ME 410 – Week 3

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(a) Text Description (400 words max)

We implemented joystick mapping for thrust and pitch, then built full PID control for pitch. Joystick vertical axis mapped linearly to both desired thrust (thrust_neutral ± thrust_amplitude) and desired pitch (±pitch_amplitude = 10°).

In each control loop we computed:

pitch_error = pitch_desired – pitch_measured // from complementary filter

integral_error += pitch_error // I-term accumulation

pitch_speed = gyro_pitch_rate // from IMU gyroscope

Controller terms were:

P_term = Pgain × pitch_error (Pgain = 10)

I_term = Igain × integral_error (Igain = 0.1)

D_term = Dgain × pitch_speed (Dgain = 1; sign reversed after initial inversion)

Motor commands updated as:

- Front motors (1 & 3): command = thrust + P_term + I_term – D_term
- Rear motors (2 & 4): command = thrust – P_term – I_term + D_term

Outputs clamped to [0,2000]. Safety checks remained: button "B" kill, gyro > 300°/s, |pitch| > 45°, timeout > 0.35 s. For Milestone 1, we logged and plotted thrust, desired pitch, measured pitch, and motor speeds (pitch × 10, desired_pitch × 10) during thrust-only changes, pitch-only changes, and hands-off scenarios—confirming stable attitude, zero steady-state error, and proper damping after correcting the D-term sign.

We progressed through four milestones, first validating the P controller by executing thrust-only and pitch-only commands, observing motor speed, thrust, desired pitch, and measured pitch responses. Next, we implemented the D controller and plotted motor speeds, measured pitch, and gyro-derived pitch velocity under hands-off and joystick thrust tests. We then integrated the I controller, adding integral saturation at ±100 and testing with incremental pitch setpoints until saturation. Finally, we combined P, I, and D into a full PID controller, verifying performance during rapid ±5° back-and-forth pitch oscillations,

slow pitch setpoint changes, slow thrust changes, and hands-off scenarios, all while ensuring safety kills were triggered correctly.

(b) Task Assessment Task Assessment

What went well:

- P, I, and D terms integrated seamlessly, yielding stable pitch control.
- Logged data produced clear plots showing improved damping and elimination of steady-state error.
- Safety interrupts operated correctly throughout all tests.

What did not go well:

- Initial PID fusion applied D_term with incorrect sign, causing incorrect overshoot until reversed.
- Occasional IMU input errors triggered unexpected kill timeouts.

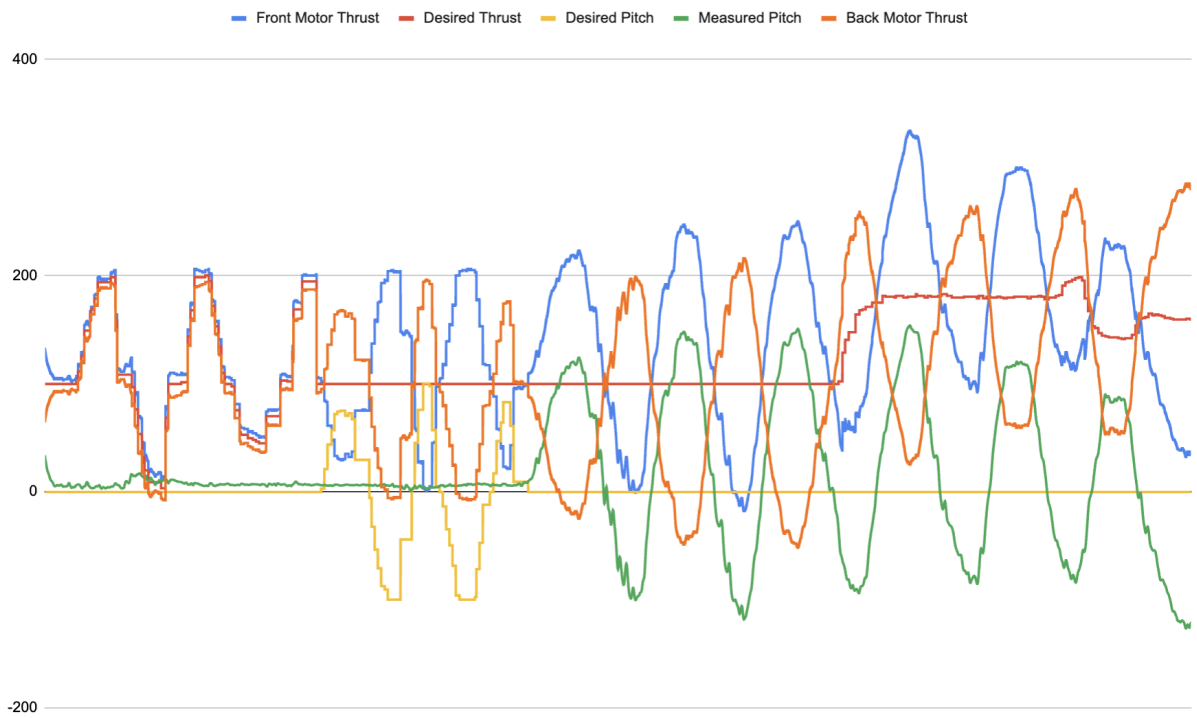
What will you change for next class:

- Modularize PID logic into a separate module with unit tests for sign conventions.

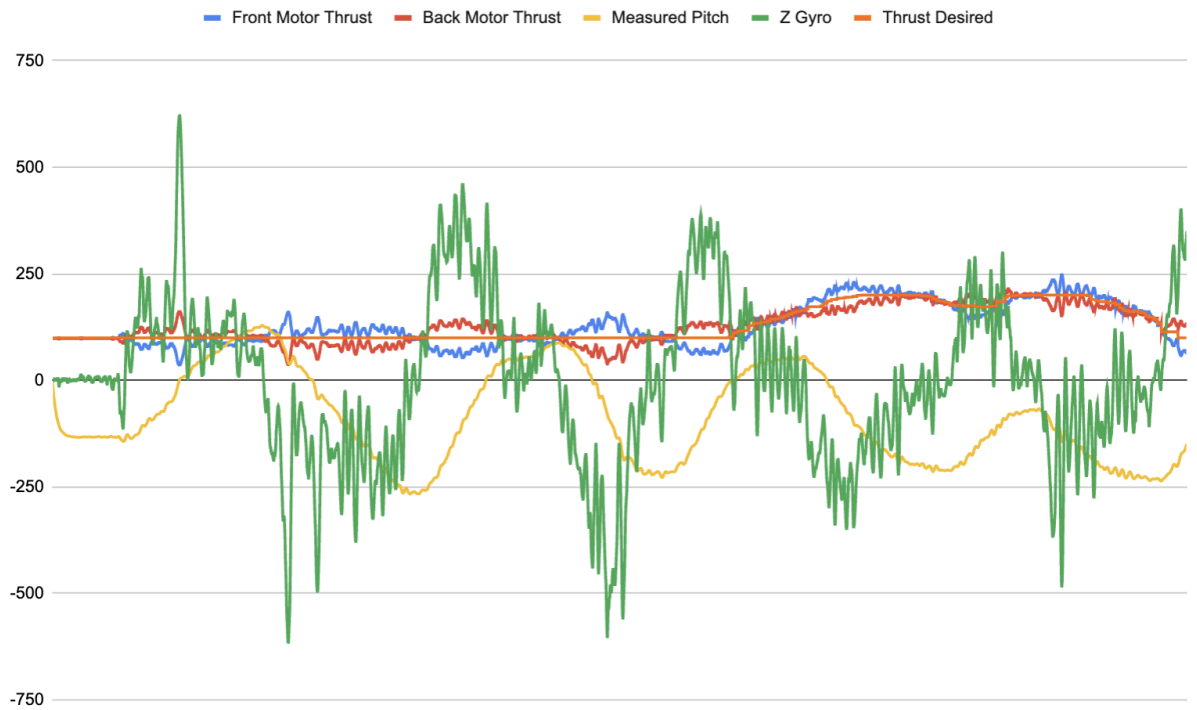
(c) Team Member Effort Report

- Jason & Christopher (each 50%): Collaboratively designed and implemented P/I/D terms, debugged sign conventions, integrated motor command logic, logged and plotted data, and performed hardware testing and report compilation.

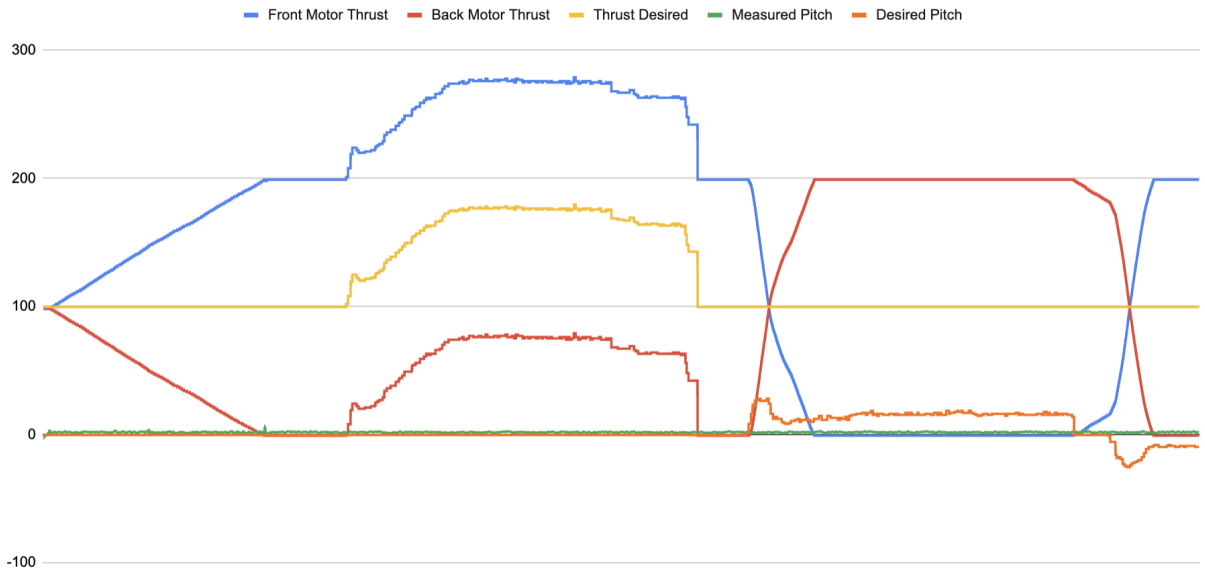
Milestone 1 - Proportional Controller



Milestone 2 - Derivative Controller



Milestone 3 - Integral Controller



Milestone 4 - Full PID Controller