Project 1 Phase 1 PID controller

状态	ELEC 5660
Lecture Note	proj1phase1.zip

P1p1.zip

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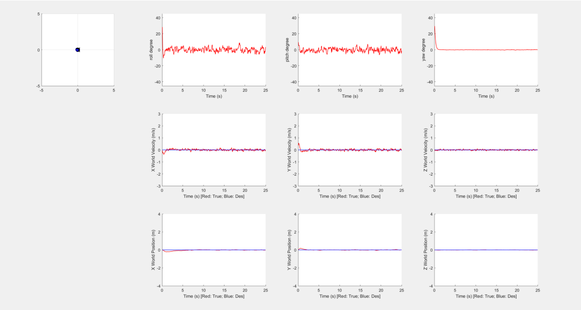
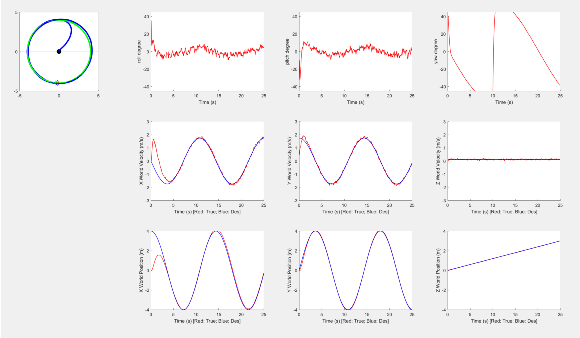
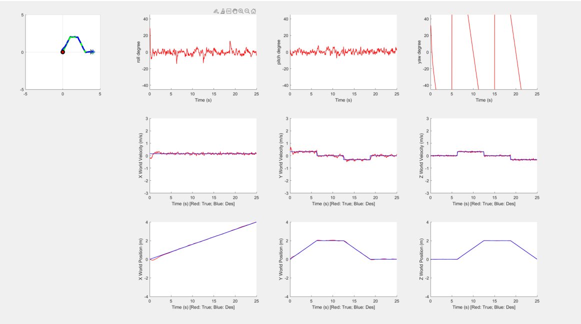


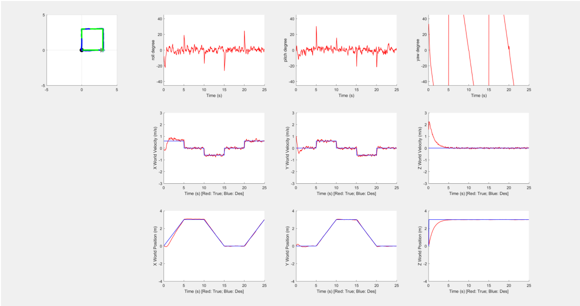
Hovering at (0,0,0)



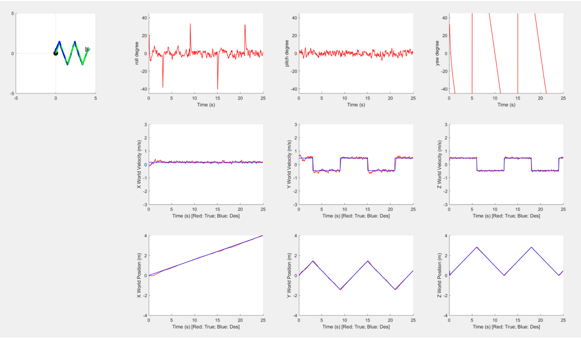
Circle with r=3



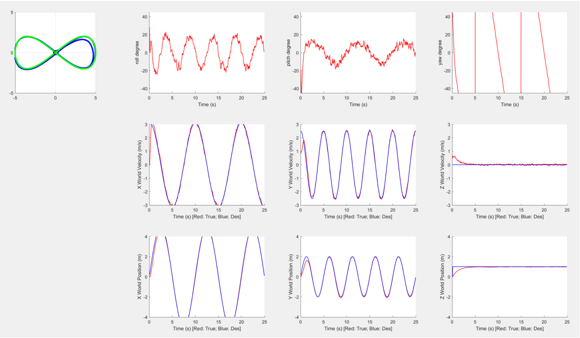
A trajectory passes waypoints (0,0,0), (1,2,0), (2,2,2), (3,0,2), (4,0,0)



A square trajectory in xy plane



A diamond-shaped trajectory



A figure-8 trajectory

Analysis

Parameters turning

Tuning control parameters is essential for optimizing quadcopter performance during trajectory tracking. The **Ziegler-Nichols method** was used to set the Proportional-Integral-Derivative (PID) controller. This approach starts with open-loop testing to determine the critical gain (Kc) and oscillation period (Pc) by observing the system's response to step inputs.

From these values, the PID parameters are calculated: Kp is set at 60% of Kc, Ki is adjusted to reduce steady-state errors, and Kd is fine-tuned to enhance stability during sharp turns. While the quadcopter performed well in smoother trajectories, it struggled with sharp turns, indicating limitations in PID control.

Future improvements could include adaptive control methods and machine learning techniques, allowing for real-time adjustments and enhanced navigation through complex environments.

Filtering function

The filtering function in the PID controller is a simple low-pass filter that smooths input signals to reduce noise in the control output. It averages the current error with the previous filtered result, using a coefficient, α, to determine the weight of the current signal. While this helps stabilize the response by preventing erratic behavior from sudden noise, it can slow the controller's reaction to abrupt changes in input. Adjusting α allows for a balance between smoothing and responsiveness: smaller values increase smoothing but reduce responsiveness, while larger values enhance responsiveness at the cost of stability.

Mean squared error (MSE) results

	Hover	Circle	Square	Plane Square	Diamond	Figure-8
Position MSE	0.004557	0.643381	0.004189	0.249877	0.005382	0.082619

The overall performance metrics indicate satisfactory results. However, it is evident that the PID controller struggles with trajectories featuring sharp angles, such as the plane square (moving at 0.6 m/s). Conversely, trajectories demanding higher speeds without sharp turns (like the Figure-8 at 4 m/s) are tracked more effectively.

Future Directions

There is potential for employing reinforcement learning techniques to achieve control under more complex conditions, such as adaptive trajectory following in varying wind conditions.

Recommendations

Further tuning of the PID parameters through continued adjustments and testing is essential, particularly for sharp-turn trajectories where the quadcopter currently struggles.

Additionally, exploring advanced control strategies, such as reinforcement learning, could enhance trajectory tracking capabilities by enabling the quadcopter to adapt to dynamic environments. Developing algorithms that account for environmental factors like wind and obstacles will also play a crucial role in improving performance. By refining these areas, we can significantly enhance the quadcopter's effectiveness in trajectory tracking tasks.