INTERNATIONAL JOURNAL OF ROBUST AND NONLINEAR CONTROL
Int. J. Robust Nonlinear Control 2016; **26**:3058–3074
Published online 4 December 2015 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/rnc.3490

Joint state and parameter robust estimation of stochastic nonlinear systems

Vladimir Stojanovic*,† and Novak Nedic

The Faculty of Mechanical and Civil Engineering in Kraljevo, Department of Automatic Control, Robotics and Fluid Technique, University of Kragujevac, Dositejeva 19, 36000 Kraljevo, Serbia

SUMMARY

Successful implementation of many control strategies is mainly based on accurate knowledge of the system and its parameters. Besides the stochastic nature of the systems, nonlinearity is one more feature that may be found in almost all physical systems. The application of extended Kalman filter for the joint state and parameter estimation of stochastic nonlinear systems is well known and widely spread. It is a known fact that in measurements, there are inconsistent observations with the largest part of population of observations (outliers). The presence of outliers can significantly reduce the efficiency of linear estimation algorithms derived on the assumptions that observations have Gaussian distributions. Hence, synthesis of robust algorithms is very important. Because of increased practical value in robust filtering as well as the rate of convergence, the modified extended Masreliez–Martin filter presents the natural frame for realization of the joint state and parameter estimator of nonlinear stochastic systems. The strong consistency is proved using the methodology of an associated ODE system. The behaviour of the new approach to joint estimation of states and unknown parameters of nonlinear systems in the case when measurements have non-Gaussian distributions is illustrated by intensive simulations. Copyright © 2015 John Wiley & Sons, Ltd.

Received 26 June 2015; Accepted 2 November 2015

KEY WORDS: stochastic nonlinear systems; extended robust filter; joint state and parameter estimation; non-Gaussian noise

1. INTRODUCTION

In the past few decades, particular attention is devoted to the system identification problems for stochastic systems, as shown by recent research [1–5]. The Kalman filter is a stochastic filter that provides state estimation of linear systems. For linear systems in presence of Gaussian noise, it is an optimal filter in terms of least mean square error. Besides the stochastic nature of the systems, nonlinearity is one more feature that may be found in almost all physical systems. Because of that, there have been increasing research efforts to improve the Kalman filter in order to overcome the nonlinearities and uncertainties. The extended Kalman filter approach has been traditionally used to recursively estimate the states of a nonlinear system corrupted by noise, which has a Gaussian (normal) distribution [6–12]. The extended Kalman filter uses local linearization to extend the scope of the Kalman filter to the problem of state estimation of nonlinear systems.

It is also known that a large number of parameters of physical systems are very difficult to determine. While some system parameters are completely known, a large number of parameters are only known within a given range, and some of them are even completely unknown. The unknown values of parameters may be the result of tolerances, impossibility of direct measurement and confidential information about system parameters, which manufacturers consider as their ownership. Thus,

*Correspondence to: Vladimir Stojanovic, The Faculty of Mechanical and Civil Engineering in Kraljevo, Department of Automatic Control, Robotics and Fluid Technique, University of Kragujevac, Dositejeva 19, 36000 Kraljevo, Serbia.
†E-mail: vladostojanovic@mts.rs

Copyright © 2015 John Wiley & Sons, Ltd.