ES-116 Project
Gesture Controlled Car

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Abstract - This document describes the process of creating a car that can be controlled through hand gestures. The car uses several components, including the MPU6050 module for motion sensing, nRF24L01+ modules for wireless communication, and the L298N driver for motor control. The car operates by wirelessly transmitting hand gesture data from the transmitter to the receiver. The receiver then decodes the data to adjust the car's speed and direction.

I. AIM

To develop an automobile that can be controlled using the user's hand gestures. It has the capability to analyze different types of gestures by systematic analysis of hand tilt angles. Based on these angle values, the car's speed and direction will be controlled.

II. COMPONENTS REQUIRED

The following components will be required for the making of the project:

Transmitter:

- Arduino Nano
- nrf24l01+ module
- nrf adapter
- MPU6050 module
- 7-12 V DC battery
- Breadboard
- Double sided tape
- Jumper wires

Receiver:

- 4WD car kit (It has 4 TT DC gear motors with wheels)
- Arduino Nano
- nrf24l01+ module
- nrf adapter
- L298N driver module
- 7-12 V DC battery
- Breadboard
- Double sided tape
- Jumper wires

III. THEORY

Components Explanation:

MPU6050 Accelerometer and Gyroscope

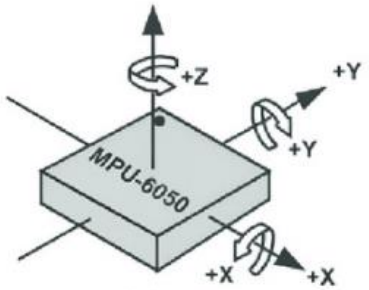

Figure 1: Working axis details (adapted from [2])

The MPU-6050 Module is an Integrated Circuit that combines a 3-axis gyroscope and a 3-axis accelerometer. The gyroscope measures the rate of rotation or angular velocity around three axes: X, Y, and Z. It uses a structure called MEMS (Micro-Electro-Mechanical Systems) technology, which has tiny vibrating elements that detect any changes in orientation. When the Module is rotated, these vibrating elements deflect, and this deflection is measured to determine the rate of rotation. On the other hand, the accelerometer measures acceleration along the same three axes, X, Y, and Z, using the same MEMS technology. The accelerometer has tiny structures that move in response to acceleration. These structures move when the Module is accelerated, and the displacement is measured to determine the acceleration. By combining data from both sensors, the MPU-6050 Module [4].

nRF24l01+ Transceiver Module

The nRF24L01+ is a 2.4 GHz ISM (Industrial, Scientific, and Medical) band transceiver module. It transmits data using radio waves. The operating voltage range of this Transceiver module is 1.9V to 3.6V. It is often used in combination with an nRF adapter, which serves as an interface between the module and the Arduino Uno/Nano. This makes it a versatile tool for wireless communication, as it can send and receive data at the same time [3].

When used in pairs, one module acts as a transmitter, and the other acts as a receiver.

The nRF24L01+ incorporates a built-in state machine responsible for managing its various operational modes. Some of the operating modes are:

TX Mode:
The nRF24L01+ module starts transmitting data by switching to TX mode. During this process, the module modulates the data onto radio waves at a specific frequency and transmits it through the antenna. The transmission will continue until all the contents of the FIFO (First-In, First-Out) are empty.

RX Mode:
When the nRF24L01+ is configured to act as a receiver, it enters RX mode. In this mode, it continuously receives and processes the signal that is being transmitted in the RF channel. The signal is then passed on to the baseband protocol engine, which checks the received packet's address and CRC to ensure its validity. If the packet is valid, it is written in the RX FIFO (It is a temporary storage area within the receiver module where incoming data packets are stored before being processed by the microcontroller). However, the incoming data is discarded if the RX FIFO is already full.

L298N Driver Module

The L298N driver module is an integrated circuit (IC), commonly used in robotics to control the speed and direction of DC and stepper motors. This is achieved by two control pins, one controlling the motor's direction and the other controlling the speed. To make the motors move forward, you set one control pin high and the other low for each motor, and if we reverse the logic, the direction will reverse.

The module typically involves the dual H-bridge configuration. An H-Bridge is a circuit that can drive a current in either polarity or be controlled by *PWM. Thus, it is used to change the direction of the motor. The speed of the DC motor depends on the input voltage it receives. It works by using the technique called L298 PWM to control input voltage and sending on-off pulses to the motors.
When the Arduino Uno/Nano sends the signal to L298N driver module, the driver processes the signals; the direction control pins set the rotation of motors. When the motor starts rotating, L298N motor drivers handle the current flow, and the PWM pins regulate the motor speed [1].

IV. WORKING PRINCIPLE

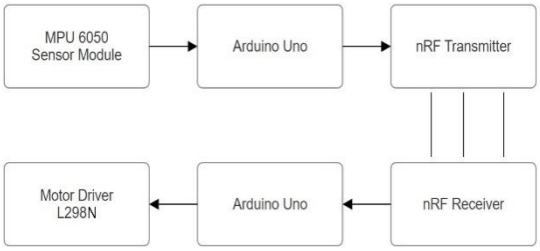

Figure 2: Workflow of circuit

Transmitter Section:

The MPU6050 module in the transmitter circuit senses how it moves and rotates using its built-in accelerometers and gyroscopes. It sends this information to the Arduino Uno/Nano, which calculates the angles of the movement in different directions (x, y, and z axes). These angles change depending on how the MPU6050 is positioned.
The Arduino redefines the obtained angle values in more usable formats by mapping it to a specific range so that it is suitable for further processing and transmission.

```
data.xAxisValue = map(xAxisValue, -90, 90, 0, 254);
data.yAxisValue = map(yAxisValue, -90, 90, 254, 0);
```

The x-axis and y-axis angles are mapped to values ranging from 0 to 254. In this mapping, 0 signifies the minimum angle (-90 degrees), while 254 denotes the maximum angle (90 degrees).

After this, the Arduino sends these mapped values to the nRF24L01+ module, which is a wireless transmitter. It uses radio waves to send the information to a receiver module. The Arduino Uno/Nano communicates with the nRF24L01+ module using the Serial Peripheral Interface (SPI) communication protocol (meaning the data is transferred using a clock signal). The nRF24L01+ module utilizes its Radio Frequency (RF) communication capabilities to establish a link with the receiver circuit. Through this communication link, the data is wirelessly transmitted to the receiver module for further processing or control.

Receiver Section (Gesture Controlled Robot):

The nRF24L01+ module integrated into the receiver circuit receives the wireless signals containing the motion and gesture data packets sent by the transmitter circuit. The Arduino uno/nano within the receiver circuit decodes the received data.

```
int mappedYValue = map(receiverData.yAxisValue, 0, 254,
-255, 255);
int mappedXValue = map(receiverData.xAxisValue, 0, 254,
-255, 255);
```

The x-axis values received are mapped from a range of 0 to 254 to a range of -255 to 255. This mapping makes sure that the values are centered around 0. Negative values indicate left steering, and positive values indicate right steering. The mapped x-axis value is used to adjust the speeds of both left and right motors. If the value is negative, it means that the car should turn left, and if it is positive, the car should turn right.

Similarly, the y-axis values received are mapped from a range of 0 to 254 to a range of -255 to 255. This mapping ensures that the values are centered around 0, with negative values indicating reverse motion and positive values indicating forward motion. The mapped y-axis value is then used to adjust the speeds of both the left and right motors. If the value is negative, it means that the car should move backward, and if it is positive, the car should move forward.

* Pulse Width Modulation is a means in controlling the duration of an electronic pulse by varying the duty cycle.

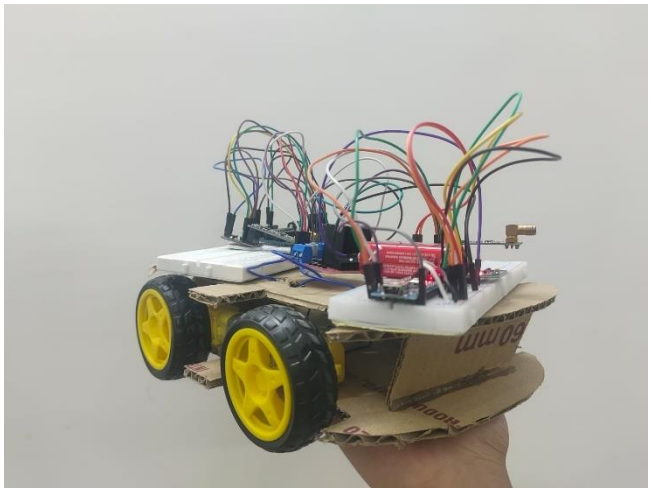

Figure 3: Final picture of the project

V. DISCUSSION

To improve convenience, we can integrate the bulky transmitter circuit into a wristband or glove using a custom-designed PCB. By condensing the circuit onto a compact PCB, the overall size and weight of the transmitter can be significantly reduced, making it more comfortable and practical to wear on the wrist or hand.

After completing the project, when we tested the car, we noticed a significant delay between the gesture movements and the car's response. We also found that the car was not responding to some of the gesture movements. Upon further investigation, we discovered that the receiver's baud rate was lower than the transmitter's baud rate, leading to data loss. This mismatch in communication resulted in delays in the car's movements. We resolved the issue by adjusting the baud rates, which improved the car's movements.

Another problem we faced was powering the car; we drained 6, 9V batteries while testing due to the high-power consumption of the motors and other electronic components. The speed of the car was also lower because of the lower power from the battery.

VI. SCOPE FOR FUTURE WORK

In the future, we can make some advancements in the gesture-controlled car project, such as implementing more accurate gesture recognition algorithms for finer control and responsiveness. Also, we can make a road model of this car, which people can drive on the road, particularly those with disabilities who would benefit from this. These improvements would make the gesture-controlled car more versatile, intelligent, and adaptable to various applications and environments.

VII. REFERENCES

[1]Sawkare, R. (2024) *Everything you want to know about L298n motor driver*, *Vayuyaan*. Available at: https://vayuyaan.com/blog/everything-you-want-to-know-about-l298n/ (Accessed: 19 April 2024).

[2] https://www.researchgate.net/figure/MPU6050-module-a-sensor-module-b-working-axis-details-and-c_fig1_370797001

[3]Staff, L.E. (2023) *In-depth: How NRF24L01 wireless module works & interface with Arduino*, *Last Minute Engineers*. Available at: https://lastminuteengineers.com/nrf24l01-arduino-wireless-communication/ (Accessed: 19 April 2024).

[4]Sahil *et al.* (2024) *Buy MPU6050 module online in India*, *Robocraze*. Available at: https://robocraze.com/products/mpu-6050-triple-axis-accelerometer-gyroscope-module (Accessed: 19 April 2024).