**Laboratory work 8**
**Tracking and forecasting in conditions of measurement gaps**

Performance – Monday, October 14, 2019
Due to submit a performance report – Wednesday, October 16, 2019

The objective of this laboratory work is to develop the estimation and tracking algorithm in conditions of measurement gaps, 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 3-4 on October 14, 2019 and the team will submit one document reporting about the performance till October 16, 2019. Within your group, you may discuss all issues openly, and discuss and debate until you reach a consensus.

**Here is the recommended procedure:**

1. Generate a true trajectory $X_i$ of an object motion disturbed by normally distributed unbiased random acceleration $a_i$ with variance $\sigma_a^2 = 0.2^2$

$$x_i = x_{i-1} + V_{i-1}T + \frac{a_{i-1}T^2}{2}$$
$$V_i = V_{i-1} + a_{i-1}T$$

   In general measurements of coordinate $x_i$ are performed every second with variance of measurement noise $\sigma_\eta^2 = 20^2$. Observation interval is 200 seconds. However, there are measurement gaps.

   Probability of measurement gaps is
   a) $P = 0.2$;

   *Hint 1: Create measurements with gaps*
   To create the measurements with gaps, create the random value $\xi$ that is **randomly** distributed at every step $i$. If $\xi_i \leq P$, then $z(i) = NaN$ (gap), if $\xi_i > P$, then $z_i = x_i + \eta_i$.

   *Hint 2: Kalman filter in condition of gaps*
   Kalamn filter is a recurrent algorithm consisting of two procedures, extrapolation and filtration. We do filtration when we have the available measurements. When the measurements are absent, to not interrupt the recurrent process, at filtration step we should indicate that the filtered estimate is equal to extrapolated estimate $X_{i,i} = X_{i,i-1}$ and filtration error covariance matrix is equal to extrapolation error covariance matrix $P_{i,i} = P_{i,i-1}$. We do this as we don't have any information to improve our estimates at filtration step (no measurements).

2. Develop Kalman filter to track moving object under this conditions.

3. Determine filtered and extrapolated errors of estimation (1 step and 7 steps ahead) over 500 runs of filter. Compare them with true estimation errors.

4. Analyze the decrease of estimation accuracy in conditions of measurement gaps.
   Compare results when of probability of measurement gaps is
   a) $P = 0.3$;
   b) $P = 0.5$;
   c) $P = 0.7$;

5. 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.**

6. 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.