Laboratory work 4

Determining and removing drawbacks of exponential and running mean. Task 2

I. Comparison of the traditional 13-month running mean with the forward-backward exponential smoothing for approximation of 11-year sunspot cycle

II. 3d surface filtration using forward-backward smoothing

Performance - Friday, October 6, 2017
Due to submit a performance report – Tuesday, October 10, 2017

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 2-4 on Friday, October 6, 2017 and the team will submit one document reporting about the performance till Tuesday, October 10, 2017. 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:

I. Comparison of the traditional 13-month running mean with the forward-backward exponential smoothing for approximation of 11-year sunspot cycle.

II. 3d surface filtration using forward-backward smoothing.

Here is the recommended procedure for part I:

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,
   folder 'Files/Week 1_ October 2_6_2017/Lab 4/data for lab/sunspot/Matlab'

   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

   Format:
   Column 1: year
   Column 2: month
   Column 3: monthly mean sunspot number

2. Make smoothing of monthly mean data by 13-month running mean.
   13-month running mean $\bar{R}$

$$\bar{R} = \frac{1}{24}R_{i-6} + \frac{1}{12}(R_{i-5} + R_{i-4} + \cdots + R_{i-1} + R_i + R_{i+1} + \cdots + R_{i+5}) + \frac{1}{24}R_{i+6}$$

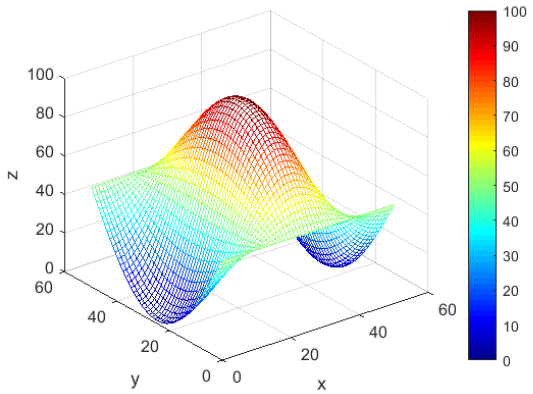
Comment:
First six months in the available data are averaged to get the smoothed estimates.
The same with last six months of data.

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

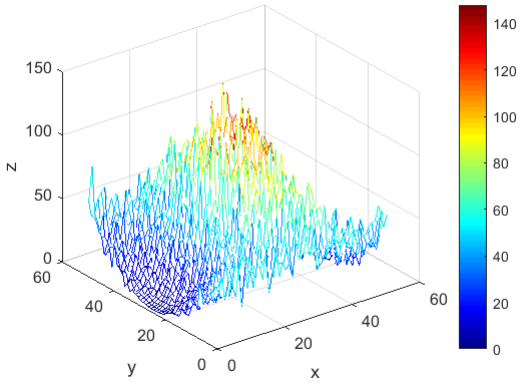
Here is the recommended procedure for part II:

3d surface filtration using forward-backward smoothing.

The goal of this task is to reconstruct the 3D surface (A) on the basis noisy measurements of the surface (B) in conditions of uncertainty.



A. True surface



B. Noisy measurements of surface

1. Download surface data from Canvas,
   folder 'Files/ Week 1_ October 2_6_2017/Lab 4/data for lab/surface/'
   In the folder you will find two Matlab files:
   - noisy_surface.mat (available measurements to work with)
   - true_surface.mat (true surface to compare the estimation results)

2. Plot noisy and true surface for visualization purposes.
   To plot 3d surfaces in matlab, there is a command "mesh".
   You can assign a colormap for the plot, i.e., "colormap jet", "set(gca,'colormap','jet')"
   The plot should be accompanied with the "colorbar".

3. Determine the variance of deviation of noisy surface from the true one.
   Hint: You may reshape the matrix (difference between the noisy and true surface) into one array ("reshape command") and then determine the variance of obtained array.

4. Apply forward-backward exponential smoothing to filter noisy surface measurements.
   The smoothing constant can be $\alpha = 0.335$
   Hint: There should be 4 steps in forward-backward smoothing of a surface.
   Step 1: Forward exponential smoothing of rows (from left to right).
   Step 2: Backward exponential smoothing of results obtained at step 1 (from right to left).
   Step 3: Forward exponential smoothing of results obtained at step 2 along the columns (from bottom to top).
   Step 4: Backward exponential smoothing of results obtained at step 3 along the columns (from top to bottom).

5. Compare visually the obtained estimation results and true surface.

6. Determine the variance of deviation of smoothed surface from the true one. Compare the variance with that from item 3.

7. Try greater and smaller values of smoothing coefficient α and explain the affect on estimation results.

8. General conclusions.

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, 2017
     Main procedures also should be commented, for example
     %13-month running mean
     …here comes the code

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