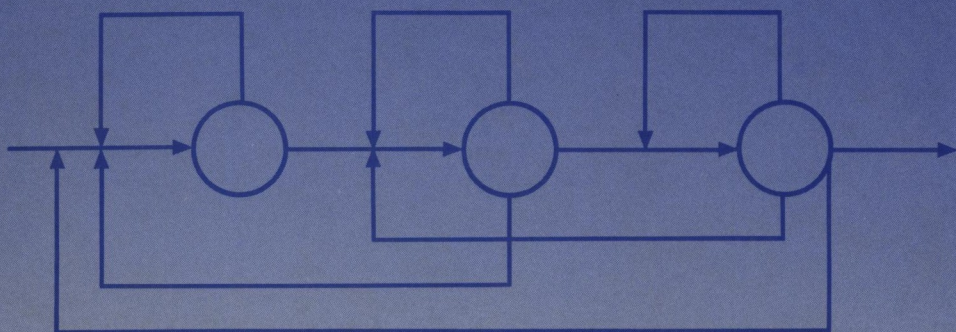


Discrete Event Systems

Sensitivity Analysis
and Stochastic
Optimization
by the Score
Function Method



Reuven Y. Rubinstein
Alexander Shapiro

Contents

1 Preliminaries	1
1.1 Introduction	1
1.2 Output Analysis of the Simulated Data	8
1.2.1 Planning Queueing Simulations	15
1.2.2 Batch Mean Method	16
1.2.3 Regenerative Simulation	17
1.3 Variance Reduction Techniques	22
1.3.1 Importance and Modified Importance Sampling	23
1.3.2 Control Random Variables	27
1.4 The framework for sensitivity analysis	31
1.5 Exercises	32
2 Sensitivity Analysis and Stochastic Optimization of Discrete Event Static Systems (DESS)	35
2.1 Introduction	35
2.2 Sensitivity Analysis of the System Performance	37
2.3 The “What if” Problem	47
2.4 Optimization of DESS	55
2.5 Variance Reduction Techniques	62
2.6 Appendix A. Convergence of the Estimators of the Optimal Solutions	66
2.7 Appendix B. The Radon-Nikodym Derivative	75
2.8 Exercises	77
3 Sensitivity Analysis and Stochastic Optimization of Discrete Event Dynamic Systems (DEDS)	81
3.1 Introduction	81
3.2 Sensitivity Analysis of the System Performance	84
3.2.1 The Score Function Process	84
3.2.2 The Case of Unknown Parameters	96

3.2.3 Asymptotic Properties of the SF Estimators	100
3.3 Decomposable and Truncated Estimators	104
3.3.1 Decomposable Score Function Estimators	106
3.3.2 Truncated Score Function Estimators	110
3.3.3 Network Topological Design	116
3.3.4 Numerical Results	118
3.4 Conditional Score Function Method	123
3.5 Optimization of DEDS	133
3.6 Sensitivity Analysis and Robustness of the Optimal Solutions .	145
3.7 Exercises	148
4 What is a “Good” Reference System to Simulate	153
4.1 Introduction	153
4.2 How to Choose “Good” Reference Parameters for DESS	159
4.3 How to Choose “Good” Reference Parameters for DEDS	164
4.4 Estimating Rare Events	182
4.5 Extensions	195
4.6. Appendix. Convexity Results	198
4.7 Exercises	205
5 Extensions of the SF Method	207
5.1 Introduction	207
5.2 Direct, “Push out”, and “Push in” Estimators	212
5.2.1 Direct Estimators	212
5.2.2 Smoothness and Variance Reduction	214
5.2.3 Sensitivity Analysis via the IPA Technique	216
5.2.4 Sensitivity Analysis by the “Push out” Technique	219
5.3 Sensitivity Analysis with Autocorrelated Inputs	236
5.3.1 Introduction	236
5.3.2 Direct Estimators	237
5.3.3 The “Push in” Technique	239
5.3.4 The “Push out” Technique	239
5.3.5 Numerical Results	242
5.4 Exercises	245
6 Statistical Inference of Stochastic Optimization Programs	247
6.1 Introduction	247

6.2 Consistency of the Stochastic Estimators of the Optimal Value and the Optimal Solution	254
6.3 The Delta Method	257
6.4 Asymptotic Analysis of the Optimal Value	264
6.5 Sensitivity and Robustness Analysis of the Optimal Solutions .	279
6.6 Asymptotic Analysis of the Optimal Solutions	291
6.7 Exercises	304
Bibliography	311
Index	333