Faculty of Engineering and Materials Science
Mechatronics Engineering Department

Nonlinear and Adaptive Control

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Assignment (2)

Due date: Saturday 24/11/2018

Name	
ID	
Group number	

Note:
Assignments not Submitted in this form will NOT be accepted.
Cheating will not be tolerated and it's your responsibility to ensure the genuineness of your Work.
Assignments are graded.
The simulations part will constitute 50 % of the quiz's grade.

Problem 1

The physical model of a cart moving with position x attached to it a pendulum oscillating with angle θ , with cart equipped with a linear motor for providing input force and the pendulum is un-actuated. The objective of the control design is to make the cart position x follow desired position trajectory x_d with keeping the oscillations of the pendulum within stable bounds.

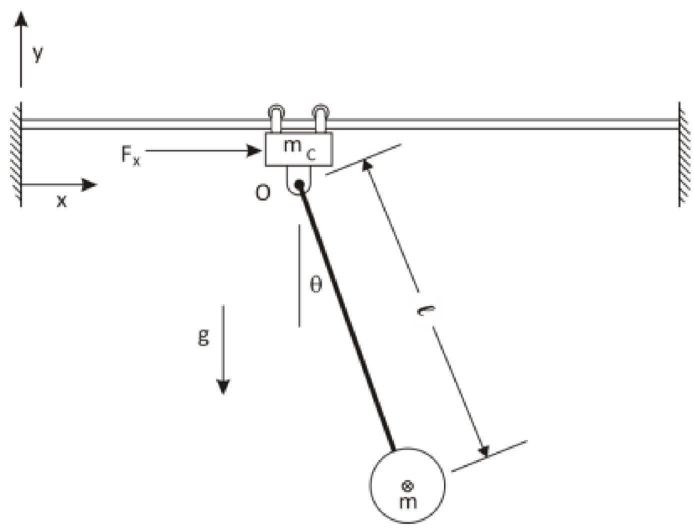

Figure 1 – Pendulum on cart

Using Lagrangian equations, it can be easily shown that the dynamic equation of the pendulum-cart system is

$$(m_c + m)\ddot{x} = F_x - B_x\dot{x}$$
$$glm\sin(\theta) + lm\ddot{x}\cos(\theta) + ml^2\ddot{\theta} = -B_a\dot{\theta}$$

Requirements:

1) Put the system in state space representation using the following states: ($x_1 = x$, $x_2 = \dot{x}$, $x_3 = \theta$ and $x_4 = \dot{\theta}$).

2) Design an input/output linearization feedback control law for F_x:

   a) Find the relative degree of the output.

   b) Transform the system into the normal form.

   c) Design a trajectory tracking feedback control law.

d) Is the internal dynamics stable?

3) Using MATLAB/Simulink, implement the controller for a pendulum-cart system using the following numerical values:

Parameter	Value
m_c	0.7 [Kg]
m	0.32 [Kg]
B_x	15 [N.s/m]
B_a	0.0015 [N.s/m]
l	0.44 [m]
g	9.81 $[m/s^2]$

a) Provide screen shots of the Simulink model.

b) Provide screen shots of the time response of all states and desired position of cart where desired position is 0.2 m.

c) Comment on your results.

Simulate for 10 seconds for zero initial conditions.