Estimation for Control

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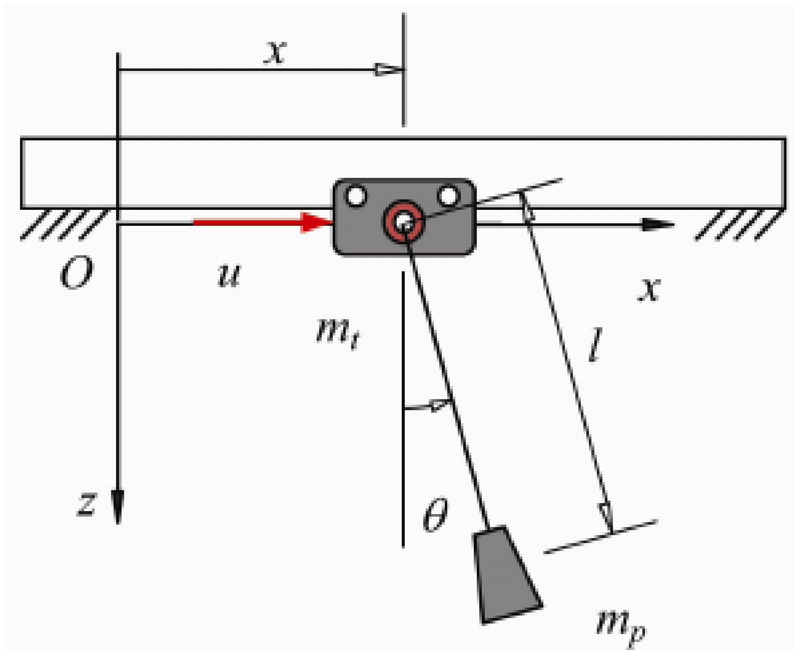
1 Introduction

The purpose of this research paper is to obtain a better understanding of the estimation for control. We selected a random project in order to implement it and to observe its behavior. We start by calculating and simulating the nonlinear model of crane. Afterwards, we the linearize around the equilibrium point. Secondly we calculate a controller to stabilize the given system.

2 2D overhead crane system

Consider a crane system shown in Figure 1. We have a pendulum attached to a support which moves only on the x-axis. The system has only one input u, which is force acting on the trolley. We assume that all the initial data is given (x, mt, l, mp, teta). The purpose is to control the movement displacement of the trolley.



3 Nonlinear model

The equation describing our system are:

$$(m_t + m_p)\ddot{x} + m_p l cos\theta\ddot{\theta} - m_p l\dot{\theta}^2 sin\theta + f_{11}\dot{x} = u \tag{1}$$

$$m_p l cos\theta\ddot{x} + m_p l^2\ddot{\theta} + m_p g l sin\theta = 0 \tag{2}$$

They parameter values are given in the table below.

Table 1: Multirow table.

Parameter	**Notation**	**Value**
Trolley mass	m$_t$	2
Payload mass	m$_p$	0.85
Length of rope	L	0.6
Gravitational acceleration	G	9.81
Damping coefficient on the trolley	f$_{11}$	10

The equations presented in (1) and (2) are nonlinear. In order to create a linear controller, we will linearization our system. In our case the linearize around 0, meaning our trolley is stationary. We will observe the behavior of our system using the Simulink model in Figure 2.

4 Linearized model

We evaluate the derivatives in point 0:

$$\frac{\partial(1)}{\partial \ddot{x}} = mf + mp \tag{3}$$

$$\frac{\partial(1)}{\partial \dot{x}} = f \tag{4}$$

$$\frac{\partial(1)}{\partial x} = 0 \tag{5}$$

$$\frac{\partial(1)}{\partial \ddot{\theta}} = mp \cdot l \cdot cos(\theta) \tag{6}$$

$$\frac{\partial(1)}{\partial \dot{\theta}} = -2 \cdot mp \cdot l \cdot cos(\theta) \tag{7}$$

$$\frac{\partial(1)}{\partial \theta} = -mp \cdot l \cdot \ddot{\theta} \cdot sin(\theta) - mp \cdot l \cdot \dot{\theta}^2 \cdot cos(\theta) \tag{8}$$

$$\frac{\partial(2)}{\partial \ddot{x}} = mp \cdot l \cdot cos(\theta) \tag{9}$$

$$\frac{\partial(2)}{\partial \dot{x}} = 0 \tag{10}$$

$$\frac{\partial(2)}{\partial x} = 0 \tag{11}$$

$$\frac{\partial(1)}{\partial \ddot{\theta}} = mp \cdot l^2 \tag{12}$$

$$\frac{\partial(1)}{\partial \dot{\theta}} = 0 \tag{13}$$

$$\frac{\partial(1)}{\partial\theta} = mp \cdot l \cdot cos(\theta) \tag{14}$$

We simulate our system using the Simulink model presented in Figure 3.

5 State feedback control

In this part we will calculate a state-feedback control for our the linearized and nonlinearized model. We consider the system:

A = $\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 5.0031 & 0 & 0 \end{bmatrix}$