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Design & Control An Inverted Pendulum

A. Introduction

The inverted pendulum (IP) follows a T-shape structure with 2 BLDC motors at the end of the arms. Its central shaft is attached to a bearing, which allows it to swing left and right up to 90 degrees from the balanced position.

The objective of this project is to program an PID controller to balance the IP even in the case of external disturbance.

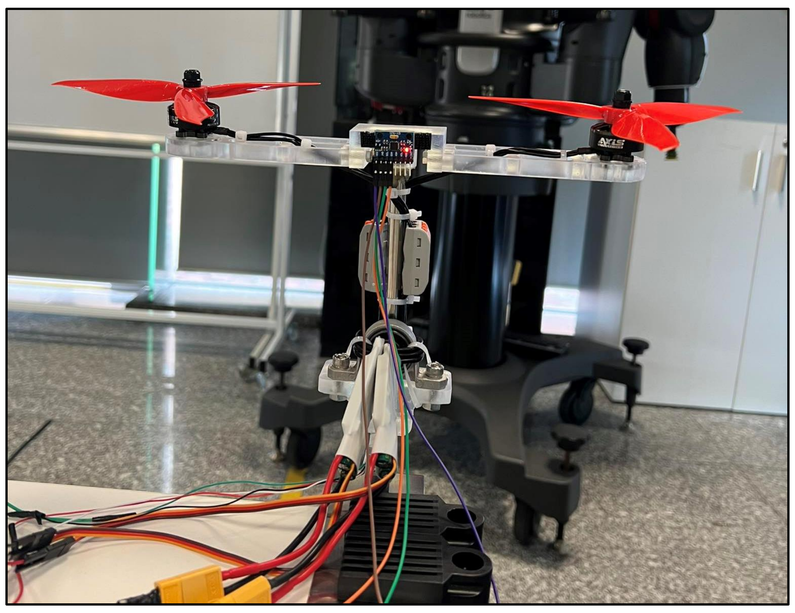
B. Methodology

By attaching an IMU sensor to the IP, as the IP swings, the Roll angle will change and reflect the angle between the central shaft and horizontal surface.

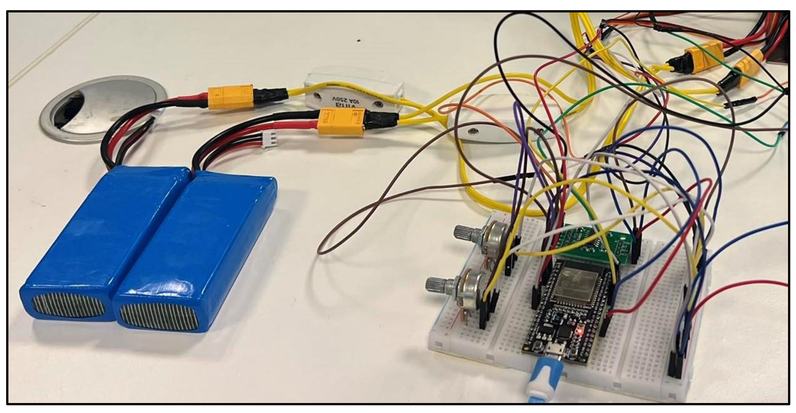
And the job of the PID is to control the 2 motors to create lift force to reduce that angle to zero or balance the IP.

C. Bill of Materials

2 BLDC Motors, 2 30a ESC, GY-521 6DOF IMU MPU 6050.



ESP32-VROOM-32D Microcontroller, HX711, Loadcell and 2 Batteries.



D. Data Visualization Application

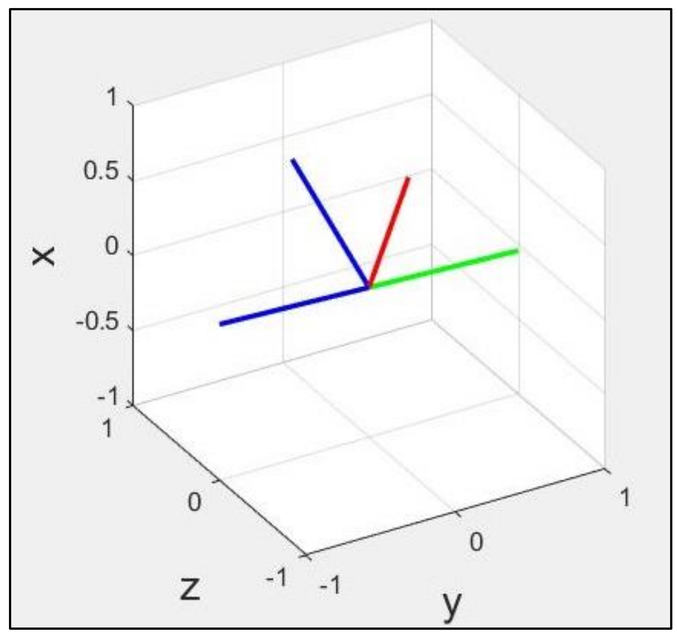
For every IoT project, it is important to have an application with GUI to view and monitor the operations of a system. My major contribution is to create an app with Matlab App Designer. The app will display the system's data as text and graphs.

Roll:	0.06	degrees
Pitch	-0.16	degrees
Yaw	0.38	degrees

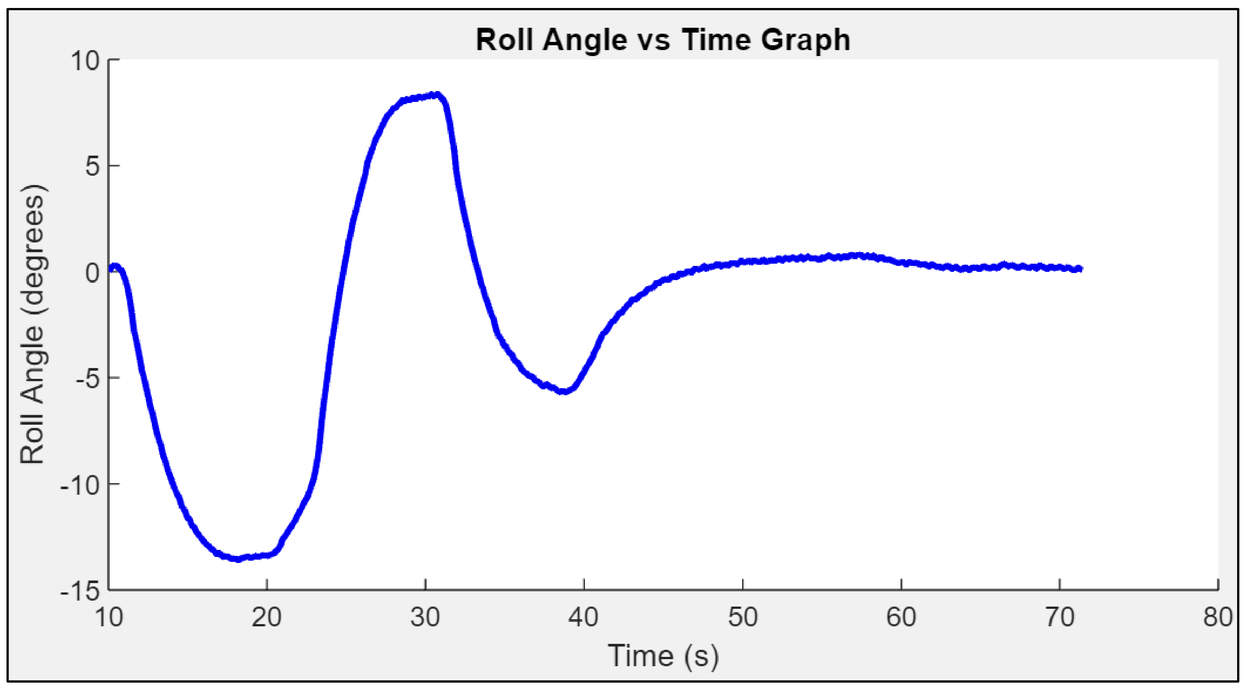
IMU Orientation Display

Throttle 1:	1144
Throttle 2:	1385

Throttle Values Display



IMU Orientation 3D Graph at 23° Roll, 2.44° Pitch and 3.04° Yaw



Through the above graph, we can see that at first, the IP starts with a balanced position (roll = 0). After that the IP gets tilted, it swings left and right make the graph has the fell at around -14 degrees and peak at 10 degrees. After around 40 seconds, the IP became balanced (roll = 0).

E. Results & Contribution

- The project was successful as the PID controller works properly, and the inverted pendulum can balance itself after it is tilted to one side.
- Besides Matlab app, I also work on the Loadcell code and IMU reading and the code integration.
- Lastly, special thanks to Dr. Dinh-Son Vu for supervise and support me and my team on this project.