Laboratory work 7
Development of optimal smoothing to increase the estimation accuracy

Performance – Wednesday, October 11, 2017
Due to submit a performance report – Friday, October 13, 2017

The objective of this laboratory work is to develop algorithms to improve Kalman filter estimates, that is of prime importance for many practical control and forecasting problems. This will bring about a deeper understanding of main difficulties of practical Kalman filter implementation and skills to overcome these difficulties to get optimal assimilation output.

This laboratory work is performed in the class by students as in teams of 2-4 on October 11, 2017 and the team will submit one document reporting about the performance till Friday, October 13, 2017. Within your group, you may discuss all issues openly, and discuss and debate until you reach a consensus.

Here is the recommended procedure:

1. Reminder

Smoothing procedure is performed in backward in time and is applied to forward Kalman filter estimates. Smoothing takes into account both current and future measurements and therefore provides improved estimation compared to Kalman filter.

2. The trajectory of a moving object is disturbed by normally distributed unbiased random acceleration a_i with variance $\sigma_a^2 = 0.2^2$. All other conditions are the same as in Lab 5. Develop forward Kalman filter algorithm.

3. Develop backward smoothing algorithm to get improved estimates of state vector X_i

   Hint
   The recurrent algorithm of smoothing is presented on charts Topic_3_Optimal approximation at state space.pdf, page 52.

4. Make $M = 500$ runs of smoothing and compare true estimation error with errors of smoothing $P_{i.N}$ provided by smoothing algorithm.
   (a) error of smoothed estimates of coordinate x_i;
   (b) error of smoothed estimates of velocity V_i;

5. Compare smoothing errors of estimation with filtration errors of estimation.

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.