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وزارة التعليم العالي
معهـد الأهرامـات العـالي للهنـدسـة والتكنولوجيا بالسادس من أكتوبر
قسم هندسة الالكترونيات والاتصالات

Robot modeling & simulation

Autonomous Vehicle with MPU6050

Students Names:

Abobakr Mostafa Fathy
Ali Osama Ebaid
Eslam Ahmed Ibrahim
Madlen Nady Samir
Mohamed Hany Hassan
Mahmoud Mohamed Elbhrawy
Moaaz Mohamed Mohamed
Youssef Ehab Mohamed

Supervisors:

Dr. Gamal El-Sheikh

Objective:

Implement an autonomous vehicle control system using an MPU6050 sensor (an accelerometer and gyroscope), and an L298N motor driver to control the vehicle's movement. The system aims to perform tasks such as driving in a straight line, making precise turns at specified distances, and returning to its original position based on sensor input and calculated angles (yaw, pitch, and roll). The system calculates the orientation of the vehicle in real-time using the sensor data and adjusts the motors to perform the required movements.

Introduction:

With the increasing demand for autonomous systems in industries such as transportation, robotics, and smart cities, the ability to accurately control vehicle movement using real-time sensor data is critical. This project focuses on the development of an embedded system that controls a small-scale autonomous vehicle using an MPU6050 sensor and an L298N motor driver.

The MPU6050 is a widely-used 6-axis motion tracking device that combines a 3-axis gyroscope and a 3-axis accelerometer, providing critical data about the vehicle's orientation and motion. This data is processed by an Arduino microcontroller, which calculates roll, pitch, and yaw angles. These angles are then used to guide the vehicle's movement, allowing it to navigate along a predefined path while making precise directional adjustments.

The L298N motor driver is employed to control the vehicle's two DC motors, enabling differential control for turning and straight-line motion. By adjusting the motor speeds based on sensor data, the system can drive forward, make controlled turns, and return to its starting position.

The project showcases the application of sensor fusion and control algorithms to achieve real-time vehicle navigation, simulating the principles behind autonomous driving technologies. This approach not only demonstrates the integration of hardware components like sensors and motor drivers but also highlights the significance of embedded programming in the realm of autonomous systems.

Testing and Results:

Testing Procedure

To verify the functionality of the autonomous vehicle control system, we performed a series of tests to evaluate the relationship between the vehicle's yaw (angular orientation) and the distance it traveled. The testing setup involved the following steps:

1. Data Collection: The system was tested in a controlled environment where the vehicle was allowed to navigate a predefined path. During its movement, the yaw and distance values were recorded in real-time. These values were stored in a .txt file (long.txt), with two columns representing yaw (in degrees) and distance (in meters) respectively.
2. Data Analysis: A MATLAB script was used to load and analyze the recorded data. The yaw values were plotted against the distance to visualize how the vehicle's orientation changed during its movement. This helped in identifying any deviations or inconsistencies in the vehicle's path.

MATLAB Code

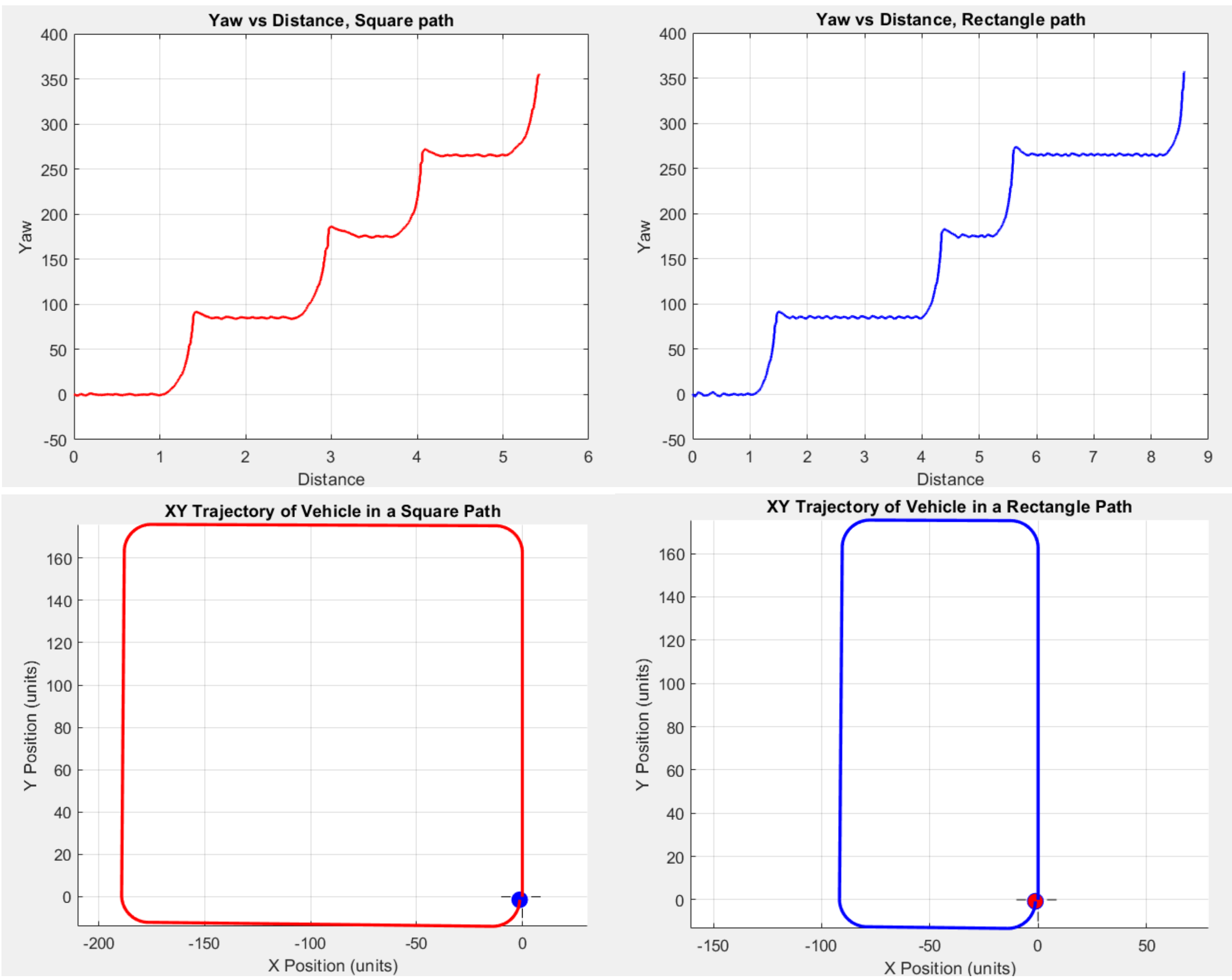
The following MATLAB code was used to process and visualize the recorded yaw and distance data:

```
% Load the data from the .txt file
data = load('long.txt');  % Replace 'data.txt' with the actual
path to your file

% Extract yaw and distance from the loaded data
yaw = data(:, 1);        % First column is yaw
distance = data(:, 2);   % Second column is distance

% Plot the yaw vs distance
figure;
plot(distance, yaw, 'b', 'LineWidth', 1.5);
xlabel('Distance');
ylabel('Yaw');
title('Yaw vs Distance');
grid on;
```

Results



The results from the data analysis are displayed in a plot showing the relationship between the distance traveled by the vehicle and its yaw (angular orientation). The key observations from the test are:

- Yaw Stability: As seen in the plot, the vehicle's yaw remained within expected bounds while moving in a straight line. Small deviations in yaw correspond to slight adjustments made by the system to correct the vehicle's course.

- Turning Points: Significant changes in yaw were observed at specific distances, which correspond to the vehicle making left turns as per the predefined path. These sharp deviations indicate the moments when the system executed its turning maneuvers.

- Path Accuracy: The system demonstrated a high level of accuracy in maintaining the intended path, as the yaw returned close to zero after completing each turn and resuming a straight path.

The plot provided a clear visual representation of the vehicle's performance, allowing us to verify that the system successfully responded to sensor inputs and adjusted its motors to navigate the path accurately.

Hardware and software:

1. **Arduino UNO** is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button shown in Fig 2.1.

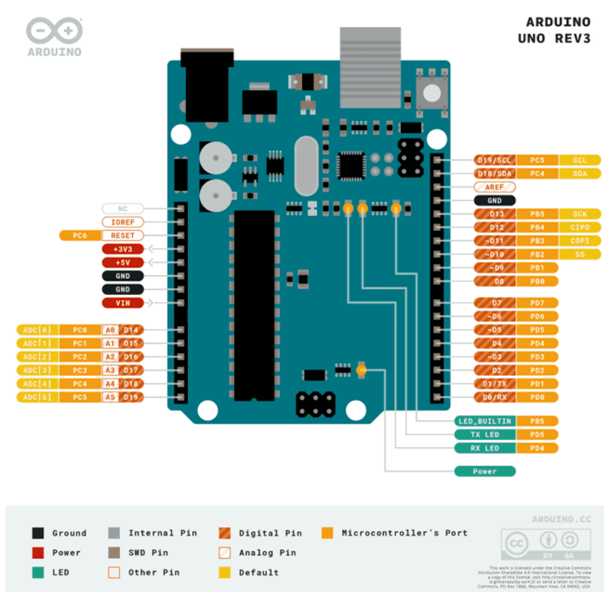


Fig 2.1 Arduino UNO pinout

2. The **MPU6050** is a 6-axis motion tracking sensor that combines a 3-axis accelerometer and a 3-axis gyroscope into a single chip. It is commonly used in applications like robotics, drones, and motion detection. The accelerometer measures linear acceleration (movement and tilt), while the gyroscope detects rotational movement (angular velocity). shown in Fig 2.2.

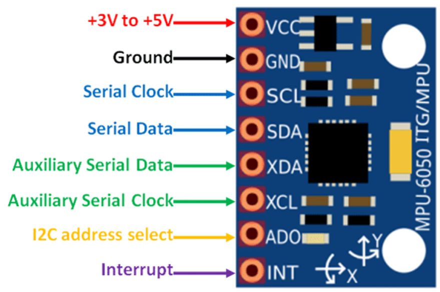


Fig 2.2 MPU6050

3. **The L298 motor driver** is a popular dual H-bridge motor driver integrated circuit (IC) Shown in Fig 2.3 commonly used in robotics and other projects requiring motor control:
   - Dual H-Bridge design.
   - Maximum Voltage: up to 46V
   - Current Handling: The L298 can handle peak currents of up to 2A per channel and 4A if a heat sink is used.
   - Enable Pins: Each H-bridge has an enable pin that allows for PWM (pulse-width modulation) control of motor speed.

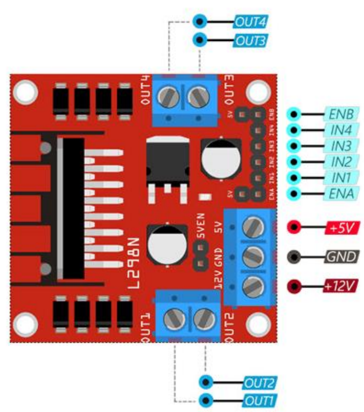


Fig 2.3 The L298 motor driver

4. An **Optical Encoder Module** is a device that measures the position, speed, or direction of an object. It consists of a code disk or strip, an LED light source, and an optical sensor. As the object moves, the disk or strip interrupts the light, and the sensor converts this into electrical pulses. shown in Fig 2.4

Fig 2.4 Optical Encoder Module

5. A **DC geared motor with wheel** in autonomous cars is an electrical device that converts electrical energy into mechanical motion, crucial for functions like propulsion and steering. It operates on direct current (DC) power and is used in various systems within autonomous vehicles, such as propulsion motors for driving wheels or steering motors for directional control. These motors enable the car to move, accelerate, decelerate, and navigate autonomously, playing a key role in the vehicle's overall functionality and movement capabilities shown in Fig 2.5

Fig 2.5 DC geared motor with wheel

6. In autonomous cars, the **rigid body** serves as a stable platform for mounting sensors such as ultrasonic and electronic components, ensuring accurate data collection. This setup minimizes vibrations and noise, which are crucial for sensor precision and system reliability. The design also enhances collision resistance and impact absorption, safeguarding internal components. Treating the car as a rigid body simplifies the mathematical analysis for motion dynamics evaluations, as shown in Figure 2.6.

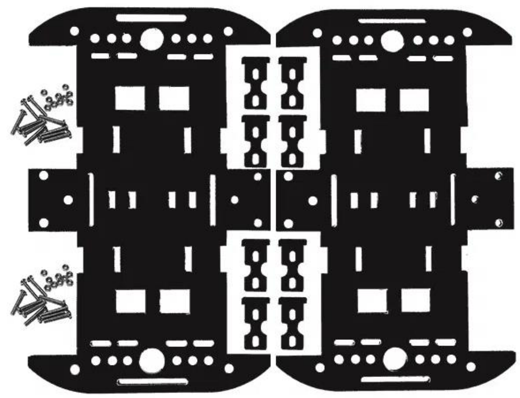


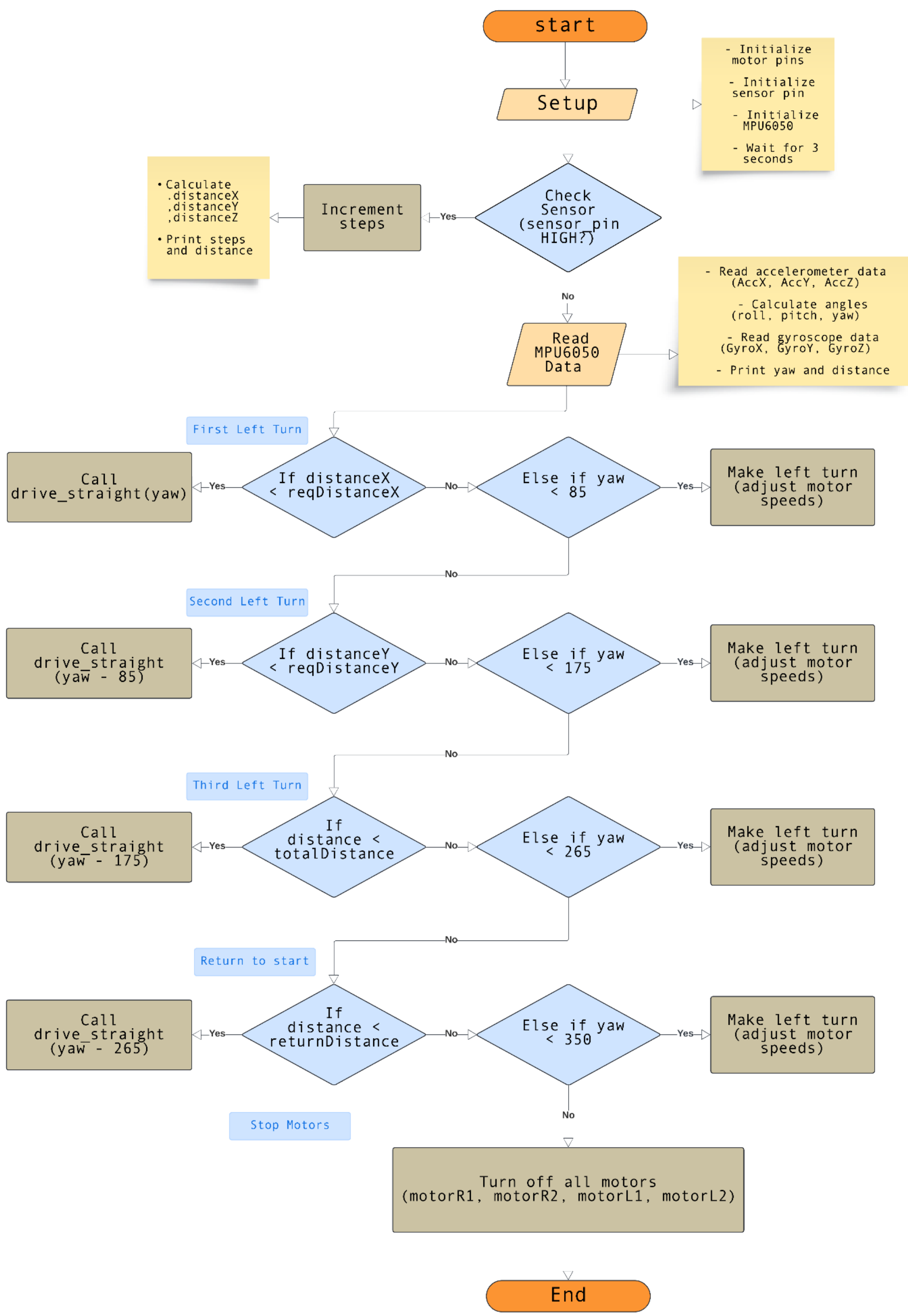
Fig 2.6 The Rigid body

7. The **Li-Ion 18650 battery** is a compact and efficient power source widely utilized across various industries. Featuring a typical capacity of 2000 mAh and a nominal voltage of 3.7V, it offers reliable performance for a multitude of electronic devices. Its flat top positive cap and rechargeable nature enhance usability and longevity.

   With dimensions of 65mm in length and 18mm in diameter, the Li-Ion 18650 battery shown in Fig 2.6 is designed to fit seamlessly into a range of applications without compromising on power output. Furthermore, its safety features include a discharge end voltage of 2.5V and a charging maximum voltage of 4.20V, ensuring optimal performance and longevity.

Fig 2.6 Li-Ion 18650 battery

FlowChart


start
Setup
- Initialize motor pins
- Initialize sensor pin
- Initialize MPU6050
- Wait for 3 seconds
Check Sensor (sensor_pin HIGH?)
Yes
Increment steps
• Calculate .distanceX .distanceY .distanceZ
• Print steps and distance
No
Read MPU6050 Data
- Read accelerometer data (AccX, AccY, AccZ)
- Calculate angles (roll, pitch, yaw)
- Read gyroscope data (GyroX, GyroY, GyroZ)
- Print yaw and distance
First Left Turn
If distanceX < reqDistanceX
Call drive_straight(yaw)
Else if yaw < 85
Make left turn (adjust motor speeds)
Second Left Turn
If distanceY < reqDistanceY
Call drive_straight (yaw - 85)
Else if yaw < 175
Make left turn (adjust motor speeds)
Third Left Turn
If distance < totalDistance
Call drive_straight (yaw - 175)
Else if yaw < 265
Make left turn (adjust motor speeds)
Return to start
If distance < returnDistance
Call drive_straight (yaw - 265)
Else if yaw < 350
Make left turn (adjust motor speeds)
Stop Motors
Turn off all motors (motorR1, motorR2, motorL1, motorL2)
End

Conclusion:

This project showed how a small autonomous vehicle can be controlled using real-time sensor data. By using the MPU6050 sensor to measure the vehicle's orientation and the L298N motor driver to control its movement, the vehicle could follow a path, make turns, and stay stable. It demonstrated the basic ideas behind autonomous driving technology using simple and affordable components. The success of this project suggests that similar techniques could be used for more advanced applications, helping pave the way for smarter and safer transportation in the future.

Appendix:

GitHub Code

https://github.com/MahmoudElbhrawy/Autonomous-Vehicle-with-MPU6050