2022/04/25

EE211 – Assignment 1

System Identification 系统识别

Objective

To familiarise students with the concept of system identification, along with developing some proficiency in practical system identification, using simple system models. Students will use the system identification tools available in Matlab, which will involve both the determination of the structure of the identified model, as well as the model parameters.

Tools and materials:

System identification toolbox, Signal processing

Exercise: 1 2

Using the input and output data provided, determine the probable structure of the system, and then the system parameters for the selected structure

利用所提供的输入输出数据，确定系统的可能结构，然后对所选结构进行系统参数的确定

Procedure

1. Visualise the data provided in the time domain; 画出波形
2. Using any section of the data, determine the best structure for the difference equation model. Use the following functions (see the note at the end of this document):
   a. struc (to set up a range of model structure possibilities)
   b. arxstruc (to evaluate the fit for each of these model structures)

   Note that you will need to plot the loss function for the results of 3.b to try to pick out good candidates.

2个可用的函数

挑选其中部分，来确定最好的差分方程模型

struc
arxstruc
arx

3. Determine the parameters of the model for the selected model structure. Note that there is a function in Matlab to do this (arx) but, for this assignment, you should arrange the data in the formulation:

$$Y = \Phi\theta$$

   where Y contains known (usually output) measurements, ø contains known (possibly input and output) measurements, and Θ is the vector of unknown parameters to be determined.

   Then, use the least-squares formula to determine θ: 最小二乘法

$$\hat{\theta} = (\Phi^T\Phi)^{-1}\Phi^T Y$$

   You need to explicitly implement this formula in Matlab.

在时域中，绘制识别模型的输出，并与提供的输出进行比较。使用与用于模型参数识别的数据不同的数据部分。

4. Plot, in the time domain, the output from the identified model, compared to the provided output. Use a different section of the data than the one that has been used for model parameter identification.
5. Check the parameter estimates, using the ARX function in Matlab. 参数提取 与3进行对比
6. Repeat steps 1, 3, 4 and 5, this time adding varying levels of noise to the output y provided. Analyse the accuracy of the estimates, for at least two different noise levels.

2组 增加不同噪音

请记住，所提供的数据集长度都是10000，但是您可以在数据集的更短部分上执行参数!
检查使用不同数据长度进行参数识别，特别是不同噪声幅度(方差)对参数估计的影响。

Remember, the datasets provided are all of length 5000, but you can carry out parameter over a shorter section of the dataset! Examine the effect, on the parameter estimates, of using different data lengths for parameter identification, particularly for different noise amplitudes (variances).

Optional question 分析频谱

7. Plot the spectrum of the data, by calculating a fast Fourier transform (FFT). This can be done using the FFT function. Note that the spacing between frequency bins is 2*pi/(N*T), where N is the number of data points and T is the sampling period. See if you can identify individual spectral components corresponding to signal and noise.

通过计算快速傅里叶变换(FFT)，绘制数据的频谱。这是可以做到的
使用FFT函数。注意，频率箱之间的间隔是2*pi/(N*T)，其中N是数据点的数量，T是采样周期
看看你是否能识别出对应于信号和噪声的个别光谱成分。

Note on model structure selection

Step 1: using STRUC, define a probable range of model structures, in the form [NA,NB,NK], where NA and NB are the orders of the denominator and numerator respectively, and NK is the order of a pure delay term. For example:

```
>> NN = struc(1:3, 1:3, 0:2);
```

Note that an AR model [NA,NB,NK] corresponds to the following difference equation:

$$y(k) + a_1 y(k-1) + \cdots + a_{NA}(k-NA) = b_1 u(k-NK) + \cdots + b_{NB}(k-NB-NK+1)$$

or to the following transfer function model:

$$H(z) = \frac{b_1 + b_2 z^{-1} + \cdots b_{NB} z^{-NB+1}}{1 + a_1 z^{-1} + \cdots + a_{NA} z^{-NA}} z^{-NK}$$

NOTE*: You can restrict the search for model stuctures to the ranges NA=1:3, NB=1:3,NK=0:2.*

参数限定

Step2: using ARXSTRUC, compute the loss function[1] of each of the model structures (first row of output V in the example below):

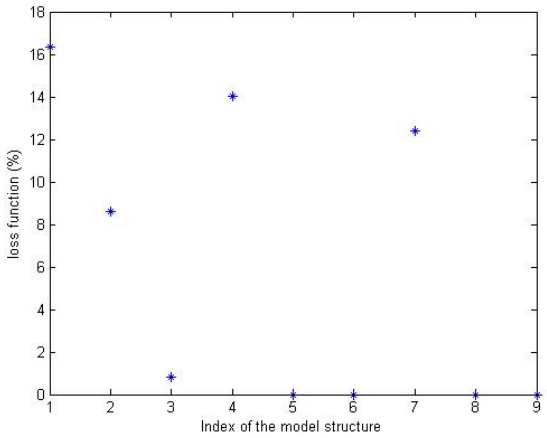
```
>> V = arxstruc(ZE,ZV,NN);
```

计算每个模型结构的损失函数 (下例中输出V的第一行):

[1] i.e. % of data not explained by each model

选择合适的模型结构。有两个标准很重要:损失函数必须尽可能小，但模型也应该尽可能简单。选择可以手动完成(通过绘制损失函数)。例如，结构n. 5和6看起来是很好的候选。

Step 3: selection of the appropriate model structure. Two criteria are important: the loss function must be as small as possible, but the model should also be as simple as possible.
Selection can be done manually (by plotting the loss function). Here for example, structures n. 5 and 6 look like good candidates.



You can also have a look at the function SELSTRUC (see below)!