Book Reviews

Estimators for Uncertain Dynamic Systems A. I. Matasov (Dordrecht/Boston/London: Kluwer, 1999) *Alexander B. Kurzhanski*

The problem of estimating the state of a dynamic process on the basis of available noisy measurements (observations) is one of the well-known key problems in modern systems and control theory which needs not to be introduced. Its development was based, roughly speaking, on considering two types of models for the noise, the first of which is stochastic (mostly Gaussian) and the second is "set-membership," where the noise is taken to be unknown but bounded with bounds given in advance. The solutions to these problems in the modern context consist in jointly considering a pair of equations—the basic system equation and the equation for the measurement device whose measurement output is taken to be known online. The system and the measurement inputs are then taken to be either stochastic with given parameters of the distributions or deterministic but unknown to the observer, being bounded, however, with given bounds. Respective estimation theories (of "stochastic filtering" and "guaranteed estimation" accordingly) have been fairly successfully developed for many problems in linear systems while nonlinear filtering issues are being actively tackled, being still at the heart of many discussions. Special type of estimation problems arise within the so-called H^∞ approach, when the noisy items are taken to be nonprobabilistic and unknown, but with no given bound available—which leads to game-theoretic schemes and to the specification of the estimates as saddle points for some minimax problems. The mentioned topics have a rather extensive literature which was regularly reviewed.

The present book by A. I. Matasov differs from most of the publications by combining under one cover both stochastic and deterministic approaches for linear systems with either Gaussian noise or set-membership bounds on the noise. It also considers problems with set-membership bounds on the parameters of the Gaussian distributions and thus presents a unified framework for both approaches. The issue of building such a unified framework had already been raised in some earlier papers, mentioned in the bibliography. However, the author gives his own original vision of the topic. He presents both mathematical tools and numerous examples and exercises with a definite flavor of applications and a visible desire to show how to solve the problem "to the end." The central idea consists in persisting on the construction of estimates for the "levels of nonoptimality" for simplified algorithms. The derivation of these estimates is based on duality theory of convex analysis.

The book consists of five chapters, each of which is finalized by exercises and comments by the author. Chapter I deals with the simplest guaranteed estimation problem with an emphasis on computational tools for numerical solution of the problem. Chapter II generalizes the main results to dynamic systems and gives an overview of the convex analysis and optimization theory necessary for further consideration. Chapter III deals with the comparison of the Kalman filter and the guaranteed estimator introducing the notion of "level of nonoptimality" of the Kalman filter if the latter is applied to the deterministic guaranteed estimation problem. Chapter IV deals with the "stochastic guaranteed estimation" problem when, along with uncertain deterministic perturbations, the parameters in the Gaussian distributions of the noise are unknown but bounded. Some effectively computable conservative overestimates are then derived. In the present problems one always has to deal with a tradeoff between simplicity of the algorithm and accuracy of solution and each author has to take sides. Finally, the last Chapter V deals with estimation problems for systems with an aftereffect, particularly, with a time lag in the system and in the measurement equation. Exact solutions are discussed for the dynamic case and simplified algorithms are presented for some particular classes of systems.

It is difficult, of course, to cover all the aspects of the state estimation problem. What seems to be missing here is the emphasis on the closed-loop (feedback) nature of the problem and the distinction between the estimation made *a priori* (offline) with those made *a posteriori* (online). The last requirement leads to the necessity of presenting the algorithms in a recurrent form and in comparing the computational burden of a sequence of "static" solutions and a recurrent algorithm. An experienced reader may also find some flaws in the comments and the bibliography. But as a well-known Russian proverb says "it is impossible to embrace the unbounded." The subject is enormous and for any publication there would be issues for criticism.

Thus, the monograph certainly is a very useful publication which gives a broad vision of the problem under discussion, giving a deep understanding of how to deal with uncertainty in estimation problems and how to organize the calculations. It may be recommended as a very good introduction and reference book for those who are interested in solving real-life applied problems of filtering and estimation.

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