Design and Parametric Control of Co-Axes Driven Two-Wheeled Balancing Robot

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To my dearest mother, father and Lisa for their encouragement and support

Abstract

Nowadays robots can be seen in our daily life. Recently, robotic applications and their wide range of functionalities have drawn many engineers' attentions. Two-wheeled balancing robots are typical example of unstable dynamic system. Understanding the classical theory of inverted pendulum and its dynamic system are initial steps for developing a two-wheeled balancing robot. A balancing robot's structure has two different sections. The first section contains the moving parts or wheels and the second section contains the rigid parts or chassis. An initial physical structure was designed and built and robot's specifications were measured for developing the mathematical model of two-wheeled balancing robot. Existing energies of dynamic model were observed separately and substituted into Lagrangian equation to generate the mathematical model of balancing robot. Mathematical model was generated to observe the behaviour of the model. State-space model of robot was developed and a controller was designed according to state-space model. Tilt sensor and gyroscope provide the feedbacks of closed-loop system. Two-wheeled balancing robot has some key parameters that are directly engaged with system's performance and responses. Parametric studies were done and system responses were observed by variation of key parameters. Observed results from parametric studies were applied into physical model to improve the robot performance. Kalman filter was implemented for fusing the gyroscope angular rate and raw tilt angle. A proportional-integral-derivative (PID) controller was designed to generate the required input for motor controllers to control the rotation of wheels based on the Kalman filter's output.

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Table of Contents

List of Figures

List of Tables