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Special Issue for Journal of Advances in Information Fusion

Title: Nonlinear Derivative-Free Filters: Theory and Applications

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Brief summary of the special issue:

The special issue of the journal is aimed at the state estimation of nonlinear discrete-time stochastic dynamic systems. In particular, theoretical advances and challenging applications of the nonlinear derivative-free (sigma-point) filters are treated.

The special issue will extend the scope and results of the special session "SS12-ASPF - Advanced Sigma-Point Filters: Analysis, Sigma-Point Set Design, and Applications" organized at the 17th International Conference on Information Fusion.

Motivation and a general call for contributed papers to the special issue:

Introduction

State estimation is a focal point of vast majority of navigation, positioning, and tracking systems. Besides these systems, the state estimation is also crucial in various areas and applications where knowledge of the state is required for a (multistep) prediction, control, fault detection, or generally for decision making.

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The general solution to the state estimation problem, assuming a stochastic state-space model of a system and the Bayesian approach, is given by the Bayesian recursive relations (BRRs). The BRRs are used for computation of probability density functions (PDFs) of the state conditioned by all available measurements. The conditional PDFs provide a full description of the immeasurable state.

The closed form solution to the BRRs is available only for a few special cases, among which a linear Gaussian system is the most significant. The solution results, in terms of the estimation algorithm, in the Kalman filter (KF). In other cases, i.e., for nonlinear or non-Gaussian systems, it is necessary to apply some approximate methods.

Many approximate estimation methods have been proposed in the past five decades. Among them, the local (KF-based) methods have attracted considerable attention and currently, these methods are mostly used in practical estimators. They adopt the KF design technique also for nonlinear systems with the conditional moments of the state estimate being recursively computed instead of the conditional PDF. In the literature the local filters are also referred as "Gaussian filters" or "Kalman filters".

The classical local filter is the extended Kalman filter (EKF). The EKF was developed in the seventies and is based on a linearization of the nonlinear functions in the state-space model by the first order Taylor expansion. Later on, the second order Taylor expansion and also other expansions have been used instead. In the late nineties, conceptually different derivative-free approximations have been proposed. Contrary to the Taylor expansion based linearization, they are predominantly based on an approximation of the state estimate description by a set of deterministically chosen weighted points (so called sigma-points), preserving the nonlinear functions in the state-space model. Such approximations are usually denoted as the unscented transform (UT) and a number of versions working with different number and spread of points have been proposed so far (e.g., higher-order, scaled, reduced, smart

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transformations). The resulting filters are then denoted as the unscented Kalman filters. Recently, novel approximations based on various integration rules have been introduced for the local filter design. The rules might be either deterministic (e.g., quadrature or cubature) or stochastic, and in fact, they can be viewed as a certain alternative to the UT.

Scope

The proposed special issue will focus on the area of the local derivative-free filter design for nonlinear stochastic dynamic systems. In particular, theoretical advances and challenging applications of the nonlinear filters will be of interest for the issue with the special emphasis on the following aspects:

- novel concepts and algorithms in derivative-free estimation methods (for filtering, prediction, and smoothing),
- design of novel derivative-free approximation techniques,
- analysis, in-depth comparison, and performance evaluation of approximations used in derivative-free estimation methods,
- numerical aspects of implementation,
- challenging applications.

In summary, the goal of the special issue is to gather recent achievements in the field of derivative-free estimation methods and to provide theoretical advances in the design of the methods and their challenging real-world applications.

Deadline for paper submission: March 31, 2015

During the submission of the paper please clearly indicate that the submitted paper is targeted to the special issue “Nonlinear Derivative-Free Filters: Theory and Applications”.

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Jindrich Dunik has received his Ing. (M.Sc.) degree in automatic control in 2003 and the PhD degree in cybernetics in 2008, both from the University of West Bohemia, Czech Republic. Until 2010 he was with the Department of Cybernetics, University of West Bohemia, focusing on the state estimation and system identification methods. Then, from 2010 he has been with the Aerospace Advanced Technology Europe, Honeywell International, working in areas of inertial and satellite based navigation systems and integrity monitoring methods. From 2013 he is with the Department of Cybernetics, University of West Bohemia, with the research interest in nonlinear state estimation and nonlinearity or non-Gaussianity measures. He is author or co-author of 40 technical papers in journals (e.g., IEEE Transactions on Automatic Control, Automatica) and at conferences (IFAC, ISIF, IEEE), and patents in the fields of nonlinear filtering, system identification, navigation, and integrity monitoring. He is also reviewer of several international conferences and journals (e.g., IEEE Transactions on Automatic Control, Automatica, Circuits, Systems & Signal Processing, Journal of Aerospace Engineering).

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