Topic: A self-Balancing robot using PID/LQR Technique with a Line Following Capability

Introduction

Two-wheeled Self-balancing robot has become an ideal platform in verifying various control algorithms and a useful tool in civilian and military.

We want to combine the LQR and PID control techniques to achieve a better self-balancing result. Additionally, we also want to implement the line following capability for the robot which will help us to check our control algorithm[1].

Aim

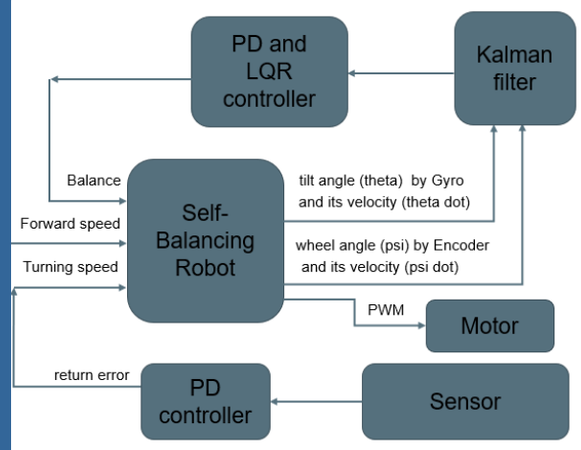
The purpose of our project is to combine two control techniques which are PID and Linear-Quadratic Regulator (LQR) together to achieve the self-balancing function. Moreover, we also want our robot has the line following capability by applying PID controller.

Method

Self-balancing: We combined PID and LQG (combine the LQR controller with the Kalman filter) techniques to achieve the self-balancing capability. We build a state space model for the LQR to decided the Q and R matrixes and use the Kalman filter to estimate the next state.

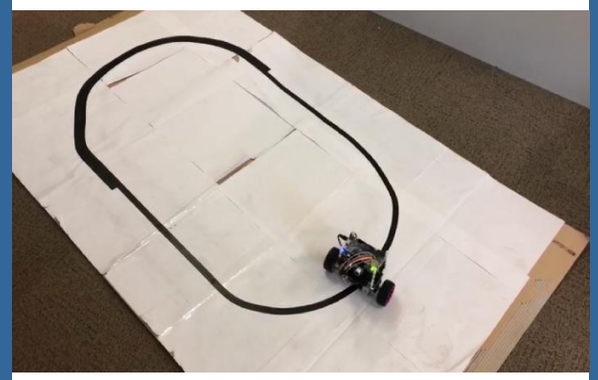
Line following: We used light dependent resistor (8 components) to detect the line. By adding weight to each components the robot will know how to adjust itself to the right track. GPIO 1 is the port that we used to connect our sensor.

Project diagram:



Results

The self-balancing is doing well during the demonstration. After we combining the PID and LQR techniques, robot can maintain balance throughout the demonstration, which proves that our algorithm for the self-balancing part works fine. Robot can self – correct when it deviates the line on the ground. Moreover, thanks to the LQR controller the robot performed well on the uneven board (the performance is show in figure down below) However, when we applying the line following part, there was still some overshot when the robot takes turn. We believe the problem is mainly caused by two reasons: 1. misapplying the parameters of the PID or LQR controller [2]. 2. Malfunction of the sensor some times [3].



Reference

[1] Banggui ZHENG, Yibin HUANG, and Congying QIU, "LQR+PID Control and Implementation of Two-wheeled Self-balancing robot," Applied Mechanics and Materials, vol. Vol. 590 (2014), pp. 339-406, 2014.

[2] M. Engin, "Embedded LQR controller design for self-balancing robot," p. 1, 9 June 2018.

[3] Liang Sun, Jiafei Gan, "Researching Of Two-Wheeled Self-Balancing Robot," Beijing University of Technology Institute of Artificial Intelligence and Robotics, Beijing, 2010.

Conclusion

Combine LQR and PID control technique will truly improve the performance of the self-balancing process. The combination algorithm will cut down the design and has a strong robustness during the self-balancing and line following. This is a challenge work for our group, we appreciate the help of our lecturer: Aline I. Maalouf .

Future Work

We csn build a more accurate model to generate the parameters for our LQR controller to get a better result.