

Contents

Preface vii

Chapter I Introduction to Estimation Theory 1

Chapter 2 Review of Probability Theory and Random Variables 7

- 2.1 Introduction 7
- 2.2 Probability Theory 7
- 2.3 Random Variables 11
- 2.4 Algebraic Operations on Random Variables 20
- 2.5 Expectations 26
- 2.6 Summary 31

Chapter 3 Stochastic Processes 32

- 3.1 Introduction 32
- 3.2 Probability Expressions 33
- 3.3 Expectations 34
- 3.4 Spectral and Orthogonal Representations 39
- 3.5 Linear System Response 46

- 3.6 Summary 65
- Problems 65

Chapter 4 Gauss-Markov Processes and Stochastic Differential Equations 68

- 4.1 Introduction 68
- 4.2 Gaussian Processes 69
- 4.3 Markov Processes 74
- 4.4 Stochastic Differential Equations 82
- 4.5 Mean-and-Variance Propagation for Nonlinear Systems 102
- 4.6 Summary 113
- Problems 113

Chapter 5 Decision Theory 116

- 5.1 Introduction 116
- 5.2 Single-observation Decision Theory 118
- 5.3 Multiple-observation Decision Theory 125
- 5.4 Composite-hypothesis Testing 142
- 5.5 M -ary Hypothesis Testing 145
- 5.6 Sequential Decision Theory 148
- 5.7 Sequential Detection of Markov Signals in Gaussian Noise 157
- 5.8 Summary 171
- Problems 171

Chapter 6 Basic Estimation Theory 175

- 6.1 Introduction 175
- 6.2 Bayesian Estimation Theory 176
- 6.3 Maximum Likelihood Estimation 195
- 6.4 Properties of Estimators 203
- 6.5 Error Analysis and Prior Statistics 209
- 6.6 Linear Minimum Variance Estimation 231
- 6.7 Least-squares Estimation 237
- 6.8 Summary 249
- Problems 249

Chapter 7 The Optimum Linear Filter 251

- 7.1 Introduction 251
- 7.2 The Optimum Linear Discrete Filter 253
- 7.3 The Optimum Linear Continuous Filter 283
- 7.4 Stationary Processes—Wiener Filter 303
- 7.5 Asymptotic Behavior 321
- 7.6 Summary 328
- Problems 328

Chapter 8 Extensions of the Optimum Linear Filter 332

- 8.1 Introduction 332
- 8.2 Colored Noise 333
- 8.3 Smoothing and Prediction 347
- 8.4 Error Analysis and Prior Statistics 376
- 8.5 Divergence 412
- 8.6 Summary 417
- Problems 417

Chapter 9 Nonlinear Estimation 420

- 9.1 Introduction 420
- 9.2 Conditional-mean Estimation 421
- 9.3 Maximum a Posteriori Estimation 441
- 9.4 Relations between Nonlinear Filter Algorithms 457
- 9.5 Nonlinear Smoothing 479
- 9.6 Summary 495
- Problems 495

Appendix A Matrix Inversion Lemma 499

Appendix B Optimization 501

Bibliography 505

Index of Tables of Estimation Algorithms 519

Subject Index 521