FH Joanneum

Graz

Model Based Design

Balanbot

Training Unit 05

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Graz, December 20, 2018

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Contents

Introduction

Part I
Laboratory Sesseion 06

1 Model

$$\ddot{x} = \frac{1}{M}\sum_{cart} F_x = \frac{1}{M}\left(F - N - b\dot{x}\right) \tag{1}$$

$$\ddot{\Theta} = \frac{1}{I}\sum_{pend} \tau = \frac{1}{I}\left(-Nlcos\Theta - Plsin\Theta\right) \tag{2}$$

$$N = m\left(\ddot{x} - l\dot{\Theta}^2 sin\Theta + l\ddot{\Theta}cos\Theta\right) \tag{3}$$

$$P = m\left(l\ddot{\Theta}^2 cos\Theta + l\ddot{\Theta}sin\Theta\right) \tag{4}$$

[TODO - Figure of Model]

2 Discretization from non-linear model

2.1 Places for discretization

2.2 Zero force response

2.3 Positionstep

3 Linearization

$$x = \frac{4.126e-06s^2 - 0.0001025}{2.3e06s^3 + 4.128e07s^2 - 7.172e-05s - 1.025e-05} \tag{5}$$

$$\theta = \frac{1.045e-05s}{2.3e-06s^3 + 4.182e-07s^2 - 7.172e-05s - 1.025e-05} \tag{6}$$

4 Discretization linear model

4.1 Forward Euler

$$z = e^{sT} \approx 1 + sT \quad \rightarrow \quad s \approx \frac{z-1}{T} \tag{7}$$

$$hallo \quad = \quad hallo \tag{8}$$

4.2 Backward Euler

$$z = e^{sT} \approx \frac{1}{1+sT} \quad \rightarrow \quad s \approx \frac{z-1}{Tz} \tag{9}$$

$$hallo \quad = \quad hallo \tag{10}$$

4.3 Trapezoidal or Tustin

$$z = e^{sT} \approx \frac{1+sT/2}{1-sT/2} \quad \rightarrow \quad s \approx \frac{2\,(z-1)}{T\,(z+1)} \tag{11}$$

$$hallo \quad = \quad hallo \tag{12}$$

5 System analysis

6 Control function

Part II
Laboratory Sesseion 07

List of Figures