Lab #2 – Feedback Control of a Ping-Pong Ball

Nathan Fant and Brandon Collings, Group #12, Friday 3:30PM

Exercise 1

1.1 Screenshots & Tables

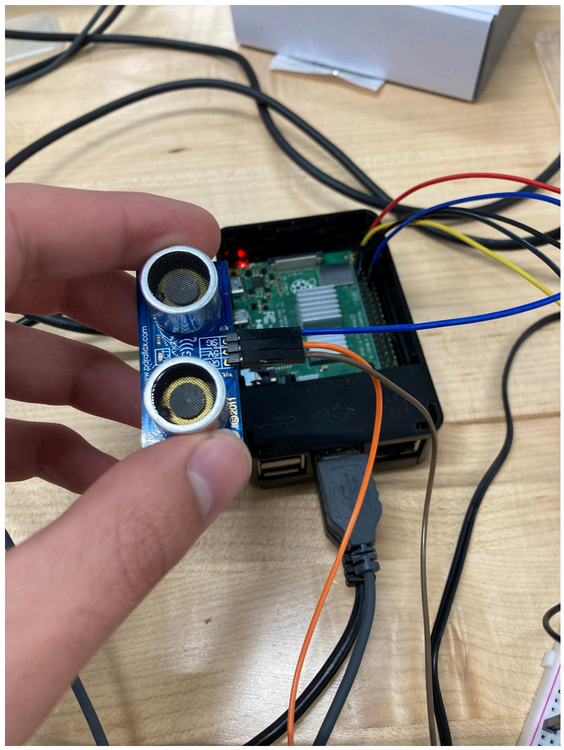
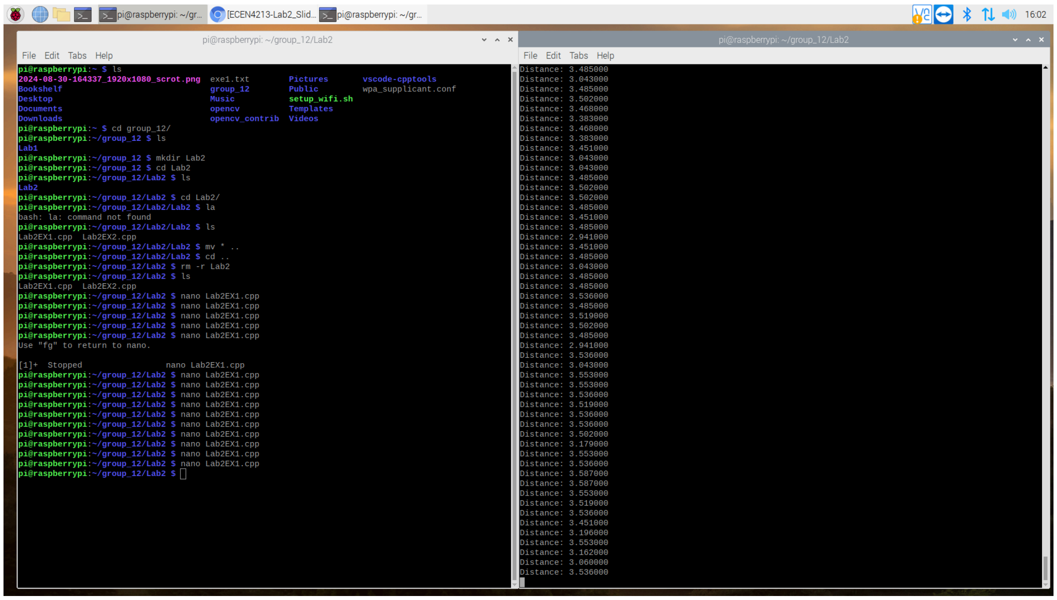


Photo of sensor connected to Raspberry Pi.



Terminal output of Lab2EX1.cpp

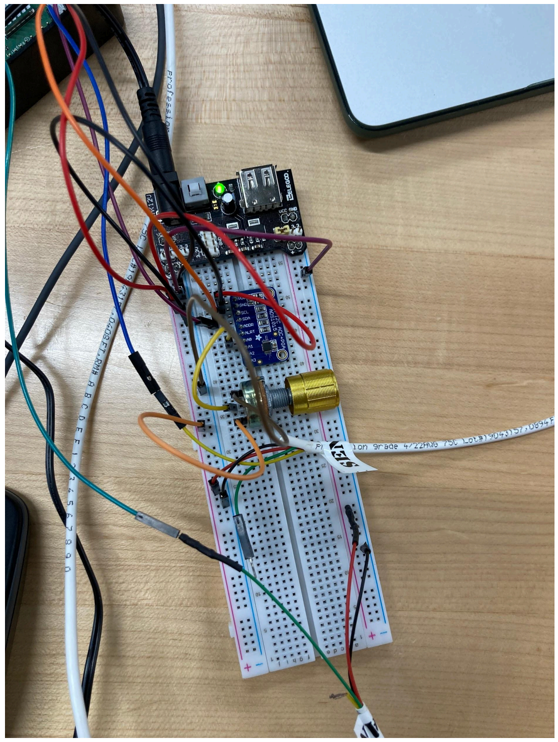
1.2 Summary

Exercise 1 was a simple exercise to familiarize us with the operation of an ultrasonic sonar. We connected it directly to the power, ground, and signal pins on the Raspberry Pi. We then created a program that printed out the distance objects were from the sensor. This was achieved by taking the difference between the send and receive times of the sensor, multiplying them by the speed of sound, and then dividing by two to get the distance of the object.

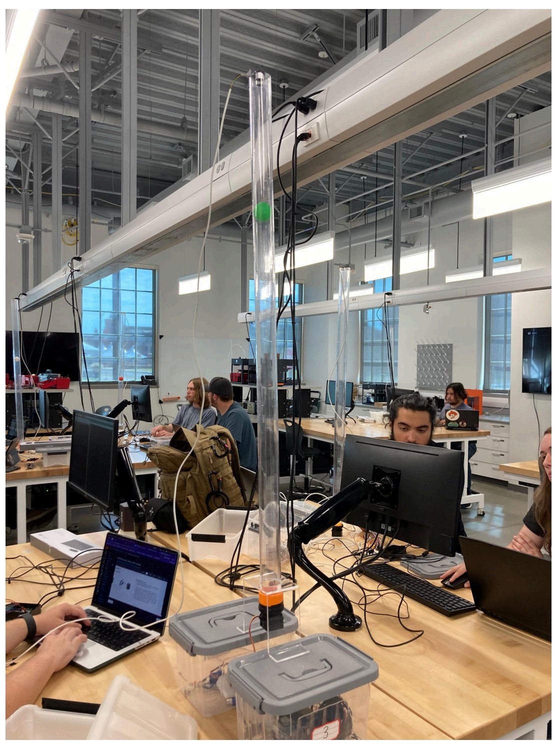
Exercise 2

2.1 Circuit

2.2 Summary



Circuit of potentiometer-controlled fan.



Ping pong at consistent height in the tube.

2.2 Summary

Exercise 2 introduced a much greater challenge. In this portion of the lab, we built a circuit that used a potentiometer and an ADC to control the desired height of a ping-pong ball in an acrylic tube. We used a closed-loop feedback system to achieve this. Our control scheme was a Proportional Integral Derivative (PID) feedback system. The basics of PID are not complicated, but properly tuning a PID system is quite the challenge. It is quite difficult to use any high-level approach to tuning, so it usually comes down to a trial-and-error based tuning method. This can be a bit hard to benchmark, but after enough time, we were able to achieve satisfactory results.

Supplemental Questions

1. Briefly summarize what you learned from this lab.

   In this lab we learned about sonar sensors and their applications in PID control. PID stands for Proportional-Integral-Derivative. PID control is a control loop that uses feedback from sensors to calculate corrective action to turn an unstable output into a stable output. We exercised our knowledge of PID to control the height of a ping-pong ball in a tube.
2. In PID control, how will the values of the P, I, and D parameters affect your control performance?

   Proportional control is the foundation of any PID system. It provides most of your gain and control. The other two parameters act to improve proportional control. The higher you boost proportional, the faster it will react, but the more oscillations the output will have. Next is the derivative component. Derivative acts to modify the output value based on the rate of change. The higher the rate of change, the larger the dampening effect of the derivative component. Last comes the integral element. Integral seeks to make up for small differences between the desired and actual values. If the controller settles in on a wrong value, the integral will build up an error over time until the controller is compelled to move closer to the desired value.

3. How did you decide the value of the P, I, D parameters to achieve a good control performance?

   We approached tuning by using a trial-and-error method. We first began with increasing the proportional coefficient until oscillation began to occur. Next we modified the derivative coefficient until the oscillation was critically damped. Finally, we modified the integral coefficient until the desired setpoint was reached.

Acknowledgements

We certify that this report is our own work, based on our own personal study and research and that we have acknowledged all material sources used in its preparation, whether it be books,

articles, reports, lecture notes, and any other kind of document, electronic or personal communication, We also certify that this report has not previously been submitted for assessment anywhere, except where specific permission has been granted from the coordinators involved.

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References

1. Provided Lab Manual
2. Provided Supplemental Documentation