INTERNATIONAL JOURNAL OF ROBUST AND NONLINEAR CONTROL
Int. J. Robust Nonlinear Control 2016; **26**:445–460
Published online 12 February 2015 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/rnc.3319

Robust Kalman filtering for nonlinear multivariable stochastic systems in the presence of non-Gaussian noise

Vladimir Stojanovic*,† and Novak Nedic

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

SUMMARY

The presence of outliers can considerably degrade the performance of linear recursive algorithms based on the assumptions that measurements have a Gaussian distribution. Namely, in measurements there are rare, inconsistent observations with the largest part of population of observations (outliers). Therefore, synthesis of robust algorithms is of primary interest. The Masreliez–Martin filter is used as a natural frame for realization of the state estimation algorithm of linear systems. Improvement of performances and practical values of the Masreliez-Martin filter as well as the tendency to expand its application to nonlinear systems represent motives to design the modified extended Masreliez–Martin filter. The behaviour of the new approach to nonlinear filtering, in the case when measurements have non-Gaussian distributions, is illustrated by intensive simulations. Copyright © 2015 John Wiley & Sons, Ltd.

Received 2 July 2014; Revised 17 December 2014; Accepted 21 January 2015

KEY WORDS: extended Kalman filter; stochastic nonlinear systems; non-Gaussian noise; robust filtering

1. INTRODUCTION

The design of controllers is largely based on the theory and findings of system identification [1–4]. The area that deals with filtering theory, remains vibrant, as shown by recent research [5–9]. Kalman filter has an extremely wide range of applications, not only for the state estimation of a dynamical system in the presence of measurement and process noise but also for the estimation of the model parameters. In the case when the process and measurement noise have Gaussian distributions, it is well known that the Kalman filter is the optimal filter for linear systems, in terms of least mean square error.

Multivariable systems represent an important class of systems in practice. Special attention is devoted to their identification [10–13]. In this area, the problem of identification was considered in the deterministic framework or with the assumption that the stochastic disturbance has a Gaussian distribution. Intense practical studies [14] have not shown justification of the assumption of normal distribution of disturbances. The noise in measurements is a combination of errors from many different sources and generally has not a Gaussian distribution. Namely, in population of observations, there are rare large observations, and the result is that stochastic disturbance has a non-Gaussian distribution. As a result, the efficiency of the identification algorithm based on the assumption of the Gaussian distribution of disturbances is reduced. Because of this, a great effort has been invested for the synthesis of robust identification algorithms that have low sensitivity to changes in the disturbance distribution. The fundamental contribution, in this sense, was given by Huber [15] who laid the foundations of an area known as robust statistics. This theory, rather than the assump-

*Correspondence to: Vladimir Stojanovic, 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@open.telekom.rs