1

Recursive Least Square Estimation

In this project you will experiment with recursive least squares algorithms and estimation of system parameters using different inputs.

1.1 System description

Use the files provided to you for Project Set 2, to generate the data necessary for this project. For this project we would like to estimate an FOTD model using Least Squares and Recursive Least Squares. You may use your existing estimate of the time delay from the previous project or you may choose to estimate it using LS or RLS. We shall experiment with a variety of inputs. The inputs you shall consider are,

(a). $u(t) =$ zero mean unit variance normal noise
(b). $u(t) = k_p y(t-d)$ (you need to determine the best value for $0 \leq d$)
(c). $u(t) = k_p sgn(y(t))$ where sgn is the sign function

1.2 Problem sets

The problem tasks are as follows (to be submitted by **Tuesday 7th of Mordad 1399**). Please note the following:

- You need to present your results in a report. The report should include all your results. **Marks will only be awarded to results which are present in your report**.
- Your report should be typed, **no longer than 30 pages AND 3000 words**.
- All your m-files should also be submitted.
- Please check that your files run correctly and are **compatible with 64-bit MATLAB 2013b**, prior to submission. If your file do not run correctly no marks will be awarded at all.
- You should have **one main m-file from which all other m-files may be run**. Your main m-file should produce figures and results in exactly the same order in which they appear in your report. Failure to do so will result in a loss of marks

Q1). Determine what is a suitable sample time for this system. Fully explain the reasons behind your choice (you may use information you previously gained about the system).

Q2). Derive a discrete model structure for a FOTD model.

Q3). Using standard least squares, obtain a least squares estimate of the parameters of the model using each on the above inputs.

Q4). Using the RLS algorithm, obtain a least squares estimate of the parameters of the model using each on the above inputs. In each case you need to preset a time graph which shows the estimate of the model parameters at each sample time.

Q5). Present a detailed discussion on the effect of the input on the performance of the RLS algorithm. Your analysis should;

1. Include an analysis of the estimation residuals including a statistical analysis (covariance).
2. Contain suitable graphical means to display the results of your analysis.
3. Contain a discussion on whether the observations are inline with your expectations.

Q6). By experimenting with different initial values for P and $\hat{\theta}$, discuss the impact of the initial conditions on the speed of convergence and the accuracy of the estimate. You need to find a suitable means of displaying your results. What can you conclude from your observations?

Q7). Show mathematically, if the results of the LS and the RLS algorithms should be the same? Use the LS and RLS models you found to verify your prediction.

Q8). Compare the computational CPU and Memory resources required to calculated the RS and the RLS models.