**Laboratory work 4**

**Determining and removing drawbacks of exponential and running mean**

Performance -Tuesday, April 8, 2016

Due to submit a performance report – Thursday, April 14, 2016

The objective of this laboratory work is to determine conditions for which broadly used methods of running and exponential mean provide effective solution and conditions under which they break down. Important outcome of this exercise is getting skill to choose the most effective method in conditions of uncertainty.

This laboratory work is performed in the class by students as in teams of 2 on April 8, 2016 and the team will submit one document reporting about the performance till Thursday, April 14, 2016. Within your group, you may discuss all issues openly, and discuss and debate until you reach a consensus.

This laboratory work consists of two parts:

1. Backward exponential smoothing
2. Drawbacks of running mean
3. *This part can be done at class or at home.* Comparison of the traditional 13-month running mean with the forward-backward exponential smoothing for approximation of 11-year sunspot cycle.

***Here is the recommended procedure for part I*:   
*Backward exponential smoothing***

1. In lab 3 (part II) you have already applied running and exponential mean to random walk model with noise statistics . In this conditions results of exponential smoothing demonstrated significant shift (delay) of estimations.
2. Please apply backward exponential smoothing to forward exponential estimates.

Объяснить про искажение процесса, суть – больше сглаживается измерительных ошибок.

1. Make visual comparison of results. Plot true trajectory , measurements , running and backward exponential mean. Make conclusions which method provides better accuracy.
2. Compare estimation results of running mean and backward exponential smoothing using deviation and variability indicators.

***Here is the recommended procedure for part II*:   
*Drawbacks of running mean***

First we will analyze a process which rate of change is changed insignificantly and measurement noise is great. Second we will study a cyclic process, and measurement noise is small.

***First trajectory***

1. Generate a true trajectory of an object motion disturbed by normally distributed random acceleration

Size of trajectory is 300 points.

Initial conditions:

Variance of noise ,

1. Generate measurements of the process

–normally distributed random noise with zero mathematical expectation   
and variance .

1. Determine empirically the window size of running mean and smoothing coefficient (forward exponential smoothing) that provide the best estimation of the process using measurements . As this process is not random walk model you cannot apply equations for optimal smoothing coefficient. Подсказка – траектория близка к прямой, но шумы измерений большие.
2. Chose better smoothing method using deviation and variability indicators.

***Second trajectory***

1. Generate cyclic trajectory according to the equation

Periods of oscillations is T=32 steps.

*Hint:* To determine period, please define corresponding angle frequency from equation (radian per one step).

– normally distributed random noise with zero mathematical expectation   
and variance .

Size of trajectory is 200 points.

Initial conditions: .

1. Generate measurements of the process

–normally distributed random noise with zero mathematical expectation   
and variance

1. Apply running mean with window size to measurements .
2. Determine the period of oscillations for which running mean with given for every group window size
3. produces inverse oscillations
4. leads to the loss of oscillations (zero oscillations)
5. changes the oscillations insignificantly

Group 1: ; Group 2: ; Group 3: ; Group 4: ;   
Group 5: ; Group 6: ; Group 7: ;

1. Make conclusions about conditions of 8a,b,c.

***Here is the recommended procedure for part III:***

***(can be made during the class or at home)*:  
*Comparison of the traditional 13-month running mean with the forward-backward exponential smoothing for approximation of 11-year sunspot cycle***

1. Download monthly mean sunspot number from Canvas.

Group 1: data\_group1.mat

Group 2: data\_group2.mat

Group 3: data\_group3.mat

Group 4: data\_group4.mat

Group 5: data\_group5.mat

Group 6: data\_group6.mat

Group 7: data\_group7.mat

1. Make smoothing of monthly mean data by 13-month running mean.

*13-month running mean*

*Comment:*

First six months in the available data are averaged to get the smoothed estimates.

The same with last six months of data.

1. Make forward-backward exponential smoothing of monthly mean sunspot number.  
   Is there a smoothing constant that provides better results compared to 13-month running mean according to deviation and variability indicators?

***Performance report***

1. Performance report should contain all the items listed
2. The code should be commented. It should include:

* Title of the laboratory work, for example

% Converting a physical distance to a grid distance using least-square method

* The names of a team, indication of Skoltech, and date, for example,   
  %Tatiana Podladchikova, Skoltech, 2016

Main procedures also should be commented, for example

%13-month running mean

…here comes the code

1. If your report includes a plot, then it should contain: title, title of x axis, title of y axis, legend of lines on plot.