Advances in Interval Kalman Filtering: theoretical aspects and examples

Jun XIONG[1,2], *Carine Jauberthie*[1,2], *Louise Travé-Massuyès*[1]

[1] *LAAS-CNRS, 7 avenue du Colonel Roche, 31077 Toulouse Cedex 4, France,*

[2] *Universit de Toulouse; UPS, INSA, INP, ISAE; LAAS; F-31077 Toulouse, France*

Abstract

State estimations from experimental measures are usually obtained within a stochastic framework in which uncertainty is taken into account through appropriate assumptions about probability distributions of noise and model error.

However, some sources of uncertainty are not well-suited to the stochastic uncertainty assumption and are better modeled as bounded uncertainty. This is typically the case for modeling the tolerance on parameter values, for which the manufacturer provides low and high bounds corresponding to the inherent variance of technological processes.

In this presentation, we consider filtering of discrete time linear models with bounded uncertainties on parameters and measurement noise modeled by gaussian distribution. This work is based on a previous work [1] in which the classical Kalman filtering technique [2] has been extended to interval linear models with known classical statistical assumptions. As the expressions for deriving the Kalman filter involve matrix inversion, one must find a way to implement this tricky algebraic operation whithin an interval framework. In [1] it is suggested to use upper bound of interval matrix as a regular matrix to-be-inverse to provide a sub-optimal solution that does not preserve guaranteed results, some solutions are lost. Our contribution consists in proposing an alternative approach to solve the interval matrix inversion problem without loss of solution while controlling the inherent pessimism of interval calculus.

An original approach is proposed to limit highly overestimation effects propagating within the interval Kalman filter recursive structure. In particular the gain of the filter is obtained by a calculus based on the set inversion algorithm inspired by SIVIA. Some examples are developed.

References

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