Title: Noise Covariance Matrices in State Space Models: Overview, Algorithms, and Comparison of Estimation Methods

Proposers: Jindrich Dunik, Ondrej Straka
University of West Bohemia, Czech Republic

Intended audience: The tutorial is intended for researchers, engineers, and graduate students interested in the state estimation, target tracking and navigation, decision making, and system identification.

Prerequisites: Basic knowledge of probability, statistics, and linear algebra will be helpful.

Description and course material:

Knowledge of a system model is a key prerequisite for many state estimation, signal processing, fault detection, and optimal control problems. The model is often designed to be consistent with random behaviour of the system quantities and properties of the measurements. While the deterministic part of the model often arises from mathematical modelling based on physical, chemical, or biological laws governing the behaviour of the system, the statistics of the stochastic part are often difficult to find by the modelling and have to be identified using the measured data. Incorrect description of the noise statistics may result in a significant worsening of estimation, signal processing, detection, or control quality or even in a failure of the underlying algorithms.

The tutorial introduces a more than six decades long history as well as recent advances and the state-of-the-art of the methods for estimation of the properties (or statistical description) of the stochastic part of the model with a special emphasis on the state-space model noise covariance matrices estimation. The tutorial covers all major groups of the noise statistics estimation methods, including the correlation methods, maximum likelihood methods, covariance matching methods, and the Bayesian methods. The methods are introduced in the unified framework highlighting their basic ideas, key properties, and assumptions. Algorithms of individual methods will be described and analysed to provide a basic understanding of their nature and similarities. Performance of the methods will also be compared using a numerical illustration.

The attendees will be provided with course notes and sample implementations of the selected methods.

Presenters: Jindrich Dunik, Ondrej Straka; University of West Bohemia, Czech Republic

Biographical sketches:

Jindrich Dunik is a scientist at the Department of Cybernetics, University of West Bohemia (UWB), Czech Republic and at the Aerospace Advanced Technology Europe, Honeywell

International. He received his Ing. (M.Sc.) and Ph.D. degrees in Automatic Control in 2003 and 2008, respectively, both from the UWB. Until 2010, he was with the UWB. From 2010 he is with Honeywell and from 2013 with the UWB working in the areas of state estimation and navigation system design and integration. He is the author or co-author of more than 50 technical papers (both journal and conference) and granted patents. He has 8 years of the teaching experience at the UWB and, currently, he is teaching graduate courses on “System Identification and Filtering” and “Adaptive Systems”. Dr. Dunik was a recipient of Werner von Siemens Excellence Award in 2014 for most important result in the basic research.

Ondrej Straka received his M.Sc. and Ph.D. degrees in cybernetics from the University of West Bohemia, Pilsen, Czech Republic, in 1998 and 2004, respectively. Since 2015, he has been an Associate Professor with the Department of Cybernetics, University of West Bohemia. He has fifteen years of the teaching experience at the UWB. Currently, he is a lecturer for graduate and post-graduate courses on estimation theory, stochastic systems and processes and mathematical control theory. He has published over 70 journal and conference papers and was involved in development of several software frameworks for nonlinear state estimation and system identification. He has participated in a number of projects of fundamental research and in several project of applied research (e.g., GNSS-based safe train localization and attitude and heading reference system). His current research interests include local and global nonlinear state estimation methods, system identification, noise covariance matrix estimation in state-space models, performance evaluation, and fault detection in navigation systems. Dr. Straka was a recipient of Werner von Siemens Excellence Award in 2014 for most important result in the basic research.