Model Predictive Control

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1 Introduction

This note documents the Model Predictive Control (MPC) method for the two wheel balancing robot. Many people has built similar self-balancing robots. Almost all of them uses PID control as the control strategy. For position estimation, some uses Kalman filters, and others uses complementary filters.

The purpose of using MPC in this robot is not trying to invent a new MPC technique, which usually the case for research papers. But rather I intend to 1) practice MPC and 2) test how well MPC behaves compares to other control schemes.

2 Robot Coordinates

As shown in Figure 2, θ_k and ω_k denotes the angular position at time step k, respectively. Counter-clockwise rotation is positive. u_k is the linear wheel velocity with positive to the right. Robot specifications can be found in Table 1

Figure 1: Robot Coordinates

Specification	Notation	Value
Center of Gravity (CoG)	h	?? 0.2m
Mass	m	?? 1.1kg

Table 1: Robot specification

3 Problem Formulation

The model is a 1-input-2-output model.

$$x_{k+1} = f(x_k, u_k) \tag{1}$$
$$y_k = C(x_k)x_k \tag{2}$$

$x_k = [\theta_k \ \ \omega_k]^T$ is the system state. Linearize Equ 1, we have

$$x_{k+1} = A(x_k)x_k + B(x_k)u_k \tag{3}$$
$$y_k = C(x_k)x_k \tag{4}$$

where

$$A(x_k) = \frac{\partial f}{\partial x_k}, B(x_k) = \frac{\partial f}{\partial u_k} \tag{5}$$