Robust Kalman Filtering

The optimality of the Kalman filter does not only depend on an accurate, linear model but also on perfectly known parameters of the prior and noise distributions. This requirement is not special to the Kalman filter but is rather an inherent problem deeply rooted into Bayesian filtering and, in parts, also frequentist statistics. The attendants will learn how this problem can be overcome by using hybrid approaches that rely on a combination of stochastic and set-membership methods. The approach is thoroughly explained along with solutions to new challenges arising. Furthermore, using the example of event-based estimation, the attendants will learn how these versatile approaches not only help to improve our modeling of the true uncertainty but also help to make use of the absence of information.

The following topics will be covered.

1. Introduction
    - Robust Bayes: The Bayesian answer to valid criticism
    - Set of densities: A solid framework for robust recursive Bayesian estimation
2. Overview
    - Overview of alternative approaches
3. Filtering using hybrid approaches
    - Introduction of an example requiring Robust Kalman filtering
    - First steps and challenges: The Credal Set Kalman filter
    - Working with inherently limited parameters: The Ellipsoidal Set Kalman filter
4. Extensions
    - Linear Min-max Mean Squared Error Estimation
    - For sensor networks: Distribution Calculation
5. Applications
    - Building truly “credible” credible regions
    - Using negative information in event-based estimation

Intended Audience

The intended audience are users and researchers of stochastic filtering dealing with uncertainties that are not purely stochastic, such as discretization uncertainty and set-membership constraints, or are dealing with negative information. The presented approaches will not only help them understand a more general way to model their systems, but can also help them reduce non-linearity of their system and measurement models. Attendants must be familiar with the Kalman filter to take full advantage of this tutorial.

Speakers

The speakers for this tutorial will be Benjamin Noack and Florian Pfaff.

Benjamin Noack received his Diploma in Computer Science at the University of Karlsruhe, Germany, in 2009. He graduated as Dr.-Ing. (Doctor of Engineering) at the Karlsruhe Institute of Technology (KIT), Germany, in January 2013. Since 2013 he is a senior researcher at the Karlsruhe Institute of Technology (KIT), Germany. His research interests are in the area of multi-sensor data fusion, distributed and decentralized Kalman filtering, combined stochastic and set-membership approaches to state estimation, and event-based systems.

Florian Pfaff started his involvement with Robust Kalman filtering during his master thesis and is co-author of papers presenting important advances. He started as a PHD student at the Karlsruhe Institute of Technology (KIT) in 2014 after completing his master's degree for which he received an award due to his outstanding performance.