

CONTENTS

| | |
|--|----|
| <i>Preface</i> | ix |
| I Introduction | |
| 1.1 System Science in Sociotechnology | 1 |
| 1.2 Mathematical Modeling and Bilinear Systems | 4 |
| 1.3 System Identification | 7 |
| 1.4 Volterra Series Analysis | 12 |
| References | 18 |
| II Controllability | |
| 2.1 Background | 21 |
| 2.2 Controllable Bilinear Systems | 23 |
| 2.3 Sufficient Conditions for Complete Controllability | 27 |
| 2.4 Equilibrium Set of Bilinear Systems | 34 |
| 2.5 Reachable Zone for Equicontinuous Control | 38 |
| 2.6 Miscellaneous Controllability Properties | 46 |
| 2.7 Stability Analysis | 48 |
| 2.8 Conclusions | 49 |
| References | 51 |
| III Optimal Control | |
| 3.1 Background | 53 |
| 3.2 Optimal Bilinear Regulation | 56 |
| 3.3 Bang-Bang Processes | 67 |

| | |
|---|-----|
| 3.4 Fuel-Optimal Control | 78 |
| 3.5 Discrete Bilinear Control | 88 |
| 3.6 Quasi-Linear Programming | 91 |
| 3.7 Optimal Feedback Control | 95 |
| 3.8 Conclusions | 97 |
| Appendix A Sufficient Condition of Optimality | 99 |
| Appendix B Optimum Number of Switchings for STVM | 101 |
| Appendix C Gradient Computation | 103 |
| Appendix D Number of Switchings for Fuel-Optimal Policy | 104 |
| References | 107 |

IV Nuclear and Thermal Control Processes

| | |
|----------------------|-----|
| 4.1 Nuclear Fission | 112 |
| 4.2 Heat Transfer | 128 |
| 4.3 Reactor Control | 130 |
| 4.4 Reactor Shutdown | 142 |
| 4.5 Conclusions | 147 |
| References | 149 |

V Ecologic and Physiologic Control

| | |
|--|-----|
| 5.1 Populations of Species | 151 |
| 5.2 Biochemical Processes and the Cellular Plant | 153 |
| 5.3 Compartmental Models | 155 |
| 5.4 Water Balance | 167 |
| 5.5 Temperature Regulation | 171 |
| 5.6 The Respiratory Chemostat | 179 |
| 5.7 The Cardiovascular Regulator | 185 |
| 5.8 Other Bilinear Systems | 187 |
| 5.9 Summary | 188 |
| References | 190 |

VI Socioeconomic Systems

| | |
|--------------------------------------|-----|
| 6.1 Concepts of Socioeconomic Models | 193 |
| 6.2 Urban Dynamics | 195 |
| 6.3 Background for Case Study | 198 |
| 6.4 Conclusions | 210 |
| References | 212 |

Author Index

215

Subject Index

219