Inertial Navigation and Motion Control of a Two Motor Robot

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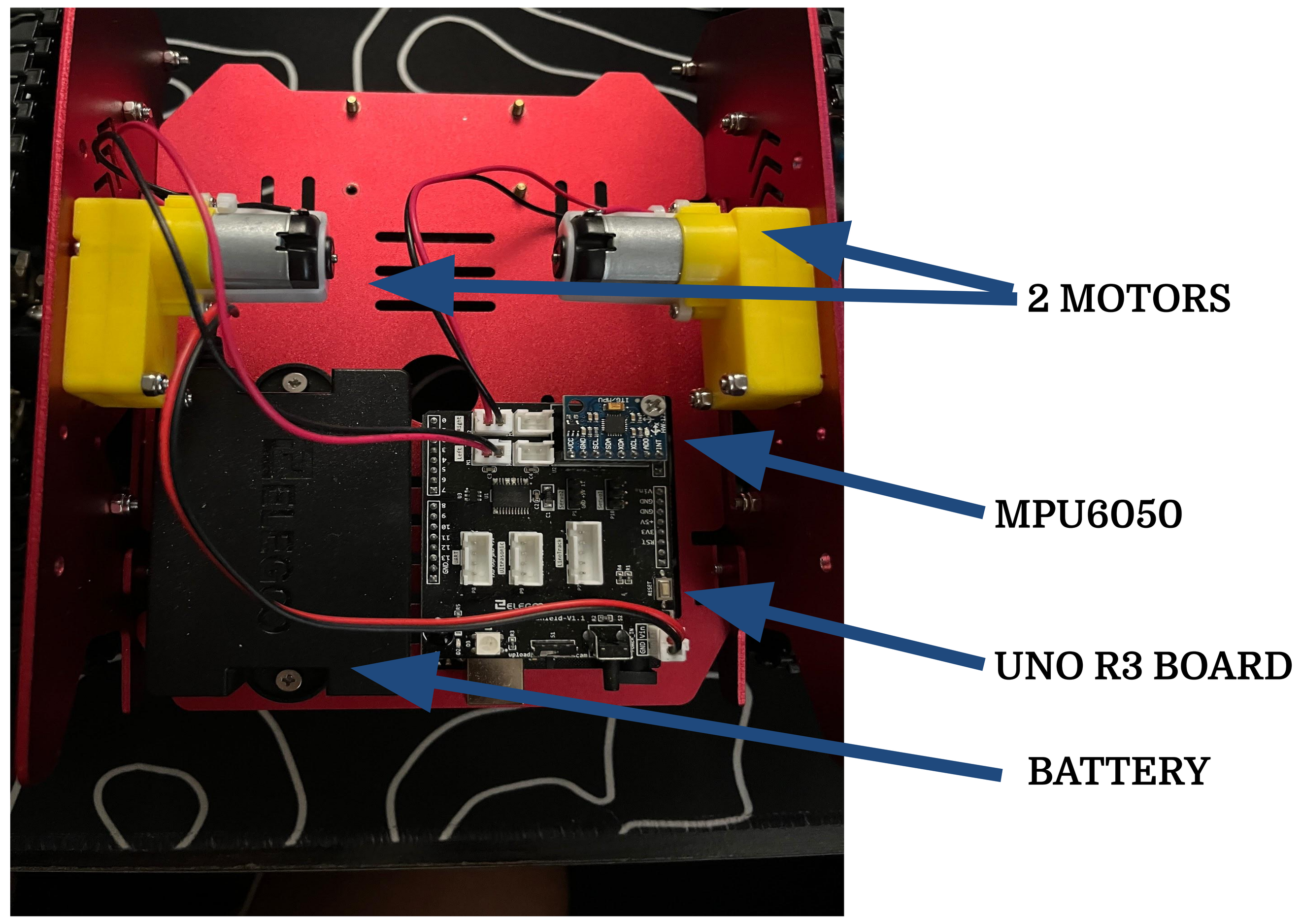
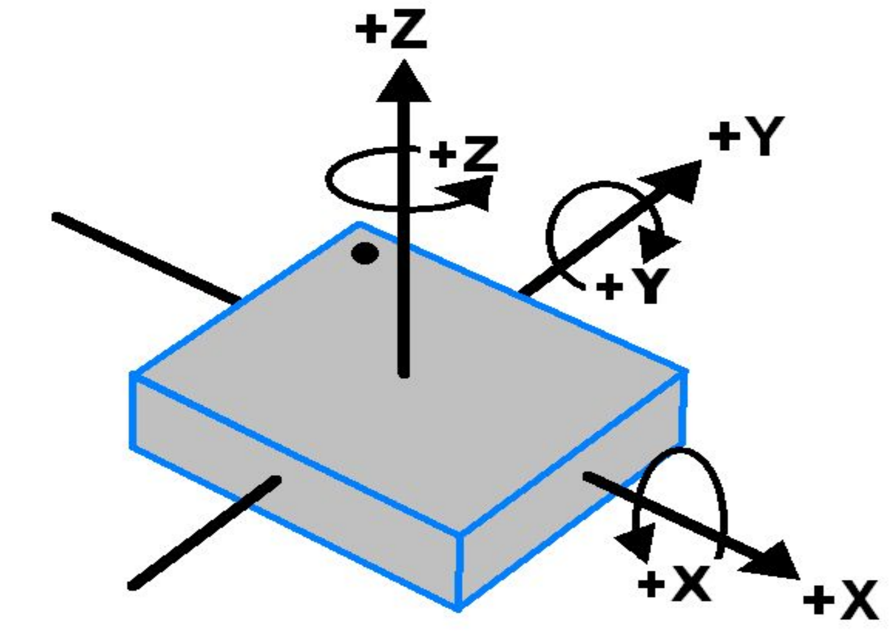
Introduction

In the 21st century, technology has become more than ever an integral part of society. And robotics has especially become more useful than ever. Ranging from self-driving cars, drones, and even owning a robotic pet, the possibilities are truly endless in this sector. Which is why, it is more important than ever to develop a basic foundation when it comes to robotics. As such, this was the perfect topic that Dr. Shuo Wu and I dedicated ourselves to researching over the course of the Finish in Five program. More specifically, the premise of this research project was to code a robot that possessed inertial navigation, with the end goal being that it would be able to autonomously navigate in a straight line.



Setup of Robot



MPU-6050 Orientation & Polarity of Rotation

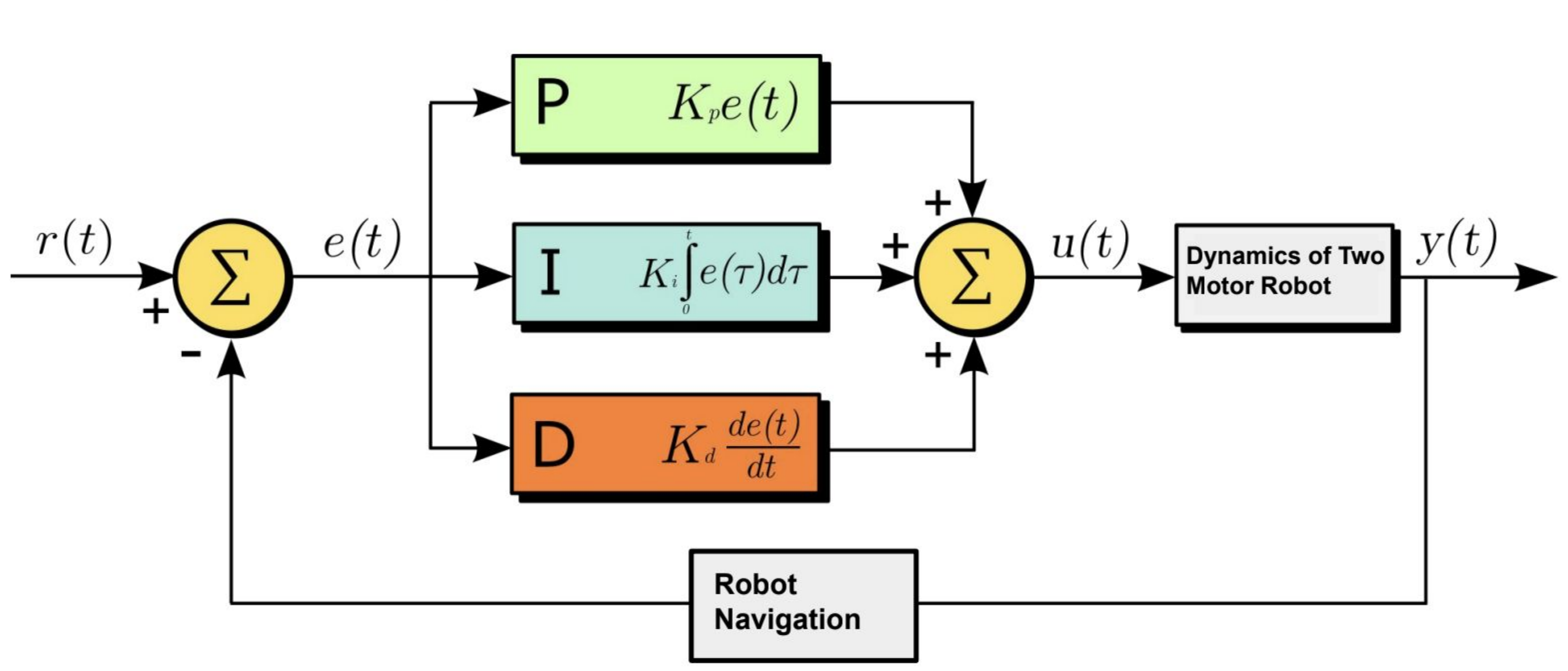
Materials

- MPU6050: This is the 3-axis gyroscope and 3-axis accelerometer which is used to track the robot's motion and orientation.
- 2 Motors/Wheels: The motor and wheels are what help the robot navigate, and paired with the MPU6050, it allows the robot to autonomously navigate in a linear path
- PID Controller: Control algorithm that maintains the robot's linear trajectory
- Arduino IDE/Uno R3 Board: The Arduino UNO R3 board is the "body" of the robot, where all inputs are connected to. Arduino IDE, a programming software is used to write code onto the board, and it is used to communicate between the motors and the MPU6050.

Methodology

- With the MPU6050's 3-axis accelerometer and gyroscope, this allowed us to track down the robot's pitch, roll, and yaw angles.
- Before utilizing the IMU module, it is always calibrated to discover the offset value, to ensure that the data will be as accurate as possible
- By using the PID controller and corrected yaw data from the MPU6050, the left and right motors can be correctly adjusted to ensure that the robot travels with minimal to zero deviation from its straight path.
  - Kp: Allows the robot to steer accordingly
  - Ki: Reduces steady-state error over time
  - Kd: Prevents over-oscillation

System Block Diagram



Results

- After weeks of integrating Arduino libraries and configuring with different setups on the robot, I was finally able to make the robot move in a straight line
- One of the most difficult parts about the result was discovering the correct Kp, Ki, and Kd values
- The values that I settled for were
  - Kp: 10.00
  - Ki: 0.05
  - Kd: 8.00

With a Kp value of 10, this allowed the robot to make strong turns, to prevent deviations. And to prevent over-oscillation from the Kp, the Kd was set to 8 to balance it out. And with a Ki of 0.05, this allowed the robot to strongly adapt to errors over time and correct them accordingly.

The PID values would be implemented into these two algorithms that would allow us to adjust the left and right motors speed:

```
int R = (Kp * error) + (Ki * integral) + (Kd * derivative) + speed;
int L = (Kp * error) + (Ki * integral) + (Kd * derivative) + speed;
```

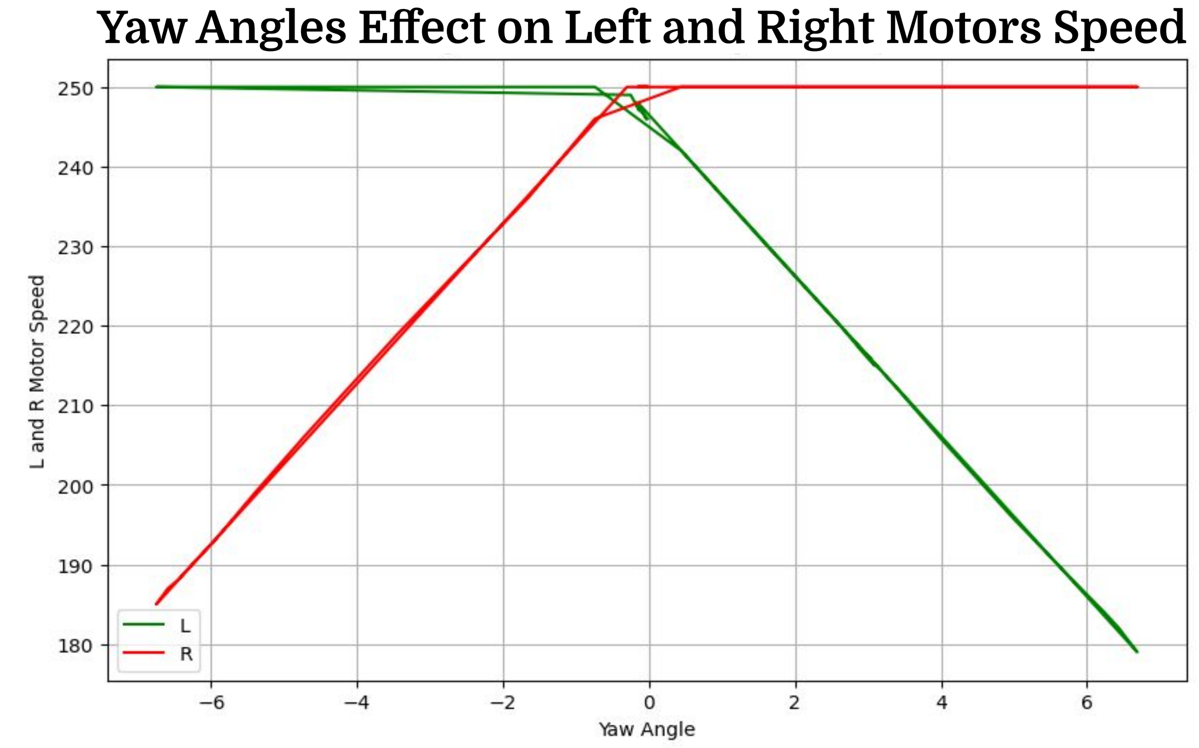
Error: Difference from current yaw angle and target yaw angle

Integral: Error variable added up over time

Derivative: Difference from previous and current error

Speed: Default motor speed of 250

Yaw Angles Effect on Left and Right Motors Speed



Conclusion

Overall, the Finish in Five Program has been an amazing experience for me. By being able to get my hands on doing research with Dr. Shuo Wu, I can confidently say that I now know more about robotics than I did at the beginning of summer! This program has shown me how Fresno State is truly a great college, and it has so many resources for students to ensure that they will become successful in the future. Although I joined into the program while barely graduating high school and lacked a lot of knowledge, Dr. Shuo Wu and everyone else made me feel at home in the program. I understand that the research I completed is only an entry-level project, but I now know that there are endless possibilities out there in the realm of robotics. Overall, it was an amazing learning experience, and the Finish in Five program allowed me to utilize my knowledge onto something I actually felt passionate about. Now entering college this Fall, I am thrilled to apply the research skills that I have learned into the academic projects that I take on in the near future.

Acknowledgements

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Robot Movement Video —>