EE 550 - Homework 1

Recursive Least Squares (RLS)

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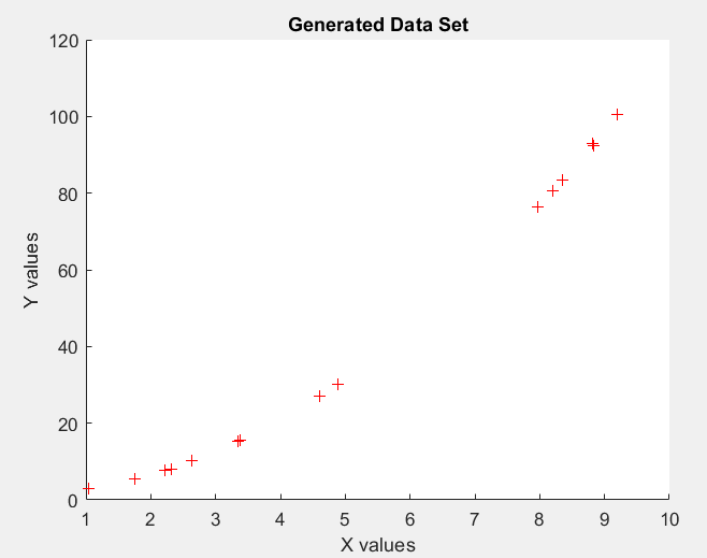
1) In order to generate the vector containing the input data points, I used the rand () function of MATLAB since it generates vectors whose elements are numbers between 0 and 1 in desired sizes. Then multiply the vector by 9 and and added 1 to its elements for them to take values between 0 and 10.

2) Then I generated the zero mean Gaussian noise elements with standard deviation (in 15x1 vector form) by using the formula that generates random numbers from the Normal Distribution:

```
[1]     y = a.*randn(1000,1) + b
```

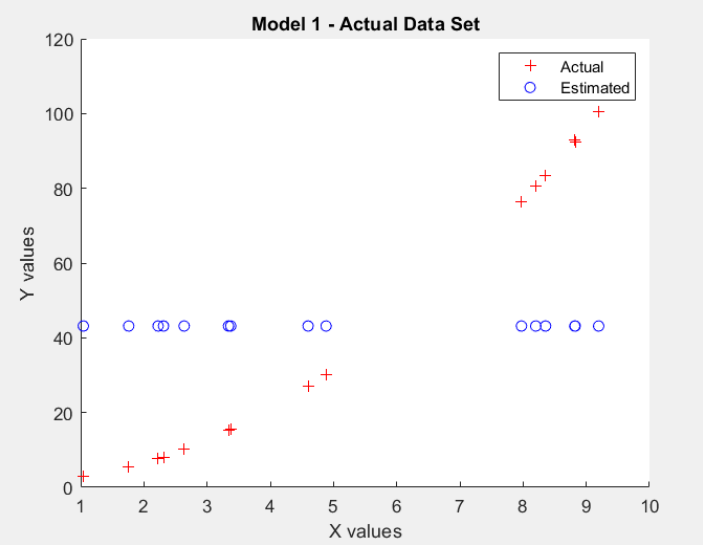
where a is the standard variation and b is the desired mean value.

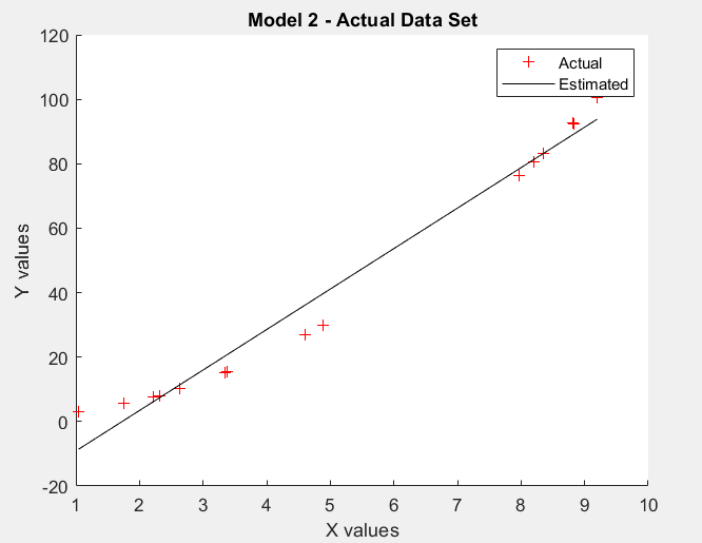


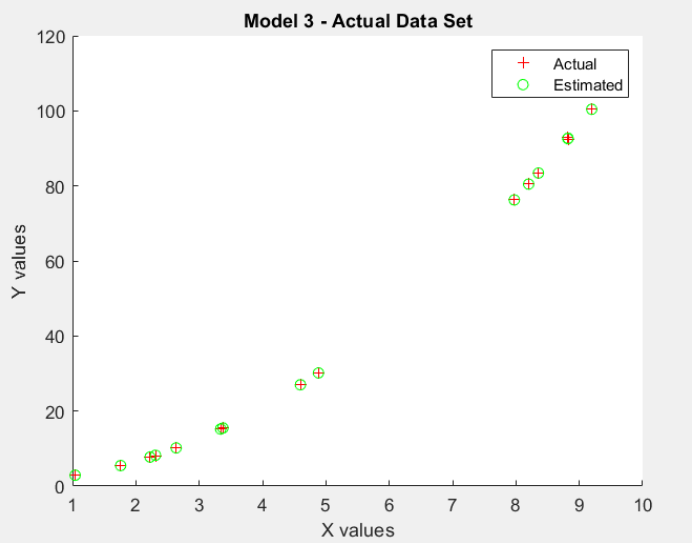
3) In each model the algorithm is constructed with the steps below:
   1) First Φ matrix is constructed with the x values generated in the first part according to the order of the system.
   2) Diagonal matrix P and weight vector w is initialized as 50 (for diagonal values) and 0 respectively.
   3) Then loop is iterated for the number of data points in the data set and in each turn new P value from its old value, K value, error value and the new estimated weight elements are calculated.
   4) Estimated weight vector is used to model the system.cc

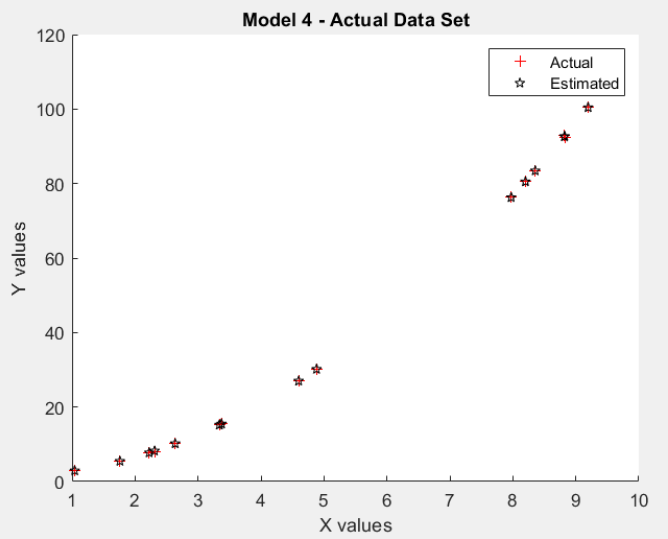
4) RLS errors are calculated with the formula " err=sum((y-y').^2) " where y' values are the y values calculated with the calculated weights in each model.

5) Plots for each model (since the points are unordered, they are given as points):









As it can be seen in the plot above, as the order of the system increases, the model fits better to the actual data set. However, as the order increases, the risk of overfitting in representing the system also grows.

6) RLS errors and estimated parameter can be seen for each model below in the table formed in MATLAB:

```
4×3 table

    Models       Estimated Parameters (theta(1) theta(2) ... theta(n))     RLS Errors
    ______    ____________________________________________________________    ______

    {'Model 1'}      {'43.1571'                                        }        20870
    {'Model 2'}      {'-21.6717      12.5586'                          }       462.57
    {'Model 3'}      {'1.2309     0.41924      1.1273'                 }      0.19771
    {'Model 4'}      {'1.2553     0.39667      1.1329 -0.00038004'}      0.19637
```

In the table above, elements of the weight vector are shown in the second column of each with row (for each model). Also, the error is decreasing as the model fits better to the data set and the order is increasing.

[1] https://www.mathworks.com/help/matlab/math/random-numbers-with-specific-mean-and-variance.html