper at the end of the arm closes.
- It grabs the item just right, tight enough to hold it but not so tight that it breaks it.
- The arm stays still, so the object doesn't fall.
- The LCD shows Pick and tells you if the gripper is working.

Command 4 – Place (Let Go) :

- When Command 4 is sent, the Arduino tells the motor that controls the gripper to open up.
- The object is dropped gently in the right spot.
- The LCD says that the object was dropped safely.

- After letting go, the arm goes back to where it started, ready for the next job.

V .RESULT & CONCLUSION :

Commands sent over WiFi control servo motors that power the robotic arm controlled by an Arduino Uno. The transformer maintains power, whilst the LCD screen displays the updates. The system has successfully been integrated into robotic automation for remote control.

The below figures shows the output :

Command 1 – Move Up :

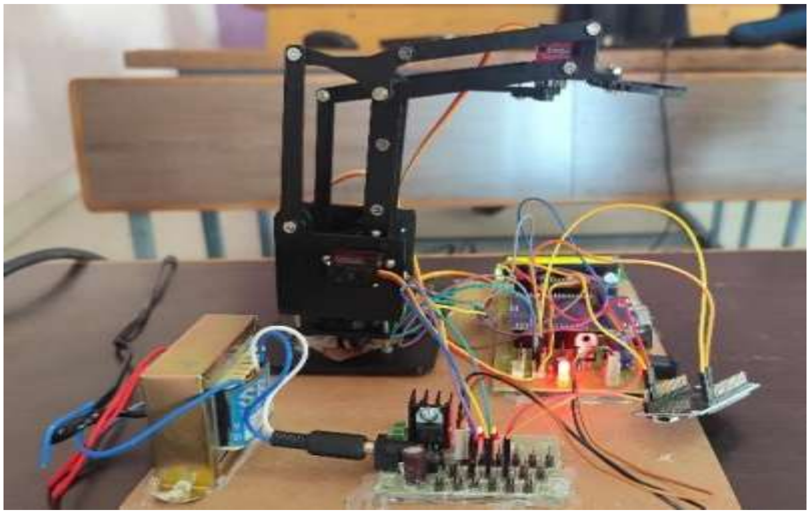

Figure 8 : robotic arm moves up for Command 1

Command 2 – Move Down :

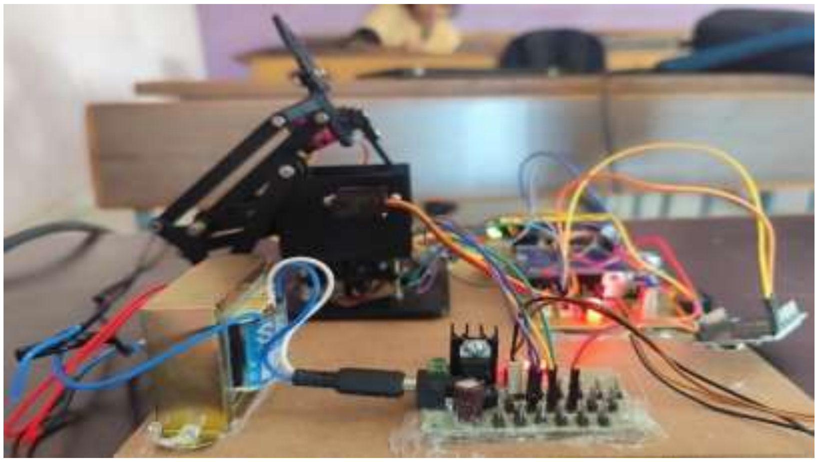

Figure 9 : robotic arm moves down for Command 2

Command 3 – Pick (Grab Something) :

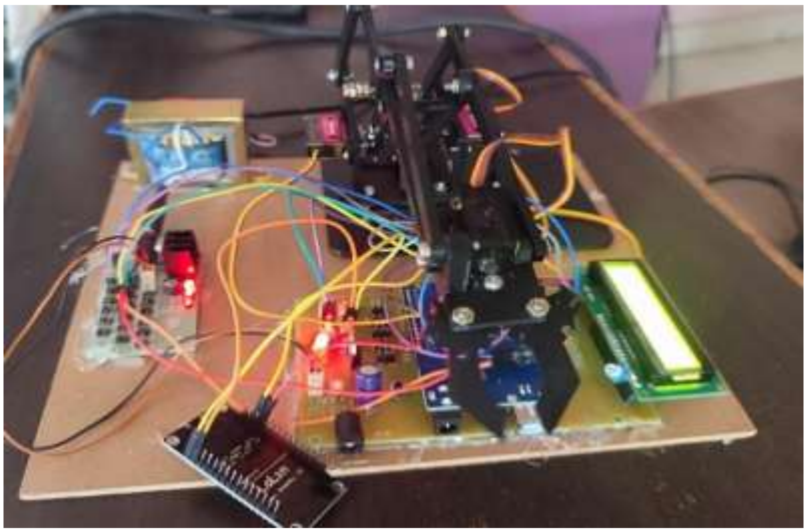

Figure 10 : robotic arm picks an object for Command 3

Command 4 – Place (Let Go) :

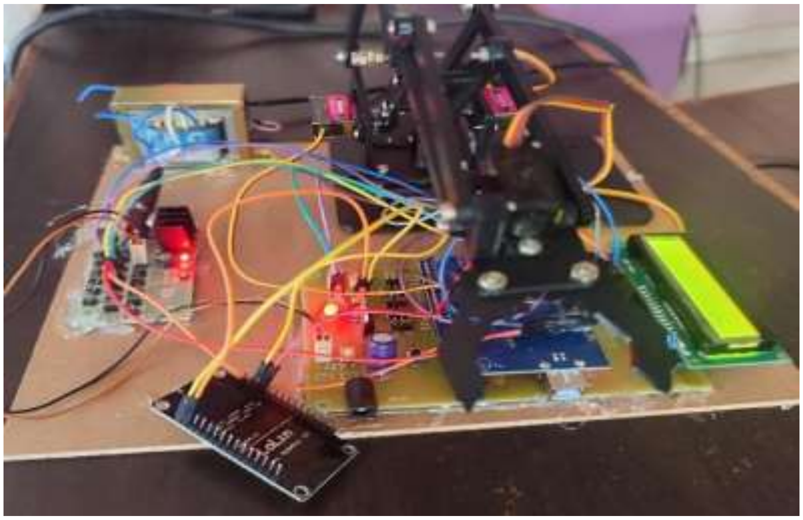

Figure 11 : robotic arm places an object for Command 4

VI . REFERENCES :

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These references provide the necessary background for the implementation and working of the robotic arm using Arduino and Wi-Fi-based control