

Preface

Filtering is one of the basic problems in the fields of systems, control and signal processing. The goal of filtering is to estimate signals that are unmeasurable through processing the measured output signals. Since the development of Kalman's optimal filtering theory for stochastic systems and Luenberger's observer theory for deterministic systems, many scholars have devoted considerable efforts to the problem of filtering. Especially, the well-known Kalman filtering theory plays a significant role in various social and engineering fields such as aerospace, astronautics, industrial processes and economic and financial systems. The Kalman filtering theory is based on the availability of the precisely-known mathematical model of the studied plant and the assumption of strict Gaussian random processes or series. However, it is usually difficult to characterize the dynamics of the studied plant exactly by a mathematical model, inevitably leading to an error between the derived mathematical model and the practical plant; moreover, it is rare for practical external noises to completely satisfy the strong Gaussian assumption. The uncertainties existing in systems and signals would greatly degrade the performance of a traditional Kalman filter and even cause divergence. Hence, it is of practical meaning to research filtering theory for uncertain dynamical systems so as to improve the robustness of a filter against uncertainties.

In systems and control areas, study on uncertain systems has drawn much attention from many researchers for a long time. Robust control theory, originating from 1970s, generally solves analysis and synthesis problems of parametric uncertain systems based on the notion of quadratic stability. Since the late 1980s, this notion has also been gradually employed to solve robust filtering problems of uncertain systems, which results in a great number of quadratic approaches to robust filter design. However, these quadratic approaches have been well recognized to be conservative due to the utilization of a common quadratic Lyapunov function for the entire uncertainty domain. In recent years, to reduce such conservatism and improve the practical applicability of robust filter design methods, parameter-dependent Lyapunov functions are introduced into robust filtering theory, and parameter-dependent approaches to robust filter design have draw a great deal of attention. The essential idea of the most popular parameter-dependent filtering results is to relax Lyapunov functions to be linearly parameter-dependent and meanwhile to fix some slack matrices, which, though relaxing the quadratic approaches, still has much limitation.

In view of the limitation of the existing parameter-dependent results, some new methods recently have been developed to derive a series of parameter-dependent approaches to robust filter design, including ours, which further release the previous restrictions on Lyapunov functions, showing great potential in conservatism reduction. This book systematically summarizes these recent developments of parameter-dependent filter design methods. Robust H_2 filtering, robust H_∞ filtering and robust energy-to-peak filtering are discussed in the book, where robust H_∞ filtering is employed as the main filtering scheme for various classes of complex uncertain dynamical systems including time-delay systems, two-dimensional systems and networked systems. Moreover, our latest work, some preliminary results on finite frequency H_∞ filtering, will also be involved at the end of the book to show a new filtering theme of future interest. Various examples are provided in the book to illustrate the effectiveness of the presented new parameter-dependent filtering results. All the results are presented in the framework of linear matrix inequality (LMI).

From the book, reader can find an overview of the latest advances in the robust filtering area and grasp the state-of-the-art methods on parameter-dependent filter design. This book can be used as a reference by researchers and engineers working in the areas related to control theory and engineering, and signal processing, and it is especially beneficial for graduate students interested in or focusing on robust filtering theory and its application. Courses like linear systems, modern control theory and robust control theory and basic mathematical background are prerequisite for reading the book. Those familiar with the LMI theory would possibly read the book more efficiently.

Harbin, China, July 2013

Huijun Gao
Xianwei Li

Robust Filtering for Uncertain Systems

A Parameter-Dependent Approach

Gao, H.; Li, X.

2014, XVI, 253 p. 45 illus., 18 illus. in color., Hardcover

ISBN: 978-3-319-05902-0