TU Delft **AE4872 (2017) – SATELLITE ORBIT DETERMINATION**

Instructor
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Assignment #1 **Group Size: 1-2 Students** **Due: 17:00h, 18 September, 2017**

Fitting of Doppler Range-Rate Observations

Electronic copy of the report as well as the computer code used should be emailed to the instructor. Overdue submission will cause the reduction of the lab grade by 20% per day (after the four grace days are used up). It is preferred that you use MATLAB. Text as well as code should be your own work.

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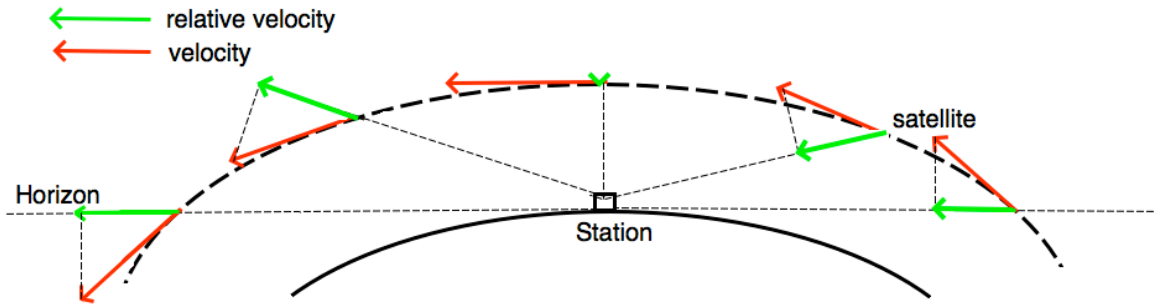
1. Parameter fitting (points: 100/100)

Satellite Doppler tracking uses the Doppler shift in the transmitted radio signal to determine the relative velocity of the satellite with respect to the receiver station. This observable is called range-rate. On top of the building of the Electrical Engineering faculty radio equipment, called DopTrack, is measuring the transmitted radio signal of Delfi-C3, which can be transformed into range-rate. The data set you will be using is from the DopTrack ground station can be found on Blackboard.

Dataset: **Delfi-C3_32789_201602210946.rre**

The data file is an ASCII file and it consists of 3 header lines and 3 columns with data: time since start recording [sec], observed frequency [Hz], and modelled range-rate [m/s]. You can download the dataset using the Matlab function: C = *importdata(filename);*



a) Fit the following function (Chebyshev function of the first kind: see section 9 in the lecture notes) through the **frequency** data using least-squares estimation:

$$f_3(x) = a_0 + a_1 x + a_2 x^3 + a_3 x^5 ,$$

where a0-a3 are the estimated parameters. Determine a0, a1, a2 and a3 (list them in the report) and plot the estimated function on top of the frequency data. Write your own code for the least squares estimation (put code in appendix of your report). (**20/100**)

b) Plot the residual between the data and the estimated function. Determine the following statistical parameters of the residual: plot a histogram of the residuals and determine the mean, median and standard deviation. Also, determine the coefficient of determination (R^2) using the covariance matrix (**20/100**)

c) By inspecting the residual plot it is clear that there is still some information in the data that is not captured by the model. Therefore, you can increase the order of the fitting function. Do the same as for a) but now for the function:

$$f_n(x) = a_0 + \sum_{i=1}^{n} a_i x^{2i-1} .$$

Write the code (put code in appendix of your report) such that you are able to change n to any positive integer, such that it can be put in a for-loop. Be aware, that with increasing n the algorithm can become unstable. Consult Section 9 of the lecture notes to handle these instabilities or normalize the data such that the numerical errors are small. Construct a table that shows the mean, median, and standard deviation of the residuals for n = 3-15. Determine coefficient of determination (R^2) using the covariance matrix. Discuss which value for n you prefer. (**20/100**)

d) Determine the optimal value of n for the given dataset using a partial F-test. Use $p < 0.05$ as the selection criteria. Discuss your approach (**20/100**)

e) Use the optimal n-function in this question, if you did not succeed in d) use n = 6. Determine the time of closest approach (TCA) and the corresponding frequency (FCA) of your preferred model. Compare your results with the values in the header lines. Show the mathematical procedure. (**20/100**)

Instructions for submitting the lab report and code

1. Please write in the beginning of the report how much time you spent on the assignment. This is used to monitor the course load throughout the year. Your name and student number should be on the report, otherwise it cannot be graded. The code should be placed in the Appendix of the report.

2. Name your report file as follows: **Student number_FirstNameLastName_Lab number_anything else**. For other files see the example below.

3. Use TurnitIn system to hand-in your report. For question please send a mail to b.c.root@tudelft.nl

   Thanks!