Assignment 8
Development of optimal smoothing to increase the estimation accuracy

Performance – Wednesday, September 23, 2020
Due to submit a performance report – Tuesday, September 29, 2020

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 4 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.

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.

6. 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.**

7. 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.