

Review on Hand Gesture Controlled Robotic Arm

Sangam Joshi¹, Dattaram Bhagat², Vaibhav Shetye³, Gauresh Tandel⁴, Heenali Korgaonkar⁵

^{1,2,3} Student, Electronic and telecommunication, Metropolitan institute of technology and management

Asst. Professor, Electronic and telecommunication, Metropolitan institute of technology and management

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ABSTRACT

Hand gesture-Based robotic control provides an intuitive and efficient method for human -machine interaction. This paper present the design and development of a robotic arm controlled using hand gesture captured through an accelerometer senser. The sensed hand movement are processed by a microcontroller to generate appropriate control signals for stepper motors used in the robotic arm. The proposed system eliminates conventional control device such as joysticks and switches, making the operation more natural and user-friendly. Experiment analysis demonstrates that the robotic arm responds accurately with minimal delay, making the system suitable for industrial automation, medical assistance, and hazardous environments applications.

Keywords— Robotic Arm, Hand Gesture Control, Accelerometer, Arduino, stepper motor, Human -Machine interface

1. INTRODUCTION

Robotics plays a vital role in automation and modern industrial systems. A robotic arm is a mechanical device designed to perform tasks similar to a human arm. Traditional robotic systems are generally controlled through joysticks, switches, or programmed instructions. However, gesture-based control provides a more natural and user-friendly approach for operating robotic systems. The Hand Gesture Controlled Robotic Arm is designed to follow the movement of a human hand using motion sensors. This system eliminates the need for physical contact or complex programming for basic movements. It enhances flexibility and accuracy in performing repetitive and risky tasks.

1.1 Existing system

Existing robotic arms are mostly controlled using wired systems, remote controls, or computer-based interfaces. These systems require skilled operation and are less intuitive. They also involve higher cost and complex hardware setups.

1.2 Proposed system

The proposed system uses a motion sensor attached to a glove to detect hand gestures. The sensor data is transmitted wirelessly to the robotic arm. The robotic arm then mimics the exact movement of the hand using stepper motors. This system is simple, cost- effective, and efficient.

2. SYSTEM DESIGN

A hand gesture controlled robotic arm is an intelligent system that enables the user to control the movement of a robotic arm using natural hand motions. The system is designed to eliminate the need for physical controllers, making operation more intuitive and user-friendly. The overall system consists of three main sections: input unit, processing unit, and output unit. The input unit typically includes sensors such as accelerometers, sensors mounted on a glove to detect hand movements and finger bending. These sensors convert physical gestures into electrical signals.

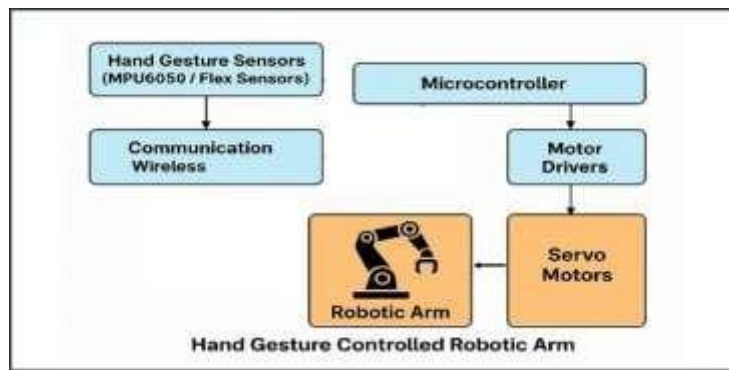


Fig 1 Block Diagram of Hand Gesture Controlled Robotic Arm

The processing unit, usually a microcontroller like ESP32, reads these signals and interprets them using programmed logic or algorithms. The processed data is then transmitted wirelessly (using Bluetooth/Wi-Fi) or through wired communication to the robotic arm. The output unit consists of the robotic arm with stepper motors, which execute the movements based on received commands. Each stepper motor controls a specific joint of the arm, enabling precise motion such as gripping, lifting, and rotation. This system design provides a real-time, efficient, and interactive method of controlling robotic systems, widely used in automation, medical applications, and industrial handling tasks.

The system is divided into two main sections:

1. Transmitter Section
2. Receiver Section

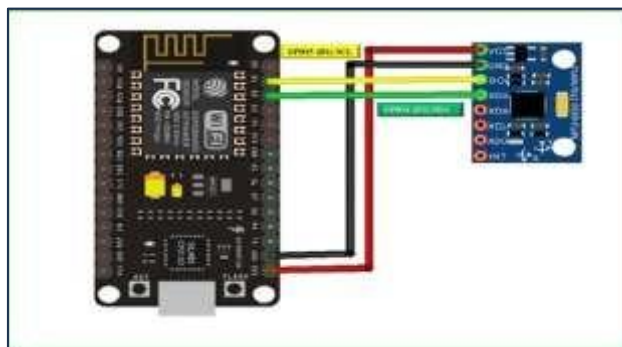


Fig. 1 Transmitter Section

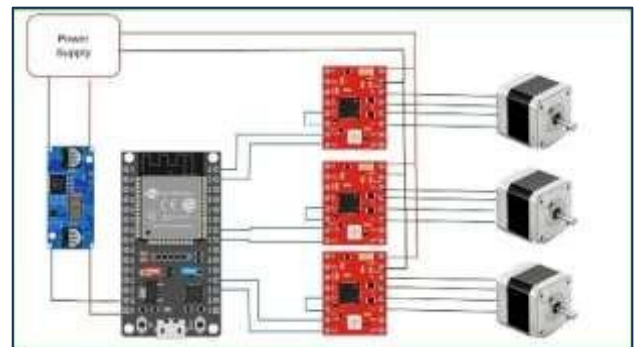


Fig. 2 Receiver Section

2.1 Hardware components

- Microcontroller (ESP 32)
- MPU6050 Accelerometer and Gyroscope Sensor
- Stepper Motors
- Robotic Arm Structure
- Power Supply

Table -1: Hardware Components Description

Component	Function
ESP 32	Processes sensor data
MPU6050	Detects hand movement
Stepper motor	Controls arm movement

2.2 Software computer

The system is programmed using Arduino IDE. Embedded C language is used to write the control program. The software reads sensor values, processes them, and generate corresponding signals for motor control.

- Embedded C programming

- Arduino IDE
- Serial Communication

3. WORKING PRINCIPALE

The working of this system is based on converting hand movements into robotic arm actions in real time. First, when the user moves their hand, the sensors placed on the glove, such as an accelerometer or flex sensors, detect the motion and changes in position. These sensors convert the physical hand gestures into electrical signals. Next, these signals are sent to the microcontroller, where they are processed and analyzed. The microcontroller identifies the type of gesture and converts it into corresponding control commands.

After processing, the command signals are transmitted to the robotic arm section, either through wireless communication like Bluetooth or through wired connections. On the receiver side, another microcontroller receives these signals and sends instructions to the motor driver circuit. The motor driver then controls the stepper motors of the robotic arm. Finally, the robotic arm moves according to the user's hand gesture, performing actions like gripping, lifting, or rotating.

3.1 Application

- Industrial automation
- Medical field assistance
- Military operations
- Hazardous material handling
- Assistive devices for disabled persons

4. CONCLUSION

The hand gesture controlled robotic arm system presents an efficient and intuitive method for human-machine interaction by translating natural hand movements into precise robotic actions. The integration of sensors, microcontrollers, and wireless communication enables real-time control with improved accuracy and flexibility. This system reduces the dependency on traditional control mechanisms such as joysticks or keypads, making it more user-friendly and accessible. The use of gesture-based control enhances operational convenience and opens up possibilities for applications in fields such as industrial automation, medical assistance, hazardous environment handling, and rehabilitation. Although the system demonstrates reliable performance, further improvements can be made in terms of gesture recognition accuracy, response time, and range of operation. Future enhancements may include the integration of machine learning algorithms and advanced sensors to achieve more precise and adaptive control.

5. REFERENCES

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