CSL Lab 04 Report

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Video link: https://youtu.be/gfeyDDGjcyk

1. Summarize what you have learned in this lab.
    - We learned the basic intuition and theory of PID control:
        - P (Proportional): Proportionally adjust the output power according the error between the desired setpoint and the actual output.
        - I (Integral): Helps in eliminating the steady-state error by integrating the error over time. It continuously adjusts the output based on the accumulated error, thus preventing the system from being stuck at a steady state.
        - D (Derivative): To dampen oscillations and prevent overshooting, also consider the slope between the current error and the previous error.
2. How you can improve the device and tell us what you did.
    - What we did:
        - Tune the parameters `kp`, `ki`, and `kd` according to the steps suggested in the slides. We tuned `kp` until the it starts to oscillate, then tuned `kd` until the oscillation stops. Finally, we tuned `ki` to eliminate the steady state error.
    - How we can improve the device:
        - We can implement a decaying adjustment rate for the integral component, which assigns a lower weight to errors from longer ago. The `ki` component would be written like: $I(t) := \alpha I(t-1) + k_i \cdot \epsilon$, where ϵ is the error, t is the time sequence, I is the integral component, and k_i is the tuned parameter.
3. Some feedback for this lab to let us know what we can improve.
    - Some problems we encountered while completing the lab:
        - The Arduino Nano exhibits considerable instability, and identical code may yeild inconsistent outcomes.
        - The FIFO data transmission is unreliable, and since it gets stuck frequently, we had to reconnect the cable to fix the issue quite often. (Or is there a specific debugging method to address this issue?)
        - Battery consumption is excessive, we used two batteries within a two-hour trial period and they failed to provide sufficient voltage for motor operation. Consequently, we had to bought our own batteries and recalibrate parameters to accommodate the significant power disparity.
    - We think it would be great if we were offered some guidelines when facing these issues. It would also be better if we had more than one 9V battery for testing.