Estimation of motion parameters in case of changing the quality of measurements data

Yulia V. Tsyganova, D.Sc.(Physics and Mathematics)[1]; Andrey A. Kalyanov [1,*]; Oleg V. Lukin [1],
[1]Ulyanovsk State University, Department of Information Technology

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Abstract

The paper addresses the problem of estimating an object's motion parameters when the quality of measurement data can change unexpectedly. Three motion models are considered: a static object, rectilinear motion, and circular motion. The solution has been obtained as an adaptive extended Kalman filter with the dynamic correction of the measurement noise covariance matrix. The proposed algorithm was implemented and tested in MATLAB.

Introduction

In this paper, to solve the stated problem, an algorithm for estimating the state vector of the object motion model in the form of an adaptive extended Kalman filter with dynamic adjustment of the value of the measurement error covariance matrix is constructed. The algorithm is based on a modification of the solution proposed in [4] for a linear stochastic signal model and a linear discrete filter. In our case, the measurement model is nonlinear, so we use an extended filter instead of the standard Kalman filter.

The purpose of this work is to build a practical algorithm for estimating the parameters of an object's motion under conditions of an unforeseen increase in the noise level in the measurement data.

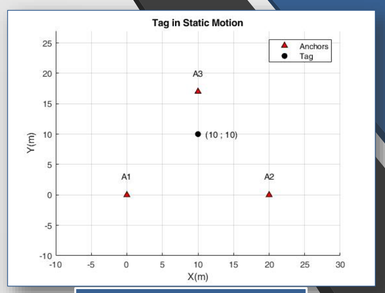

Figure 1: State Motion

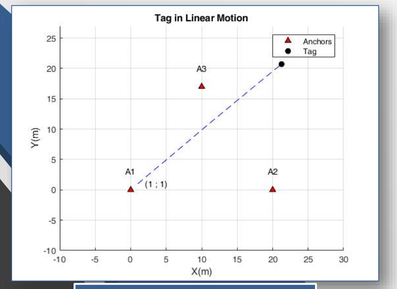

Figure 2: Linear Motion

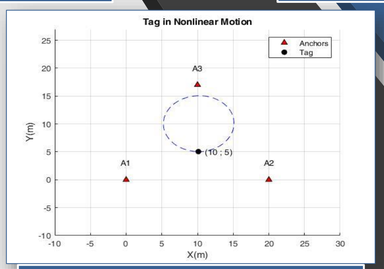

Figure 3: Nonlinear circular Motion

Proposed method

The adaptive filtering algorithm with dynamic estimation of the measurement noise covariance matrix consists of several steps, including

1) calculation of estimates of the state vector and covariance matrices of estimation errors at the prediction and filtering steps of the filter,
2) obtaining the calculated and actual residual covariance matrices,
3) calculation of a special signal function,
4) correction of the Kalman matrix in the filter equations,
5) calculation of the estimate of the covariance matrix of measurement noise.

The results of computer simulation in MATLAB for three motion models confirm the efficiency of the proposed solution.

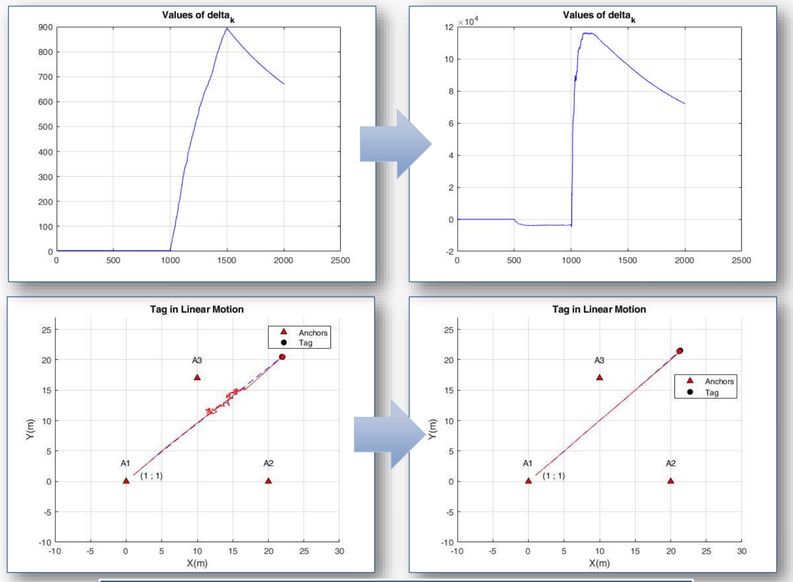

Figure 5: The result of applying the adaptive filtering algorithm (Linear Motion)

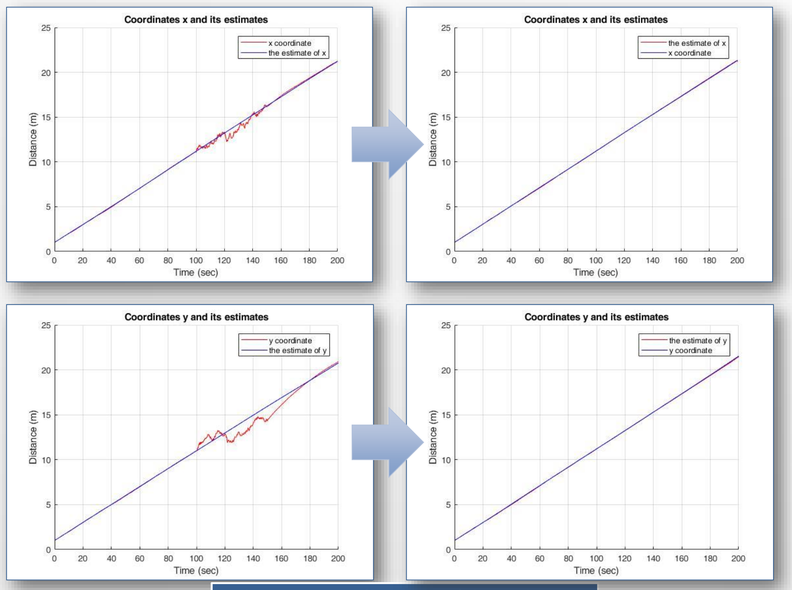

Figure 4: Coordinates and its estimates (Linear Motion)

Table 1. Experiment results

Filter Algorithm	RMSE x	RMSE y	nRMSE
Adaptive Filter	0.027222	0.03375	0.04336
Extended Kalman Filter	0.21899	0.21236	0.30505

Conclusions

The algorithm is adaptive, since it allows to dynamically adjust the value of the measurement noise covariance matrix. Testing was carried out for three motion models: a static object, rectilinear motion and circular motion. The results of numerical experiments performed confirm that when applying the proposed algorithm, the value of the error in estimating the state vector of the object model decreases compared to the conventional (non-adaptive) filter. The results of this work can be used in the development of software for mobile robotic devices.

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Contacts

*Andrey A. Kalyanov Email: andre756@yandex.ru
Ulyanovsk State University Site: www.ulsu.ru