CprE 488 – Embedded Systems Design

HW-4: PID Control

Assigned: Friday of Week 8
Due: Friday of Week 9
Points: 10

1) Sensor Basics. Review the follow resources:

- Accelerometer Intro: (Note: archived link is slow)
  https://web.archive.org/web/20230329223955/https://www.hobbytronics.co.uk/accelerometer-info
- Gyroscope Intro: (Note: archived link is slow)
  https://web.archive.org/web/20230220084525/http://www.hobbytronics.co.uk/gyro-info
- Trade-offs: (Note: archived link is slow)
  https://web.archive.org/web/20230220083746/http://www.hobbytronics.co.uk/accelerometer-gyro

a) Given a generic 3-axis accelerometer, show the math to derive the Roll and Pitch angle of the sensor. Simplifying assumption: assume the sensor will only be rotated about a single axis (X, Y, or Z), and that the sensor is static when the Roll or Pitch is calculated.

b) Repeat a) for a generic 3-axis gyroscope. Simplifying assumption: assume the sensor begins at a Roll, Pitch, and Yaw orientation of (0, 0, 0) degrees, and is then rotated about a single axis to its final orientation.

2) **PID Control.**

a) Review the following resources:

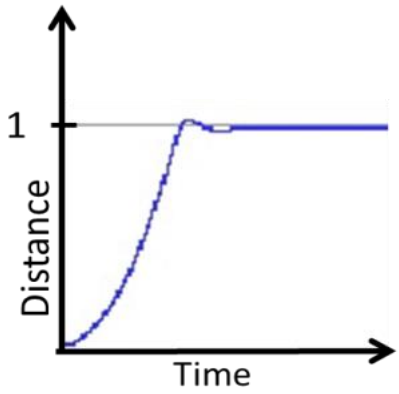
- ***PID Basics*** paragraph (pg2-3): https://class.ece.iastate.edu/cpre488/resources/controls/VyaGup13A.pdf
- Wiki PID Controller Overview: http://en.wikipedia.org/wiki/PID_controller
- Interactive PID Turning App: https://class.ece.iastate.edu/cpre488/resources/controls/PID-Car.htm
  - Original interactive website broken: https://sites.google.com/site/fpgaandco/pid-demo

b) In terms an average eighth grader could understand, explain how the P, D, and I components of a PID controller's correction output moves an object from an initial location to its goal location.

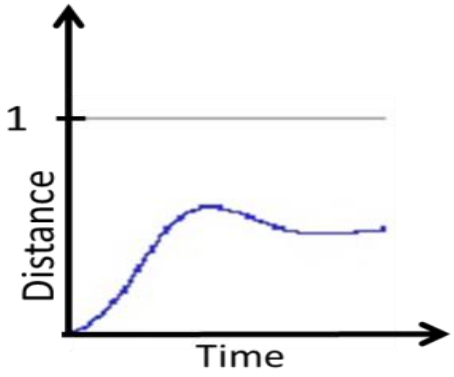
c) Provide pseudo-code for implementing the discrete version of the PID control algorithm.

d) Demonstrate that you can reason about the P, I, and D components of a PID controller. In the examples on the following page, a PID controller provides a corrective force to a ball that is being moved from point 'a' to point 'b' on a 45 degree frictionless slope. The first plot shows the response of the ball moving from a height of 0m to 1m under the control of a of properly tuned PID controller. For each of the remaining plots, the P, I, and/or D constant of a PID controller has not been tuned properly. A statement has been made for each plot. Indicate if the statement is True or False, and defend your answer.

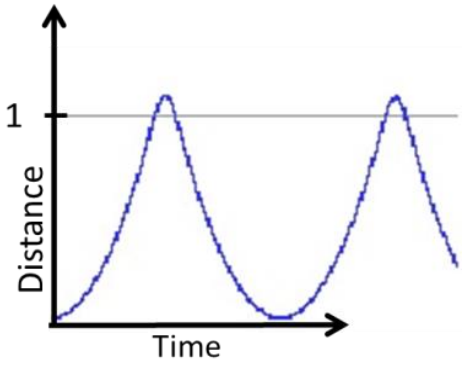
Properly tuned PID



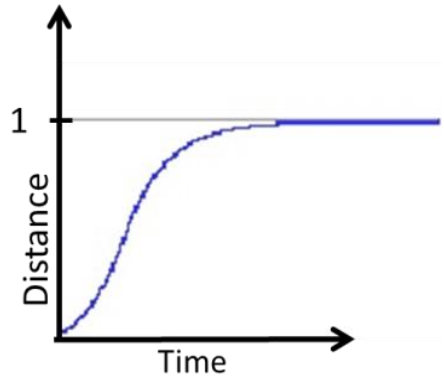
i) P constant is too large



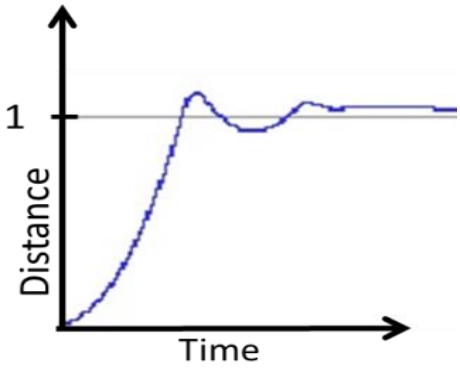
ii) D constant is too large



iii) D constant is too large



iv) I constant is too small



v) P constant too large