Results of parameter estimation using the linear formulation and least squares

The whole system's identifiable parameters have been evaluated using the least squares technique for a 2-continuous body system. The convention used in the linearization document is used here also.

The results are as follows

Parameter	Actual value	Case 1	Case 2	Case 3
μ_0	50.0000	-1.0000	50.0000	-0.9990
$\mu_0 y_{S-0c}$	15.0000	-0.3000	15.0000	-0.2997
$\mu_0 x_{S-0c}$	10.0000	-0.7000	10.0000	-0.7005
y_{1J-1c}	0	-0.0000	0	0.0000
x_{1J-1c}	0.5000	-0.0000	0.5000	0.0000

Case 1:

The linear momentum of the system is assumed to be exactly zero as discussed in the linearization document. The results clearly are not even physically correct. The linear formulation assumes momentum to constant throughout although it is unknown. The disparity has been caused because, the momentum ReDySim evaluated, although is very small but it is a non-zero quantity and it is also not constant with time. So assuming the almost zero momentum vector to be perfectly zero has caused such huge differences in the evaluated parameters which has been shown below.

In page 7 of the linearization document, the last equation is as follows

$$AX = B$$

Where A and B both of them have the trajectory data and X the unknown parameter vector

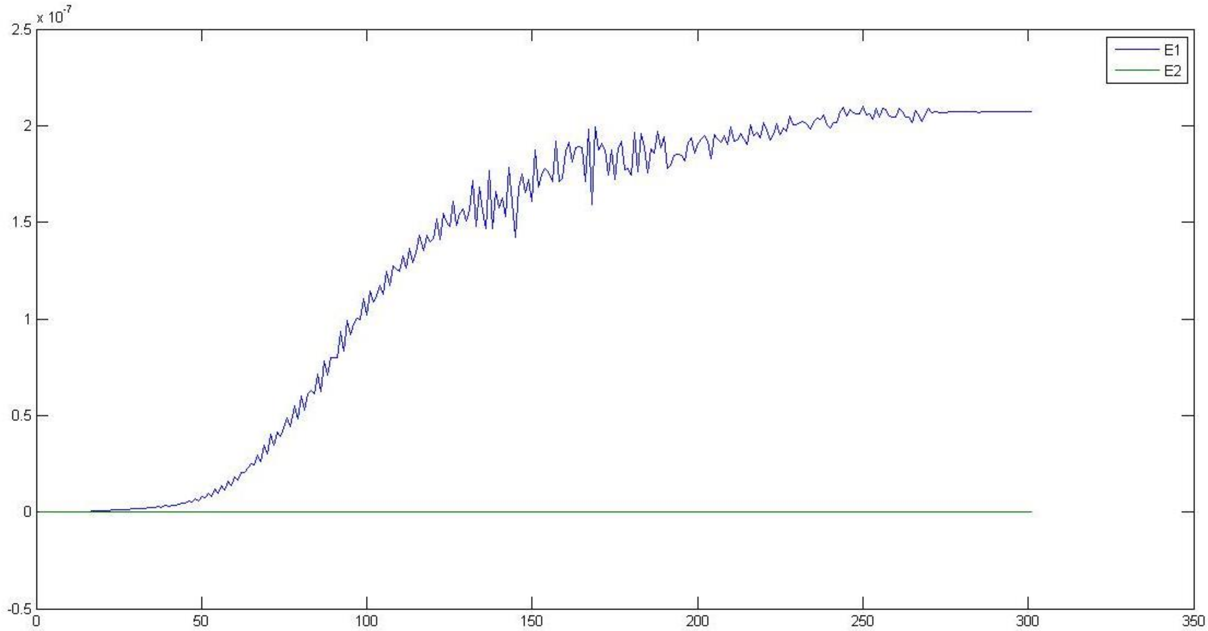
Hence, I have evaluated the following values given in equations 1 and 2 to identify the cause and found out that indeed the small non zero momentum was causing this error in the parameter values.

E1 = $AX_{actual} - B$ → 1

E2 = $AX_{identified} - B$ → 2

If X_{actual} and $X_{identified}$ are same, then both of E1 and E2 have to be same. Also, since least squares has a unique solution, parameter vectors producing same error have to be identical. Also, E2 is the least squares error only.

The plots of E1 and E2 are as follows

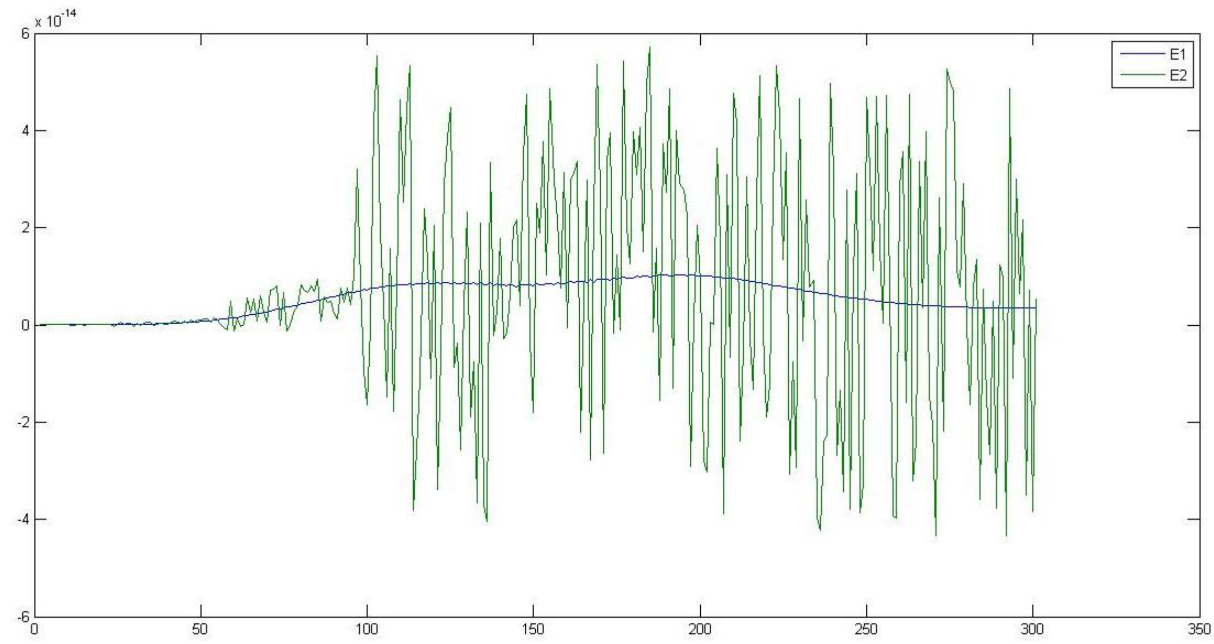


Although, the actual parameters produce an error of the order 10^-7 in B vector, LS solution in the table under case 1 is giving almost zero error. Hence momentum data was augmented from redysim to the vector B to evaluate the parameters again which is case 2.

Case 2:

If the momentum was not constant, B would have had even the momentum data. Hence the momentum data from ReDySim was also incorporated in B and the least squares was performed again. The results match exactly with the actual parameters now.

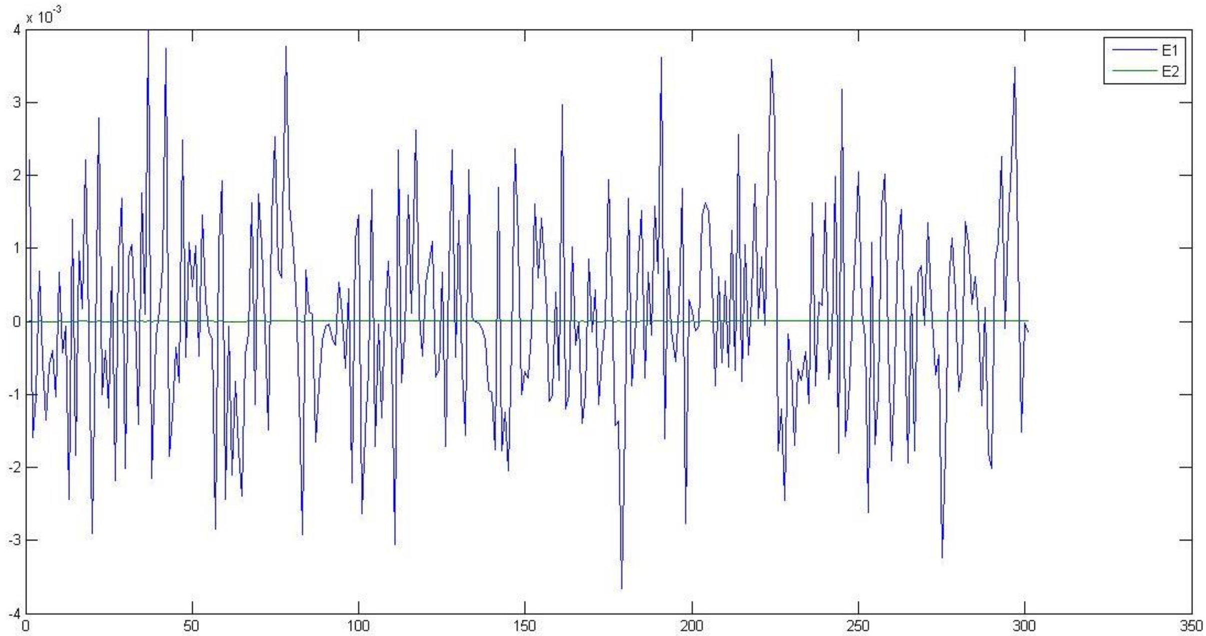
The above defined error and LS is plotted for this case also



Now both the actual parameters and the estimated parameters give error of same order. So, if the momentum is perfectly constant and if the data is free of noise all the parameters can be estimated directly using least squares. The next case considers the performance under the presence of noise.

Case 3:

To the motion data of case 2, Gaussian noise of 1% of its range was added to the data. This slight noise also has produced parameters very far from the actual values. Plots of error and LS are plotted in this case also.



Even our experimental data is effected by noise, which I think has to be carefully treated, before using it for the purpose of estimation. The method using optimization which is giving decent results for center of mass vectors with noise, but worse results for mass and inertia parameters. Even this method is effected by the noise too much. So, we have to implement some technique which eliminates noise as much as possible.

One of the vastly used method in the literature was the Extended Kalman Filtering technique. Fourier fitting mayn't be pertinent to fit the data for base because, we exactly don't know the curve it is following. Since, we know the trajectories given to the arms, we can fit the arms data with the same kind of curve which may now yield new trajectory parameters. For eg if we give sinusoidal position trajectories to the arms, the data can again be fitted with sinusoidal curves with the same frequency used as an input. Noise could be eliminated this way from the arm trajectories, but I'm still stuck at finding a way to eliminate the noise from the base experimental results.