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Prof. Ing. Boris Rohaľ-Ilkiv, CSc.
Institute of Automation, Measurement and Applied Informatics
Faculty of Mechanical Engineering
Slovak University of Technology in Bratislava

Review of the Dissertation Thesis

Author of the Thesis: *Ing. Peter Matisko*
Title of the Thesis: **Estimation of the stochastic properties of controlled systems**

Relevancy of the thesis

The presented dissertation work focuses on state estimation problems of linear stochastic systems using the Kalman filter approach. It suggests a Bayesian procedure for obtaining a proper estimate of the filter noise covariance matrices directly from the measured data. The thesis proposes optimality tests that can be used to evaluate the quality of the state estimates obtained by the Kalman filter and also discusses techniques for obtaining shaping filters in case the process noise is colored. All these problems are very current topics and are important for obtaining reliable system state estimates and thus for the correct operation of the whole control system. The proposed solutions thus promote greater opportunities for the industrial application of new advanced model-based control methods.

Objective and its fulfillment

The objectives of the thesis are clearly formulated and may be found in sub-chapter 1.2 "Goals of the thesis and main contribution"—all of them have been met. I appreciate the depth, systematic and comprehensive treatment of the given topic, both in theory and within the available options also in practical–numerical terms. This shows that the author is well oriented and knowledgeable in the problem area and the topic was mastered at the required level.

Methodology

The approaches and methods used by the author can be considered proper, correct and leading to the desired results. The author makes use of standard methods of linear (Gaussian) estimation theory, Bayesian estimation and Monte Carlo simulation. The topic was processed in the sequence of the steps: definition of aims, characterization of problem domain, the estimation procedures, their design and simulation, confrontation of the obtained theoretical results with results obtained from defined numerical examples.

Achieved results, including new knowledge

The main results and new knowledge of the work can be summarized as:

- design of a new estimator for autocorrelation functions which generates independently identically distributed values,
- design of a new algorithm based on Bayesian principles for the estimation of noise covariance matrices and its practical numerical implementation using the Monte Carlo approach,
- design of an algorithm for the adaptive Kalman filter combining previous contributions which can deal with disturbances and time-varying covariance matrices,
- design of a simple practical method for finding shaping filters in the case when the noise is colored,
- calculation of the Cramér-Rao bound as a limit of the estimation quality for the noise covariances.

Contribution for the further development of science and technology

The benefits of the work, its proposed solutions and algorithms are mainly that they are solutions that can reduce the computational complexities and memory requirements associated with the current techniques for the linear dynamic system stochastic properties estimation—specifically the noise covariance matrices. The obtained results thus move these new procedures closer to their potential practical applications. The presented solution, through simulations and numerical examples, includes a demonstration of possible applications and existing limitations.

Formal notes and questions

The submitted work technically and graphically is well processed, with a minimum of typos or mistakes.

Questions:

- explain the statement: *"the definition of the optimal Kalman filter is given by the lowest trace of the state prediction error"* on page 6 of the thesis,
- under the assumption of Gaussian noises the posterior cpdf (4.21) can really be multi-modal (see page 40, second row from the top), or the multi-modality is due to the numerical approximation?
- how is the positive definiteness of the matrices Q and R guaranteed in the algorithm stated on page 47?
- all results are verified and validated using simulations from selected numerical examples, is there also experience obtained from real measured data?

Summary

The results presented in the submitted doctoral dissertation Work by Ing. Peter Matisko, as well as the extent and quality of its publication activity, confirm his very good professional and scientific level. This confirms that the doctoral dissertation meets all the requirements for the type of work and brings new knowledge in the area of estimation of stochastic properties of linear controlled systems.

The author of the thesis **proved** to have an ability to perform research and to achieve scientific results. **I do recommend** the thesis for presentation with the aim of receiving the Degree of Ph.D.

Bratislava 1.08.2013 Prof. Ing. B. Roháľ-Ilkiv,CSc.