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Robotics Vehicle Controlled by Hand Gesture Using Pic Microcontroller

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Abstract

Abstract — This project involves the development of a robotic vehicle controlled by hand gestures using a PIC microcontroller. The system consists of a gesture detection unit with an accelerometer mounted on a glove and a robotic vehicle that responds to the detected movements. Hand gestures are captured, processed, and transmitted wirelessly to the vehicle, where the PIC microcontroller interprets the signals and controls the motors accordingly.The setup offers an intuitive and user-friendly way to control robotic movement, with applications in automation, assistive technology, and remote operations. The system is cost-effective, responsive, and demonstrates the potential of gesture-based human-machine interaction.

***Keywords:** Gesture control; Microcontroller; PIC microcontroller; Robotic vehicle; Wireless communication.*

1. Introduction

The robotic vehicle, operated through hand movements, is particularly beneficial for individuals with disabilities. It allows them to control the direction of movement simply by making hand gestures, without the need to press any buttons. The system utilizes a glove equipped with a transmitter circuit, which includes an PIC microcontroller connected to an accelerometer. This glove is worn by the user to send movement commands. On the vehicle side, there is an RF receiver, a microcontroller, and a motor driver IC that together manage the movement. The user’s hand gestures are detected and converted into commands by the microcontroller in the glove. These commands are then sent via the RF transmitter to the receiver on the vehicle. The vehicle's microcontroller receives and decodes these signals, directing the motors to move the vehicle in the desired direction [1]

- **9V Battery:** Provides the primary power supply for a circuit.This battery ensures that all the components receive the necessary voltage for operating. [2]
- **Diode:** Prevents reverse polarity, ensuring that the circuit does not get damaged if the battery is connected incorrectly.It allows current to flow only in one direction, protecting the microcontroller and other components.
- **Microcontroller:** Acts as the central processing unit of the system.Receives input from the accelerometer and processes the data.Controls the communication between different components, including the encoder and RF transmitter. (Figure 1)

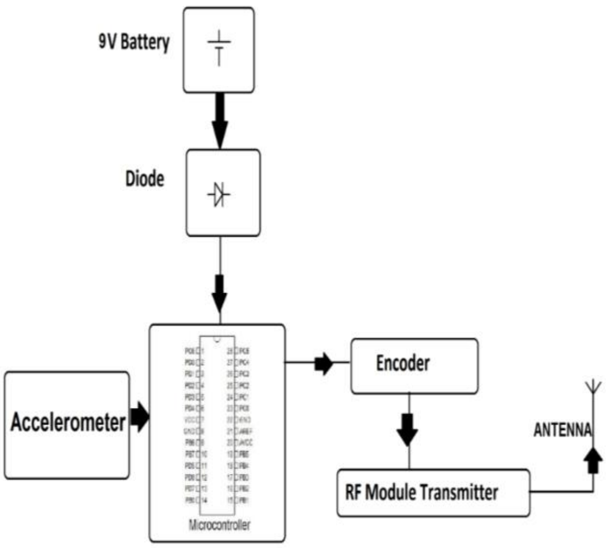

Figure 1 Block Diagram of Transmitter

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- **Accelerometer:** Measures acceleration and motion in different directions. Sends the data to the microcontroller for processing.
- **Encoder:** Converts parallel data from the microcontroller into a serial format. Ensures that the data can be efficiently transmitted over the RF module.
- **RF Module:** Transmitter Sends the encoded data wirelessly to a receiver using radio frequency. Works with the antenna to transmit signals over a specific range. [3]
- **Antenna:** Enhances the transmission of RF signals. Ensures the signal reaches the intended receiver with minimal loss.
- **6V Battery:** Provides power to the entire system, including the microcontroller, RF receiver, decoder, and motor driver.
- **Diode:** Prevents reverse polarity connections, protecting the circuit from damage. Ensures that current flows in the correct direction.
- **Antenna:** Captures the RF signal transmitted from the remote control unit. Enhances wireless communication for data reception.
- **RF Receiver:** Receives the radio frequency signals transmitted by the RF transmitter. Converts the received signal into a format that can be processed by the decoder.
- **Decoder:** Decodes the received RF signals and extracts the control signals. Sends the extracted data to the microcontroller for further processing.
- **Microcontroller (PIC16F877A)**: Acts as the central processing unit of the system. Receives decoded signals and processes them to control the motor operation. Sends control signals to the motor driver based on received input. [4]
- **Driver IC (L293D or L298):** Acts as interface between the microcontroller and motors. Amplifies low-power control signals from the microcontroller to drive the motors. Allows bidirectional motor control (forward and reverse motion).
- **Motors:** Represent the actuators of the system. Perform motion-based on the signals received from the motor driver (Figure 2)

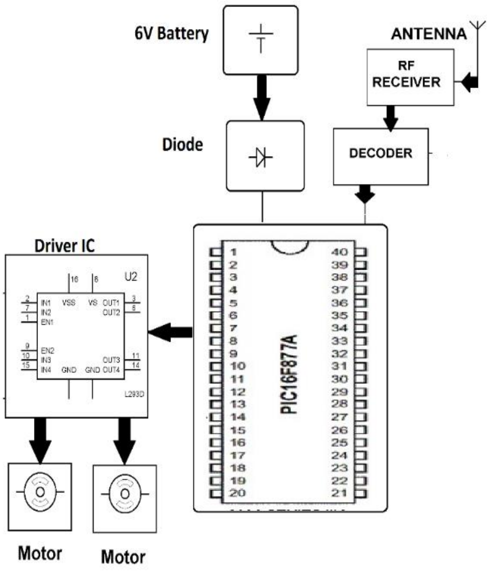

Figure 2 Block Diagram of Receiver

2. Algorithm

2.1. Transmitter Side

Step 1: Start system
Step 2: Initialize ADC and NRF24L01
Step 3: Read accelerometer X, Y values
Step 4: Convert analog to digital
Step 5: Compare with thresholds
Step 6: Decide gesture direction
Step 7: Transmit command via NRF24L01
Step 8: Repeat steps 3–7

2.2. Receiver Side

Step 1: Start system
Step 2: Initialize NRF24L01 and motor control pins
Step 3: Receive command
Step 4: Decode command
Step 5: Control motors via L293D
Step 6: Repeat steps 3–5

3. Components

- **PIC Microcontroller:** Acts as the brain of the system, processing sensor inputs and controlling motor outputs based on hand gestures. [5]
- **Robotic Chassis:** The physical frame that holds motors, wheels, and electronics, forming the body of the robot.
- **Hand Glove**: Worn by the user; it holds the accelerometer to detect hand gestures.
- **Accelerometer (ADXL335):** Senses tilt and

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orientation of the hand to determine movement direction. (Figure 3)

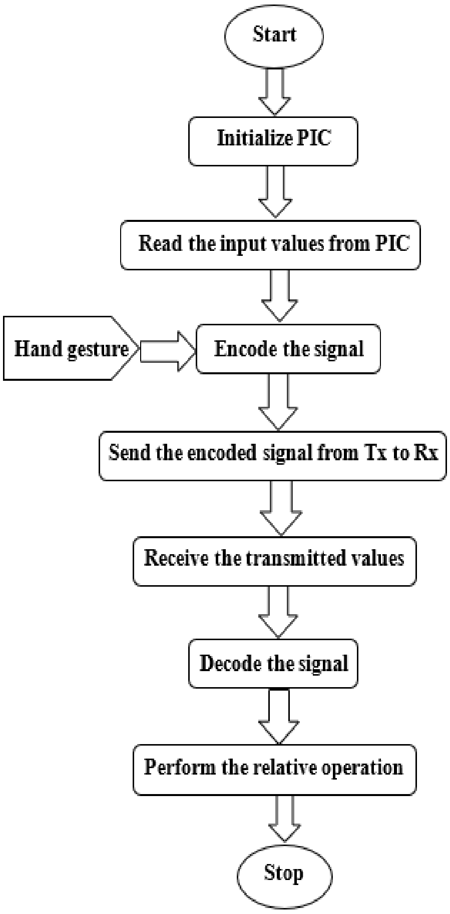

Figure 3 Flowchart

- **DC Motor:** Converts electrical energy into mechanical motion to move the robot forward, backward, left, or right.
- **Crystal Oscillator:** Provides a precise clock signal to the PIC microcontroller for accurate timing operations.
- **Resistors:** Limit current flow and divide voltages in the circuit.
- **Capacitors:** Store and release electrical energy; used for filtering and noise reduction.
- **Transistors:** Act as electronic switches or amplifiers within control circuits. [7]
- **Diodes:** Allow current to flow in one direction, protecting components from reverse voltage.
- **PCB and Breadboards:** Used for circuit prototyping (breadboard) and permanent mounting (PCB) of components.
- **LED:** Provides visual indication of power status or system activity. [6]
- **Transformer/Adapter:** Steps down AC mains voltage and converts it to DC for powering the circuit.
- **Push Buttons:** Used for manual inputs like reset or control commands during testing.
- **Switch:** Turns the system on or off by controlling power flow.
- **IC (e.g., L293D):** Integrated circuit used for specific tasks like motor driving or signal processing (Figure 4,5)

4. Results and Discussion

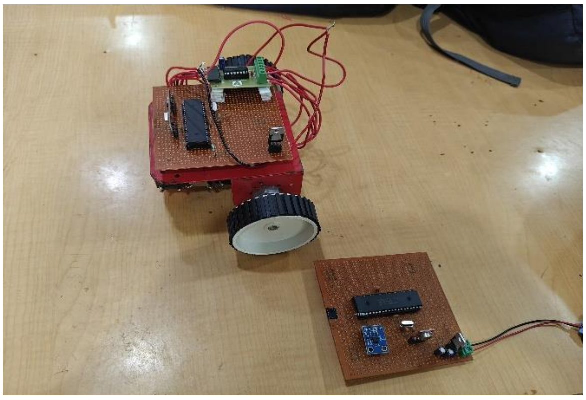

Figure 4 Hardware Model

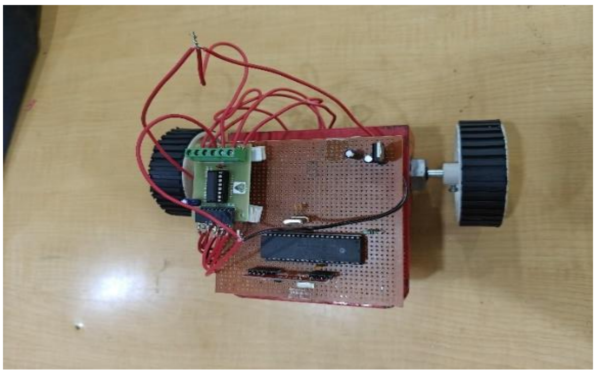

Figure 5 Hardware Model

5. This System is Divided into Two Main Sections

Transmitter Section – Hand Gesture Detection

5.1. Accelerometer Sensing

- The ADXL335 accelerometer is mounted on a glove worn by the user. It senses the tilt or

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orientation of the hand across 3 axes: X, Y, and Z.

- When the user tilts their hand in a certain direction (e.g., forward, backward, left, right), the voltage levels on the X and Y outputs change. [8]

5.2. Analog to Digital Conversion

The analog voltage signals from the X and Y axes of the ADXL335 are fed into the ADC inputs of the PIC18F4520.The microcontroller converts these analog values into digital form for processing.

5.3. Gesture Interpretation

- Based on predefined threshold values for the X and Y axes, the PIC18F4520 determines the direction of the gesture:
- Hand Forward → Move Forward
- Hand Backward → Move Backward
- Hand Tilt Left → Turn Left [9]
- Hand Tilt Right → Turn Right
- Hand Flat/Stable → Stop

5.4. Wireless Transmission

- Once the direction is determined, a corresponding command is sent through the NRF24L01 RF module. This module transmits the command wirelessly to the robot.
- Receiver Section – Robotic Vehicle Movement [10]
- Data Reception
- The NRF24L01 receiver module on the robotic chassis receives the command sent from the transmitter. The command is passed to the PIC18F4520 microcontroller.

5.5. Command Decoding

The microcontroller interprets the received data and decides which direction the robot should move.

5.6. Motor Control

- The microcontroller sends control signals to the L293D motor driver IC.
- L293D acts as an interface between the microcontroller and the DC motors.
- Based on the signals received, L293D drives the motors in the desired direction:
- Move Forward → Both motors forward
- Move Backward → Both motors backward
- Turn Left → Left motor stop, right motor forward
- Turn Right → Right motor stop, left motor forward
- Stop → Both motors stop [11]

6. Pros and Cons

6.1. Pros

- **Intuitive Control:** Hand gesture control provides a more natural and intuitive method of controlling a robotic vehicle compared to traditional methods like joysticks or buttons. Users can control the vehicle just by moving their hand.
- **Wireless Operation:** This system often utilizes wireless communication (e.g., Bluetooth or RF), which allows the user to control vehicle from the distance, enhancing flexibility and convenience. [12]
- **Enhanced User Experience:** The gesture-based interface creates an interactive and futuristic user experience. It's a more immersive way to control devices and can increase the engagement of the user.
- **Simpler Interface:** Compared to complex button-based controls, the hand gesture system simplifies the interface. There's no need for physical controllers, reducing the number of parts and components.
- **Cost-Effective with PIC Microcontroller:** The use of a PIC microcontroller makes the project cost-effective. PICs are inexpensive, readily available, and easier to integrate with various sensors, making them ideal choice for such projects.
- **Potential for Multiple Applications:** This control system can be extended for various applications, such as in healthcare for controlling assistive devices, in industrial robotics, and in entertainment technologies (e.g., gaming or simulation). [13]

6.2. Cons

- **Environmental Sensitivity:** External environmental factors such as poor lighting, noise, or interference can impact the performance of the gesture recognition system, making the system less reliable in

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certain conditions.

- **Complex Calibration:** The system may require periodic calibration to ensure accurate gesture tracking. Any deviation in the setup can result in faulty operation or difficulty in recognizing gestures. [14]

Conclusion

This wireless motor control system efficiently enables remote operation using RF communication. By integrating and RF receiver, decoder, motor driver and microcontroller, the system ensures reliable signal processing and precise motor control. The use of battery-powered setup with circuit protection enhances portability and safety. This project is ideal for applications such as wireless robotics, remote vehicle control & automation, offering a cost-effective and practical solution for wireless motion control. [15]

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