Parameter Estimation using Extended KF

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***Abstract*—In this work, we explore the parameter estimation procedure using the extended Kalman-Filter on a system discussed in the literature. We found that the proposed estimation does not converge to the real values.**

***Index Terms*—State and parameter estimation, extended Kalman-Filter, linearization.**

I. Introduction

The model used in the present work is discussed in [1], given by the discrete dynamic system presented in eq. (1).

$$\begin{cases} x_{t+1} = Ax_t + \xi_t \\ y_t = Cx_t + \zeta_t \end{cases} \tag{1}$$

Where ξ_t and ζ_t are uncorrelated white noises with covariance matrices Q_t and R_t respectively.

The specific state matrices are given in eq. (2), with parameters a^1, a^2, a^3.

$$A = \begin{bmatrix} a^1 & 1 & 0 \\ a^2 & 0 & 1 \\ a^3 & 0 & 0 \end{bmatrix}, \ C = C_i \tag{2}$$

where

$$C_1 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$
$$C_2 = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 \end{bmatrix}$$
$$C_3 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}.$$

In order to estimate parameters a^i, the state must be extended with the dynamics of these parameters. Let $z_t := (x_t^T, a_t^T)^T$, where $x_t := (x_t^1, x_t^2, x_t^3)^T$ and $a_t := (a_t^1, a_t^2, a_t^3)$. Clearly, the resulting dynamic system is nonlinear, hence we use the extended Kalman-Filter (EKF). The proposed linearization is

$$\tilde{A} = \begin{bmatrix} a^1_{\text{ref}} & 0 & 0 & x^1_{\text{ref}} & 0 & 0 \\ a^2_{\text{ref}} & 0 & 0 & 0 & x^1_{\text{ref}} & 0 \\ a^3_{\text{ref}} & 0 & 0 & 0 & 0 & x^1_{\text{ref}} \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}. \tag{3}$$

II. Results

The real parameters are $a = (0.1, -0.2, 0.2)^T$, with initial conditions $z_0 = (0, 0, 0, -0.1, -0.4, 0)^T$. In table I, we present three different set of simulation parameters that were used, and the results are presented in figs. 1 to 3.

Set	C	Q_t	R_t
1	C_1	$0.01I_6$	25
2	C_2	I_6	5
3	C_3	I_6	$5I_3$

Table I: Parameters for estimation procedure.

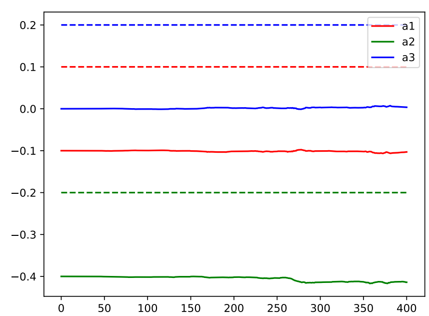

Figure 1: Parameter estimation using EKF for set 1.

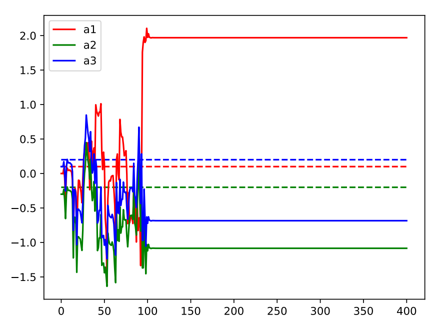

Figure 2: Parameter estimation using EKF for set 2.

The results for set 1 (fig. 1) show that the estimation does not present significant dynamics, therefore the parameters do not converge to the real values. This possible occurs since Q_t is small; after testing with more scattered noises, we obtained more movement only in the parameter a_1, which is associated with the first equation that is also the output.

Attempting to solve this problem, we propose the set 2 and 3, on which the output includes all the original states. Consequently, more changes in the estimated parameters were obtained, but it did not converge to the desired value.

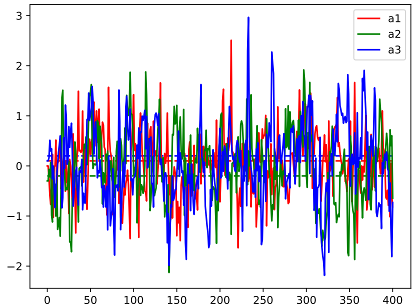

Figure 3: Parameter estimation using EKF for set 3.

III. Conclusions

All the sets proved that the proposed linearization is not suitable for estimating the real parameters. It may be possible that there exists a combination of simulation parameters such that the estimation converges, but it was not found in this work. This is left for future research.

References

[1] P. Wei, B. Xia, and X. Luo, "Parameter estimation and convergence analysis for a class of canonical dynamic systems by extended kalman filter," in *2017 3rd IEEE International Conference on Control Science and Systems Engineering (ICCSSE)*. IEEE, 2017, pp. 336–340.