**Laboratory work 2**

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

Performance - Friday, April 1, 2016

Due to submit a performance report - Wednesday, April 6, 10 p.m.

The objective of this laboratory work is to formalize a problem of placing discrete measurements on a grid scale to cover all the area of interest. This is needed for processing space data to study multi-dimensional processes. The important outcome of this exercise is the solution of problem without using classical regression models and thus avoiding bulky computations and creation of regression matrix of high dimension.

This laboratory work is performed in the class by students as in teams of 2 on April 1, 2016 and the team will submit one document reporting about the performance till Wednesday, April 6, 2016, 10 p.m. Within your group, you may discuss all issues openly, and discuss and debate until you reach a consensus.

*The description of the problem to be solved*

Let’s denote grid nodes. is determined by the following equation

(1)

– distance between grid nodes.

Satellite measurements at distances are available at sequent times .

But distance between measurements is variable

– random uncorrelated unbiased noise with constant variance

*Problem*

To develop a grid scale with length of bin equal to by minimizing distance between distances and grid nodes . That means to find starting grid node and bin length . The number of grid nodes is equal to .

*Here is the recommended procedure*:

1. First the problem should be theoretically solved on paper then the solution should be find in Matlab. Some formulas that will help you to solve the problem are provided in a separate document **Help\_formula.docx**.
2. Grid nodes will be found by minimizing the sum of squared deviations of measurement from grid nodes . Please determine the corresponding functional . Let’s assign this Equation the number (2).
3. As our final interest lies in finding and please find the dependence of on using  
   Equation (1) and rewrite the functional . Let’s assign this equation the number (3).
4. Let’s introduce a vector with two components and that should be found

And let’s introduce a matrix-row

Rewrite Equation (3) in terms of and

*Hint:*

If you need a help with multiplying matrices please look **item 1** in **Help\_formula.docx**

Let’s assign this Equation the number (4).

1. Find a derivative of functional with respect to

To find the derivative of complex function see **item 2** in **Help\_formula.docx**

To find the derivative of scalar multiple of vectors in respect to vector see **item 3 in Help\_formula.docx**

To minimize the functional the derivative should be equal to zero

You should get Equation (5)

1. Let’s introduce the following denotations
2. Rewrite Equation (5) substituting Equation (6) for .

Let’s assign this Equation the number (7).

1. Determine unknown vector from Equation (7)

Use hint

Let’s multiply both parts on

Then

Let’s assign this Equation the number (8).

**This is the solution of problem.**

*Comment:* Calculaiton of

Then

Sum of natural numbers

Then

1. Download times of measurements from Canvas. Every team will have different files to work with. Every group will have two different data set.
2. Determine and using two different data set and compare results.
3. Determine the covariance matrix of estimation error of vector
4. Performance report should contain all the items listed.
5. 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.