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GESTURE CONTROLLED CAR SYSTEM FOR ENHANCED ACCESSIBILITY USING ESP32

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Abstract
This project aims to enhance the accessibility for gesture-controlled car using ESP32 which enables mobility. This allows users to operate a car through hand gestures and it mainly focuses on the people with disabilities. An accelerometer and gyroscope module (MPU6050) is used to detect the hand movements. Here, two ESP32 microcontroller modules are used -one for transmitting the gesture commands and other one for receiving and interpreting those commands. The communication between the car and our hand is achieved through wireless transmission of the signals connected via Wifi. The L298N motor drivers are used for robust and controlled wheel movement. In response to safety, two ultrasonic sensors are placed at the front and back of the car for the indication of obstacles and to avoid accidents. This idea eliminates the need for physical input devices like joysticks and remote controls. Safety is the primary priority and is ensured using real time monitoring, emergency stop and failsafe mechanisms. The goal of this project is vehicle enhancement for the users with various mobility impairments. Thus, the integration of gesture control mechanism enhances user experience and promotes innovation in robotics. As a result, people with disabilities find it easier to use it in their daily life.

Keywords: mobility, disabilities, gesture control.

1. Introduction

In recent years, robotics plays a crucial role in development of technology. Traditionally used input devices like joysticks and remote controls, have many limitations in terms of its accessibility and ease of use [1]. As there is a demand for user-friendly robotics applications, researchers and engineers are exploring different control mechanisms that paves way for the gap between humans and the robots [2]. One of the easiest ways explored was a gesture-controlled robot, which satisfies the requirement. Thus, the way of controlling the robots and interacting with them has become much easier and understandable using gestures and normal movements [3].The primary objective of this project is to create a robotic car that can be controlled using hand gestures and allow users to easily interact with the robot. It also includes a user-friendly approach, cost effective and simple to design [4]. In its initial stage, the project employs two microcontroller modules, an accelerometer and gyroscope module (MPU6050), two L298N motor drivers, two ultrasonic sensors and batteries for power supply [5]. Its core components are two ESP32 microcontroller modules-one for transmission of the gesture commands and other one for receiving and interpreting those commands [6]. Here, communication is carried out via Wifi. An accelerometer and gyroscope module is used to sense the hand gestures and sends them to microcontroller. Two L298N motor drivers are used to control the wheel movements. Additionally, two ultrasonic sensors are used in front and back side of the car to detect obstacles and to avoid accidents [7]. Safety plays a crucial role in day-to-day life and in order to enhance safety, two ultrasonic sensors are being used. These sensors are used to continuously monitor the surrounding environment to detect obstacles [8]. In case of an obstacle, the sensors send feedback to the microcontroller, enabling the robot car to automatically adjust and avoid collision [9]. This could involve slowing down, stopping, or changing direction to avoid collisions. More than its technical sophistication and advanced technology, this project ensures social responsibility. By providing access to mobility solutions, it provides the ability and confidence to the individuals with disabilities to navigate the world in their own with their own freedom [10].

2. Literature

In 2023 Mehul Kumar Singh, Prashant Singh, Prakhar Dixit and Deepak Garg proposed a system called Hand Gesture Controlled Car. It can be remotely controlled without the need for physical controllers. The system at first was designed with Arduino Uno microcontroller. It consists of Arduino Uno, Accelerometer, Encoder and RF module. The motor is controlled by the actuation of the signals from the Arduino Uno. Accelerometer senses the movement in roll pitch and yaw axis and delivering them to the microcontroller. And the further process of encoding takes place wherein the HT12E Encoder encodes the signals and ready to be sent to the Receiver. The signals can be wirelessly transmitted using the wireless RF module. The IC works by using the input 8-bit address and 4 -bit data word. The data bits are transmitted serially. And after the signals have been sent to the receiver the decoder HT12D receives the data 8-bit address and 4-bit data word and decodes it. After the readings are decoded, it will be sent to the L298D motor driver. The motor is equipped with a feedback mechanism to provide feedback tot the users. The accelerometer can be tilted to move the motor in the desired direction. The hand gesture control is an innovative was of controlling.

In 2020 Aishwarya Mohan and Rashmi Priyadarshini proposed a system called Gesture controlled robot using accelerometer. The system consists of ADXL345, Arduino SMD, Atmega 328p, Center shaft DC motor, L293D motor driver and RF module. And the outcome of this paper is to provide a human machine interface to control the wheel chair. When the process is initiated the accelerometer is started and then it begins to sense the movement of the person. Eventually when the motion is detected the direction of the motion detected and hence the process is started. And then the motion details are being sent to the Arduino uno microcontroller. After the controller processes the data then it sends it to the receiver in the slave board. The bits are being transmitted wirelessly. Aftermath the sending of the bits they are processed and then decoded. The RF transmitter works at 9600bps and the transmission takes place. The Arduino board in the slave drives the motor using the L298D Motor driver and then wheels can be driven. This approach includes a power source of 5v battery, this 5v supply is more adequate speed while improving battery life of the model along with preventing overheating of the L29D IC and the speed of motor also can be increased to 500rpm by providing 12v supply. This model can be done affordably by removing the encoder-decoder pair, smaller chassis, lesser wheels were this compensates the driver module and microcontroller board .In the future this project can be upgraded by replacing RF module with Bluetooth module in order to facilitate communication between the transmitting and receiving circuit , installing a camera for surveillance purposes , GPS module to help in mapping hostile terrains and equipping the model with a solar battery to replace the primary power supply, and falling back on the mounted Li-Ion batteries as back-up only in case of emergency .

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3. Proposed System

3.1 Transmission

Figure 1: Transmitter

Firstly, an accelerometer (MPU6050) is used which detects the hand motions accurately and translate them into directional signals. This is done for controlling the robot car's movement. These signals from the accelerometer are translated into gesture commands using ESP32.This is being done in the transmitting end.

3.2 Communication

Then these commands are transmitted wirelessly via Wifi to the ESP32 present in the receiver end. This wireless transmission enables seamless communication between car and the user, without any need for physical connections. Wifi stands for Wireless Fidelity and it provides wireless connectivity to a wide range of devices.

3.3 Reception

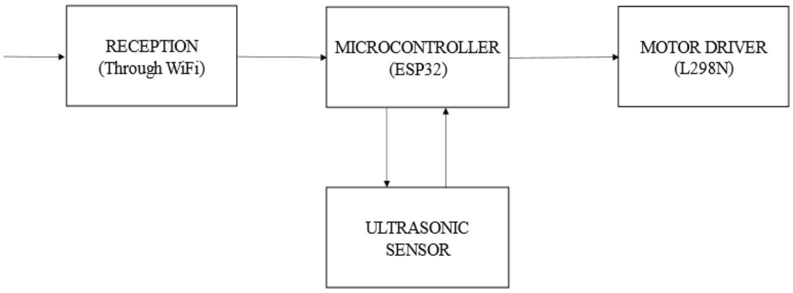


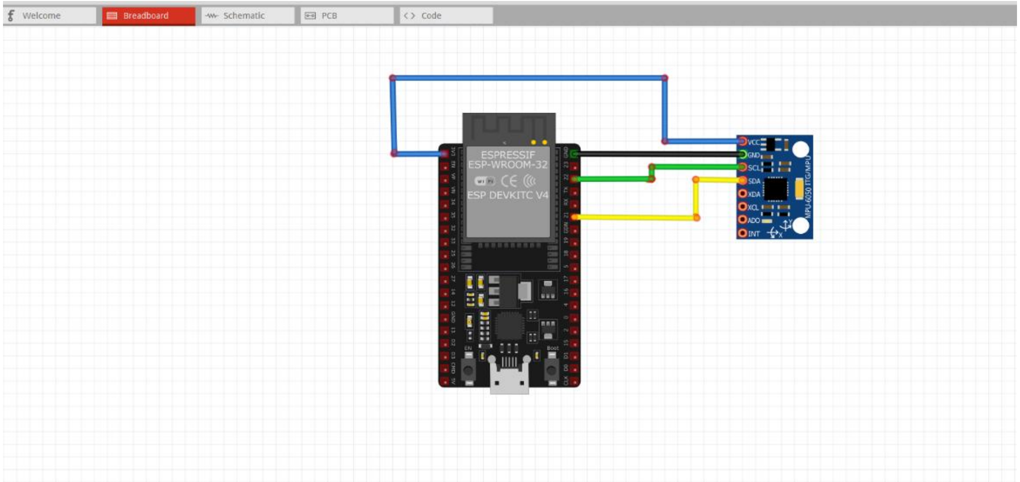
Figure 2: Receiver

Once the gesture commands are received, the ESP32 present in the receiver end interprets the gesture commands and translates them into gesture (actionable) instructions. These instructions are then being sent to the L298N motor drivers, which control the wheel movement of the car. Here, two L298N motor drivers are used- one motor driver for front right and front left wheel, which is placed at the front and another motor driver is placed at the back for back right and back left wheel. Once the L298N motor drivers receive the instructions, they adjust the speed and the direction of the car's wheels accordingly. This allows the car to respond to the user's hand gestures like moving forward, backward, turning right or turning left based on the gestures detected.

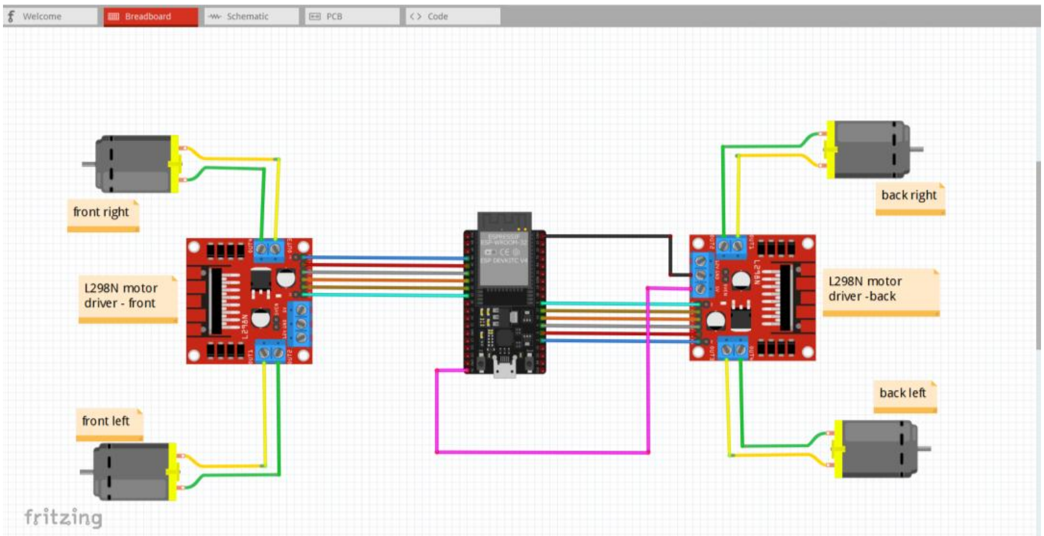
Safety is the most crucial aspect for this mechanism, and to enable safety, two ultrasonic sensors are placed at the front and back of the car. These sensors will continuously monitor the surrounding environment and check for obstacles. If there is any obstacle detected, the sensor will send signals to the microcontroller, and once the microcontroller receives the message, it will take appropriate action. This action involves slowing down, stopping or changing direction of the car in order to avoid collisions.

4.Circuit Diagram

4.1 Transmitter



4.2 Receiver



5. Software Algorithm

The algorithm for gesture-controlled car is as follows:
Step 1: Include header files for interacting with the microcontroller unit
Step 2: Initialize ESP-NOW
Step 3: Define a function setup MPU to initialize the MPU6050 sensor.
Step 4: Define constants for motor control directions and motor pin configuration.
Step 5: Initialize serial communication and Call setupPinModes to configure motor control.
Step 6: Register the callback function for sending and receiving data. Add the peer device to the ESP-NOW network.
Step 7: Check for incoming data using the callback function OnDataRecv.
Step 8: Call processCarMovement to translate control signal into motor commands.
Step 9: Introduce a delay to limit data transmission rate
Step 10: Check for incoming data using the callback function while receiving data. If no data is received within a timeout period, Stop all motors using processCarMovement(STOP).

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6. Results

The Gesture-Controlled Car System consists of two microcontrollers ESP32 and Accelerometer and Gyroscope module. These two from the principal components. Apart from these, four TT geared motors, two L298N motor driver modules and two ultrasonic sensors are also used. The overall system module is shown in Figure 1.

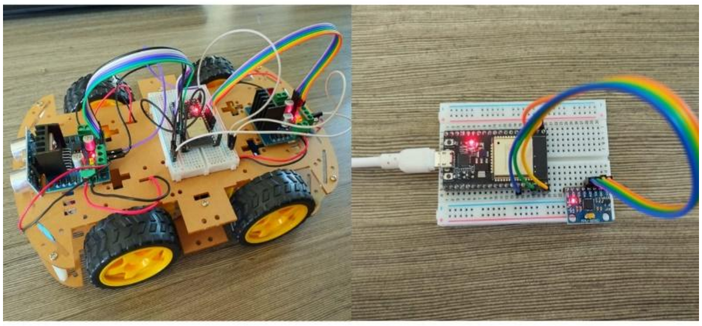

Figure 1. Gesture-Controlled Car System.

6.1 Initial Setup Description

A 5V power supply is given to ESP32. It is the operating voltage for ESP32. The MPU-6050 Accelerometer and Gyroscope module is interfaced with the controller in the transmitter. At the receiver two driver modules are interfaced with the ESP32 controller to operate the motors based on the instructions. An ultrasonic sensor is placed on the front and back to detect obstacles. Based on the output the car will move accordingly.

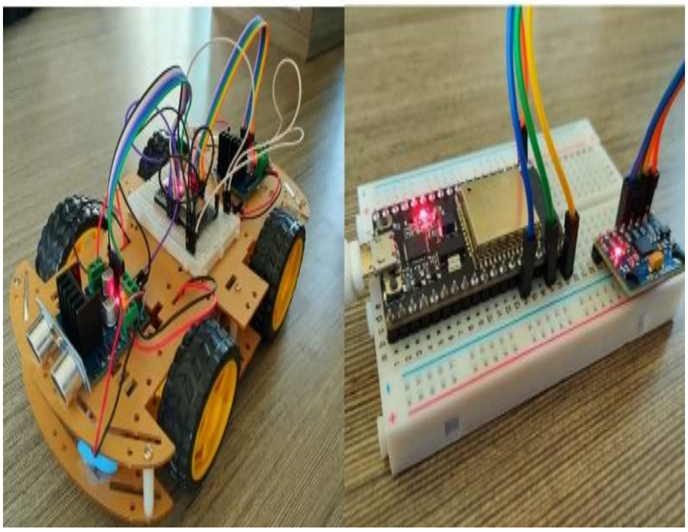

Figure 2. Initial Setup.

6.2 Transmitter Function

Transmitter consists of one microcontroller Esp32, MPU-6050 Accelerometer and Gyroscope module. MPU6050 is a MEMS module that combines a 3-axis accelerometer and a 3-axis gyroscope. It has a built-in DMP for high-performance motion processing and a 16-bit ADC for high-resolution data acquisition. The hand-gesture motions are detected and converted into 3 axes positions x, y and z based on the position of the sensor. Then the axes positions are sent to the receiver. The output of the transmitter can be viewed in the serial monitor.

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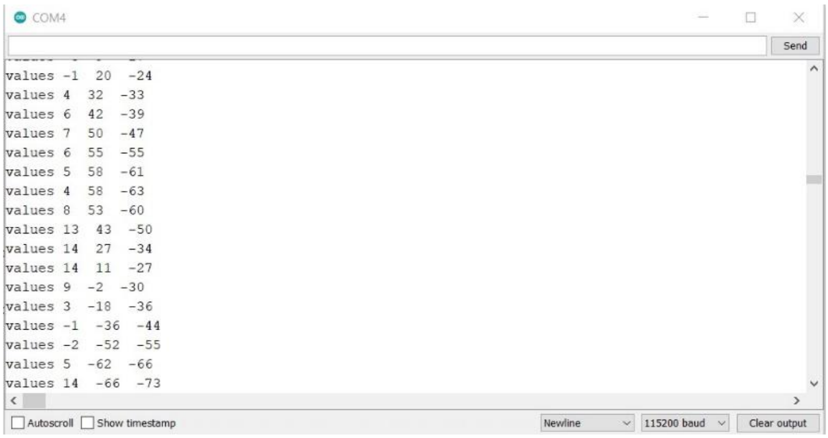

Figure 3. Transmitter Output

6.3 Receiver Function

The receiver consists of one microcontroller ESP32, two L298N motor driver modules, four TT geared motors, two ultrasonic sensor, two 9V batteries and one 3V battery. The transmitter and receiver are connected through the built-in Wifi modules. The output of the transmitter is sent to the receiver. The receiver processes the input and instructions are sent to the two driver motors. The driver motors each can control two motors simultaneously. The car will move frontward, backward, left, right and will be stopped according to the instructions.

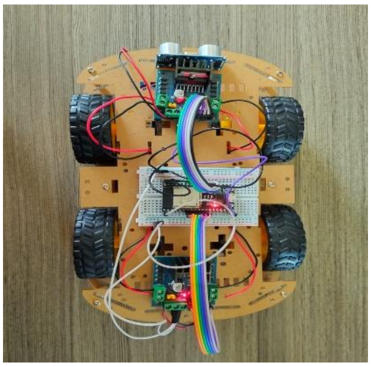
Figure 4. Receiver output

6.4 Object Detection

An ultrasonic sensor is provided at the front and back of the vehicle. It is interfaced with the controller directly. This sensor is used to avoid any objects in front and back of the vehicle and to prevent any accidents. The vehicle identifies any objects in front and back then slows and stops the vehicle.

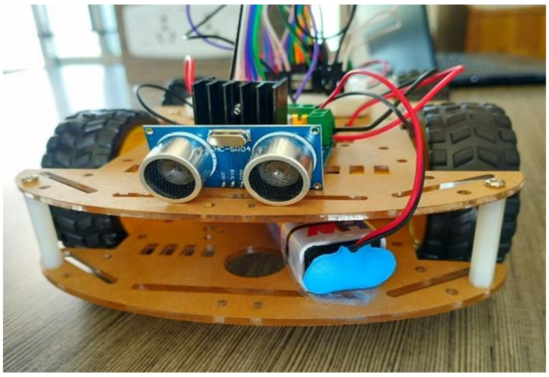
Figure 5. Object detection

7. Conclusion

The gesture-controlled mechanisms and Wifi technology in robotics represents an advancement towards enhancing accessibility. It also ensures user experience, particularly for individuals with mobility impairments. By using the advanced technology such as hand gestures, widespread availability and reliability of Wifi connectivity, this project showcases the innovation in robotics. Through real-time monitoring, safety mechanisms, and obstacle detection, the project ensures not only user convenience but also prioritizes safety. Hence, this concept showcases how robotics has improved the lives of individuals with disabilities by offering more interactive and accessible solutions for daily tasks. It also fulfils the mobility needs.

It encourages further exploration into how gesture-based interfaces can be optimized and tailored to meet the diverse needs of users. This project serves as a foundation for future research and development in the field of accessible technology. The successful implementation of a gesture-controlled car system using the ESP32 microcontroller underscores the importance of interdisciplinary collaboration in engineering and technology. As society continues to embrace smart technology in every aspect of daily life, projects like this are critical in ensuring that technological progress is inclusive, offering enhanced independence and quality of life for individuals with physical limitations.

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