**Assignment 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 - Thursday, September 10, 2020
Due to submit a performance report – Wednesday, Wednesday, September 16, 2020, 23:59 p.m.

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 4 and the team will submit one document reporting about the performance. 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_2_September_7_11/Assignment4/data for assignment /Sunspot/'

   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
   Group 8: data_group1.mat
   Group 9: data_group2.mat
   Group 10: data_group3.mat
   Group 11: data_group4.mat
   Group 12: data_group5.mat
   Group 13: data_group6.mat
   Group 14: data_group7.mat
   Group 15: data_group1.mat
   Group 16: data_group2.mat
   Group 17: data_group3.mat
   Group 18: data_group4.mat
   Group 19: data_group5.mat
   Group 20: data_group6.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* $\bar{R}$

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

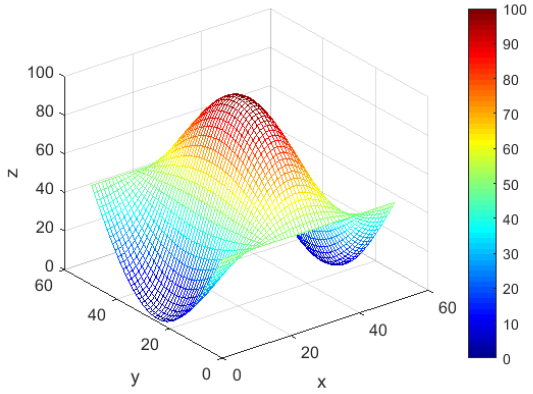
   *Comment:*
   First six months in the available data are averaged to get the smoothed estimates.
   The same with last six months of data.

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

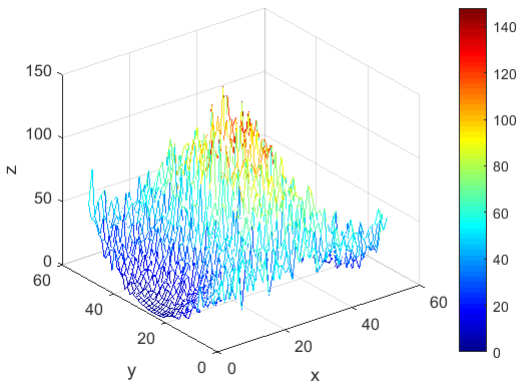
***Here is the recommended procedure for part II:***

**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_2_September_7_11/Assignment4/data for assignment /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)

   Group 1: data1
   Group 2: data2
   Group 3: data3
   Group 4: data4
   Group 5: data1
   Group 6: data2
   Group 7: data3

Group 8: data4
Group 9: data1
Group 10: data2
Group 11: data3
Group 12: data4
Group 13: data1
Group 14: data2
Group 15: data3
Group 16: data4
Group 17: data1
Group 18: data2
Group 19: data3
Group 20: data4

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 $\alpha$ and explain the affect on estimation results.

8. Make conclusions to the Assignment.
   Conclusions should be done in a form of a learning log.
   **A learning log** is a journal which evidences your **own learning and skills development.** It is not just a diary or record of **"What you have done"** but a record of **what you have learnt, tried and critically reflected upon.**

9. Prepare performance report and submit to Canvas:
   Performance report should include 2 documents:
   1) A report (PDF) with performance of all the items listed above
   2) Code (PDF)

**Notes:**

- PDF report should contain the names of team members, number of the assignment
- All questions of the assignment should be addressed
- All figures should have a caption, all axes should have labels, a legend to curves should be given, and short conclusions/discussions/results related to figures should be provided.
- The overall conclusion to the assignment should be provided in a form of a learning log.