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System Identification Via Linear Least Squares

A Report On The Characterisation Of
A Simple Cart System
Using Matlab

Wim Looman (*92692734*)
wgl18@uclive.ac.nz

Introduction

Wherein the Aims and Concepts of the Report are Introduced

Blah blah blah

Section One and Two

Wherein a Function To Fake the Model Data is Written and Tested

Before starting on identifying the system a good test is to produce a perfect model based off made up parameters and see if the identifier is capable of determining these parameters. Following from this the first step was to create a Matlab function that could take in the C and β parameters that defined the system along with a frequency to evaluate it at (ω) and a time to evaluate it for (t_{end}). This function is simply Equation **??** evaluated at the specified C, β and ω with t ranging from 0–t_{end} at a frequency of 1 kHz.

To test the model function another model function utilising Matlab's in-built `lsim` function was produced. This uses the transfer function from Equation **??** along with the input from Equation **??** to calculate the output.

Both models created were then plotted together with input values $C = 5$, $\beta = 1$, $K_p = 60$, $f = 1.8$ and $t_{\text{end}} = 3$. This can be seen in Fig. 1. Looking at this we can see that the steady state response of the two systems is tending to be the same. The major difference is in the initial response, this is because the model used in the first equation is purely a steady state model whereas the transfer function based model does base its output off the initial conditions.

Section Three (a)

Wherein A Function To Identify the System is Written

Now that a test function has been developed we can work on the identification function. This is simply creating a function that matches equation **??**. It takes in the y vector, t vector and ω frequency and produces the corresponding A_1 and A_2. From these the b and C values can be derived as equation **??** shows.

Section Three (b)

Wherein The Identification Function is Tested

To check the identification function a series of "noisy" sample data streams are created and run through the function. These are based off the test function developed earlier with each y datum multiplied by a normally distributed value. The value used had a mean of 1 and a standard deviation varied between 0 and 0.4 in steps of 0.05. Each of these standard deviations is simulated 100 times and the median and confidence intervals of the series is calculated.

Table 1 and Figure 2 show the median and confidence interval calculated using the

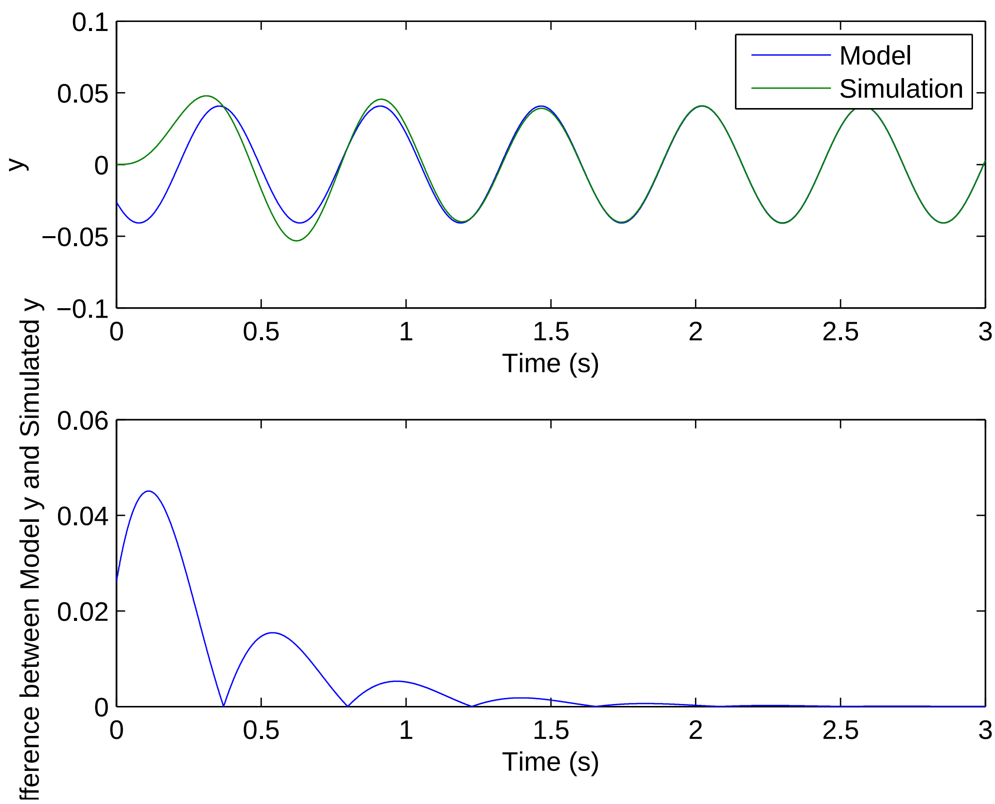

Figure 1: Model vs Matlabs simulated values

test function with $C = 5$, $\beta = 1$, $K_p = 60$, $f = 1.8$, $t_{\text{end}} = 1$ and a varying standard deviation. From these we can see that the identification of the C and β values are quite accurate, the 90% confidence interval is less than 0.3% of the found value and the difference from the correct value is less than 0.2% in the worst case.

Section Four (a)

Wherein the Cart System is Identified

Now that a function to identify the system from a series of data points has been created we can attempt to apply it to the real data.

Noise Level	Median (C)	90% CI (C)	Median (b)	90% CI (b)
0.00	5.00000	0.00000	1.00000	0.00000
0.05	4.99905	0.00164	0.99985	0.00018
0.10	5.00216	0.00388	0.99993	0.00030
0.15	4.99518	0.00512	0.99969	0.00062
0.20	5.00194	0.00802	0.99885	0.00075
0.25	4.99897	0.00869	0.99937	0.00090
0.30	4.99082	0.01174	1.00069	0.00115
0.35	4.99939	0.01295	0.99886	0.00125
0.40	5.00423	0.01503	0.99959	0.00162

Table 1: Testing the Identification Function

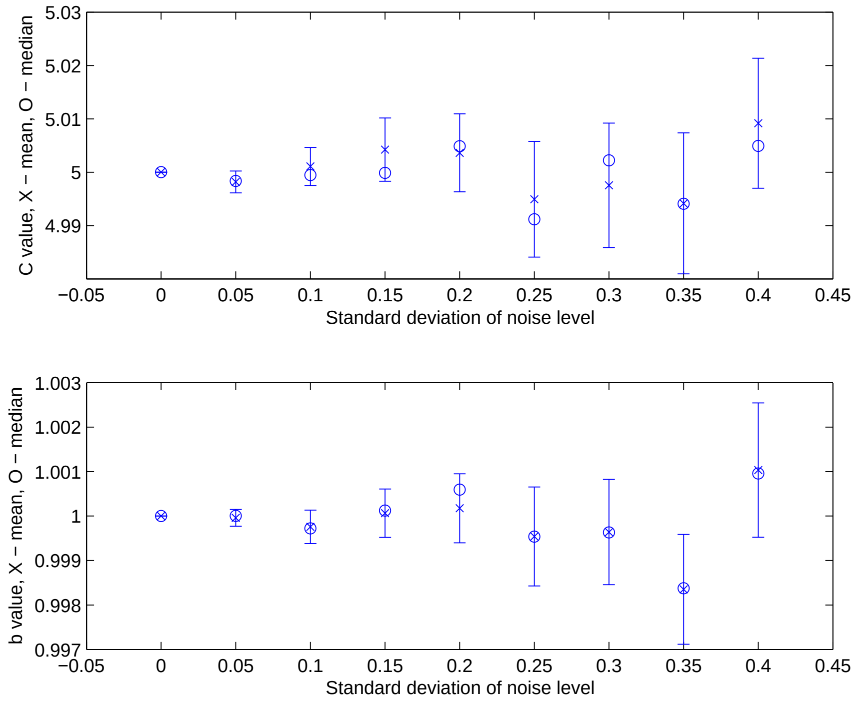

Figure 2: Testing the Identification Function

Section Four (b)

Wherein the Identification is Ridiculed

therefor

Section Five (a)

Wherein the Model and Measured Are Compared

Section Five (b)

Wherein All the Models Are Compared