

Laboratory work 8

Tracking and forecasting in conditions of measurement gaps

Performance – Thursday, October 15, 2018
Due to submit a performance report – Wednesday, October 17, 2018

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 on October 15, 2018 and the team will submit one document reporting about the performance till October 17, 2018. 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 ξ that is **randomly** distributed at every step i . If $\xi_i \leq P$, then $z(i) = \text{NaN}$ (gap), if $\xi_i > P$, then $z_i = x_i + \eta_i$.

Hint 2: Kalman filter in condition of gaps

Kalman 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 general conclusions.

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

The code should be commented. It should include:

-Title of the laboratory work;

-The names of a team, indication of Skoltech, and date;

-Main procedures also should be commented, for example

% 13-month running mean

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% 13-month running mean

...here comes the code