

論文 / 著書情報
Article / Book Information

題目(和文)	パラメータ不確かさを有する非線形システムにおけるロバスト状態推定に関する研究
Title(English)	Study of robust state estimation for nonlinear systems with parameter uncertainties
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

専攻 : Department of	機械制御システム	専攻	申請学位 (専攻分野) : 博士 Academic Degree Requested Doctor of	(工学)
学生氏名 : Student's Name	石原 新士		指導教員 (主) : Academic Advisor(main)	山北 昌毅
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

The Kalman filter (KF) provides optimal state estimates for linear dynamic systems with Gaussian process and measurement noises. For nonlinear systems, the Extended Kalman Filter (EKF) has long been the defacto standard. In recent years, effectiveness of Unscented Kalman Filter (UKF) has been attracting attention. The KF and nonlinear KFs provide appropriate estimation results when the values of parameters of the dynamic and measurement models are known. However, it is not easy to obtain accurate parameters in real applications. So we have to consider parameter uncertainties to improve estimation accuracy in real applications.

There are several works which deal with state estimation for uncertain systems. We can mention the Schmidt-Kalman filter as a traditional method. The Schmidt-Kalman filter treats the parameter uncertainties as state dependent random errors. We can also mention robust KFs as a little new method. These methods consider norm band parameter uncertainties and have less sensitive property to deviations. However, above robust KFs require specific structures for the model uncertainties, so they may not always be able to be applied to real applications. The Desensitized Kalman Filter (DKF) for nonlinear systems with parameter uncertainties has been proposed. The algorithm of the DKF is based on the principles of desensitized optimal control. The DKF doesn't require any specified structures, so it is more readily applied to real systems.

We derived robust EKF (REKF) and robust UKF (RUKF) by analyzing the influences of the parameter uncertainties on error prediction covariance matrices. These Robust Nonlinear Filters (RNF) only require nominal values of uncertain parameters so it's easy to implement in practice like the DKF. The RNF is more accurate than conventional nonlinear KFs (NKF). However the RNF has some disadvantages: (1) when there is no parameter uncertainty, estimation accuracy of the RNF may be inferior to that of the NKF and (2) the estimated values of the RNF can have some offsets by the influence of parameter uncertainties. So, we developed an adaptive RNF (ARNF) by introducing an adaptive scheme into RNF to automatically tune the influence of the parameter uncertainties.

However, the estimated values of the RNF and ARNF may have stationary errors by the influence of parameter uncertainties. Then, we linearize the nonlinear systems and decouple unknown parameter vectors from state vectors. That is to say, we treat the unknown parameter vector as unknown input to the approximated linear models. Then, we apply an unbiased minimum variance estimation (UMVE) method for the approximated linear systems with unknown input. We named this method as Approximated Minimum Variance Unbiased Filter (AMVUF). The advantage of AMVUF is that the dynamics of state estimation error is not affected by the parameter estimation error.

All proposed robust filters mentioned above only estimate state vector. However, the estimation problem of unknown parameters is also important problem in engineering fields. A joint estimation method is commonly used in the engineering fields. This method treats the uncertain parameters as new states and consider the state estimation

problem for an augmented system. And a dual estimation method is also often used in the engineering fields like the joint estimation. However, there is a possibility that transitional estimation accuracy is decreased. So, we develop a new simultaneous states and parameters estimator for nonlinear systems by extending the AMVUF. Furthermore, we derive Robust AMVUF (RAMVUF) by considering the linearization error at the derivation of the AMVUF. The RAMVUF minimizes the upper bound of error covariance matrix including effects of the parameter uncertainties and linearization error. The RAMVUF can provide more robust and accurate estimations.

The effectiveness of all proposed methods are confirmed by several numerical simulations. Finally, concluding remarks on future research directions are discussed.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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