LINEAR AND NONLINEAR FILTERING FOR SCIENTISTS AND ENGINEERS

by Nasir U. Ahmed

A BOOK REVIEW

JORDAN STOYANOV

*School of Mathematics & Statistics
University of Newcastle Newcastle upon Tyne
NE1 7RU, United Kingdom
e-mail: jordan.stoyanov@ncl.ac.uk*

(Received July, 1999; Revised April, 2000)

About 40 years have passed since R. E. Kalman and R. S. Bucy have published their first articles on estimation problems for random signals based on observations of other stochastic processes. Although their models were only linear and Gaussian, their ideas and types of results obtained were so innovative that they received enormous attention from theoretical and applied scientists. Their work is still of great significance, because the optimal filter (mean square estimator) satisfies a Riccati type equation for the error and provides a complete solution to the filtering problem. The names “Kalman-Bucy filter” and “Filtering Theory” have become a standard in many studies on contemporary stochastic problems. Let us also mention that there is an abundance of excellent monographs on this topic that reflect recent development in the area and discuss dynamic new applications. Some of them carry out mostly mathematical expositions; others are more applied. In other words, if a book emphasizes rigor, there will be little or no place for intuitive-motivational aspects, and vice versa. Notice that filtering theory itself is a branch of stochastic analysis based on such advanced techniques as conditional expectations, stochastic integrals, and stochastic differential equations. However, the progress in filtering theory is a result of contemporary mathematics based on quite sophisticated tools, such as conditional expectations, stochastic integrals, and stochastic differential equations and it is due to a deep and longstanding interrelation between various applied areas. Consequently, it seems to be not easy to write a book appealing to both mathematicians and non-mathematicians.

The book under review deals with well-selected models and clearly formulated problems and provides a comprehensive solution to filtering problems. A variety of models with discrete or continuous time parameters are presented in detail. Special attention is paid to numerical methods. Topics like control and system identification

are also covered. Additional discussions and detailed illustrative examples complement basic results. There are also useful comments about phenomena in other fields motivating these studies. The author follows a smooth style by well-balancing between the rigor and accessibility.

The material is divided into the following chapters:

1. Introduction to stochastic processes.
2. Stochastic differential equations.
3. Kalman filtering for linear systems driven by Wiener process - I.
4. Kalman filtering for linear systems driven by Wiener process - II.
5. Discrete Kalman filtering.
6. Linear filtering with correlated noise - I.
7. Linear filtering with correlated noise - II.
8. Linear filtering with correlated noise - III.
9. Linear filtering of jump processes.
10. Linear filtering with constraints.
11. Filtering for linear systems driven by second order random processes.
12. Extended Kalman filtering I, II, III.
13. Nonlinear filtering.
14. Numerical techniques for nonlinear filtering.
15. Partially observed control.
16. System identification.
17. References. Index

This reviewer has a wonderful memories about his visit to the University of Ottawa, Canada (1992). Professor Ahmed and his collaborators at the time were working intensively on the topic "linear and nonlinear filtering of stochastic processes." Their successful work resulted in publishing several papers. We have had discussions about new but difficult problems as well as the contribution of many scientists worldwide. In particular, we have noted that the books by A. Shiryaev and R. Liptser (Russian edition of 1974 and English translation of 1977/78), and G. Kallianpur (1980) were and still are basic sources in this topic and that there are reasons for that. These books, however, were often regarded as quite theoretical and not easily accessible for more general audiences, e.g. for engineers and economists who want to apply the existing results and ideas in their practice. Professor Ahmed talked about his dream some day to write his own book, which would be both rigorous mathematically and at the same time accessible to engineers. Now there is every reason to believe that his dreams have come true. He produced an attractive book on the topic. The reader will find a self-contained presentation of a reasonable number of important results in filtering theory and its applications. It is worthy of mention that many new results, especially on nonlinear filtering problems and their numerical techniques, are included in book form for the first time. Some of them belong to Professor Ahmed and his school at the University of Ottawa.

Not only will the book be met with interest by many readers, but it will serve as a useful reference book on the recent progress in this field. The book can be used for teaching graduate courses to students in mathematics, probability, statistics, and engineering. And finally, doctoral students and young researchers in the area of filtering theory and its applications can find inspiring ideas and techniques. Most

likely, this book already is or will be available at any good university library.

Linear and Nonlinear Filtering for Scientists and Engineers, by **Nasir U. Ahmed**

Publisher: World Scientific, Singapore

Year: 1998

Pages: xv + 256

ISBN 981 02 3609 3

Price: \$65.00