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for Michelle, Hoang Jr., and David

Preface

The Springer Handbook of Engineering Statistics, altogether 54 chapters, aims to provide a comprehensive state-of-the-art reference volume that covers both fundamental and theoretical work in the areas of engineering statistics including failure time models, accelerated life testing, incomplete data analysis, stochastic processes, Bayesian inferences, data collection, Bootstrap models, burn-in and screening, competing risk models, correlated data analysis, counting processes, proportional hazards regression, design of experiments, DNA sequence analysis, empirical Bayes, genetic algorithms, evolutionary model, generalized linear model, geometric process, life data analysis, logistic regression models, longitudinal data analysis, maintenance, data mining, six sigma, Martingale model, missing data, influential observations, multivariate analysis, multivariate failure model, nonparametric regression, DNA sequence evolution, system designs, optimization, random walks, partitioning methods, resampling method, financial engineering and risks, scan statistics, semi-parametric model, smoothing and splines, step-stress life testing, statistical process control, statistical inferences, statistical design and diagnostics, process control and improvement, biological statistical models, sampling technique, survival model, time-series model, uniform experimental designs, among others.

The chapters in this handbook have outlined into six parts, each contains nine chapters except Part E and F, as

follows:

- Part A Fundamental Statistics and Its Applications
- Part B Process Monitoring and Improvement
- Part C Reliability Models and Survival Analysis
- Part D Regression Methods and Data Mining
- Part E Statistical Methods and Modeling
- Part F Applications in Engineering Statistics

All the chapters are written by over 100 outstanding scholars in their fields of expertise. I am deeply indebted and wish to thank all of them for their contributions and cooperation. Thanks are also due to the Springer staff for their patience and editorial work. I hope that practitioners will find this Handbook useful when looking for solutions to practical problems; researchers, statisticians, scientists and engineers, teachers and students can use it for quick access to the background, recent research and trends, and most important references regarding certain topics, if not all, in the engineering statistics.

Prof. Hoang Pham

January 2006
Piscataway, New Jersey

Hoang Pham

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Contents

List of Tables	XXXI
List of Abbreviations	XLI

Part A Fundamental Statistics and Its Applications

1 Basic Statistical Concepts	
<i>Hoang Pham</i>	3
1.1 Basic Probability Measures.....	3
1.2 Common Probability Distribution Functions	7
1.3 Statistical Inference and Estimation	17
1.4 Stochastic Processes	32
1.5 Further Reading	42
References.....	42
1.A Appendix: Distribution Tables	43
1.B Appendix: Laplace Transform	47
2 Statistical Reliability with Applications	
<i>Paul Kvam, Jye-Chyi Lu</i>	49
2.1 Introduction and Literature Review	49
2.2 Lifetime Distributions in Reliability	50
2.3 Analysis of Reliability Data	54
2.4 System Reliability	56
References.....	60
3 Weibull Distributions and Their Applications	
<i>Chin-Diew Lai, D.N. Pra Murthy, Min Xie</i>	63
3.1 Three-Parameter Weibull Distribution	64
3.2 Properties	64
3.3 Modeling Failure Data	67
3.4 Weibull-Derived Models	70
3.5 Empirical Modeling of Data	73
3.6 Applications.....	74
References.....	76
4 Characterizations of Probability Distributions	
<i>H.N. Nagaraja</i>	79
4.1 Characterizing Functions.....	80
4.2 Data Types and Characterizing Conditions	81
4.3 A Classification of Characterizations.....	83
4.4 Exponential Distribution	84
4.5 Normal Distribution	85
4.6 Other Continuous Distributions	87

4.7	Poisson Distribution and Process	88
4.8	Other Discrete Distributions	90
4.9	Multivariate Distributions and Conditional Specification	90
4.10	Stability of Characterizations	92
4.11	Applications	92
4.12	General Resources	93
	References	94
5	Two-Dimensional Failure Modeling	
	<i>D.N. Pra Murthy, Jaiwook Baik, Richard J. Wilson, Michael Bulmer</i>	97
5.1	Modeling Failures	98
5.2	Black-Box Modeling Process	98
5.3	One-Dimensional Black-Box Failure Modeling	99
5.4	Two-Dimensional Black-Box Failure Modeling	103
5.5	A New Approach to Two-Dimensional Modeling	107
5.6	Conclusions	110
	References	110
6	Prediction Intervals for Reliability Growth Models with Small Sample Sizes	
	<i>John Quigley, Lesley Walls</i>	113
6.1	Modified IBM Model – A Brief History	114
6.2	Derivation of Prediction Intervals for the Time to Detection of Next Fault	115
6.3	Evaluation of Prediction Intervals for the Time to Detect Next Fault .	117
6.4	Illustrative Example	119
6.5	Conclusions and Reflections	122
	References	122
7	Promotional Warranty Policies: Analysis and Perspectives	
	<i>Jun Bai, Hoang Pham</i>	125
7.1	Classification of Warranty Policies	126
7.2	Evaluation of Warranty Policies	129
7.3	Concluding Remarks	134
	References	134
8	Stationary Marked Point Processes	
	<i>Karl Sigman</i>	137
8.1	Basic Notation and Terminology	138
8.2	Inversion Formulas	144
8.3	Campbell's Theorem for Stationary MPPs	145
8.4	The Palm Distribution: Conditioning in a Point at the Origin	146
8.5	The Theorems of Khintchine, Korolyuk, and Dobrushin	146
8.6	An MPP Jointly with a Stochastic Process	147
8.7	The Conditional Intensity Approach	148
8.8	The Non-Ergodic Case	150
8.9	MPPs in $\mathbb{R}^d$	150
	References	152

9 Modeling and Analyzing Yield, Burn-In and Reliability for Semiconductor Manufacturing: Overview	
<i>Way Kuo, Kyungmee O. Kim, Taeho Kim</i>	153
9.1 Semiconductor Yield	154
9.2 Semiconductor Reliability	159
9.3 Burn-In	160
9.4 Relationships Between Yield, Burn-In and Reliability	163
9.5 Conclusions and Future Research	166
References	166

Part B Process Monitoring and Improvement

10 Statistical Methods for Quality and Productivity Improvement	
<i>Wei Jiang, Terrence E. Murphy, Kwok-Leung Tsui</i>	173
10.1 Statistical Process Control for Single Characteristics	174
10.2 Robust Design for Single Responses	181
10.3 Robust Design for Multiple Responses	185
10.4 Dynamic Robust Design	186
10.5 Applications of Robust Design	187
References	188
11 Statistical Methods for Product and Process Improvement	
<i>Kailash C. Kapur, Qianmei Feng</i>	193
11.1 Six Sigma Methodology and the (D)MAIC(T) Process	195
11.2 Product Specification Optimization	196
11.3 Process Optimization	204
11.4 Summary	211
References	212
12 Robust Optimization in Quality Engineering	
<i>Susan L. Albin, Di Xu</i>	213
12.1 An Introduction to Response Surface Methodology	216
12.2 Minimax Deviation Method to Derive Robust Optimal Solution	218
12.3 Weighted Robust Optimization	222
12.4 The Application of Robust Optimization in Parameter Design	224
References	227
13 Uniform Design and Its Industrial Applications	
<i>Kai-Tai Fang, Ling-Yau Chan</i>	229
13.1 Performing Industrial Experiments with a UD	231
13.2 Application of UD in Accelerated Stress Testing	233
13.3 Application of UD in Computer Experiments	234
13.4 Uniform Designs and Discrepancies	236
13.5 Construction of Uniform Designs in the Cube	237
13.6 Construction of UD for Experiments with Mixtures	240

13.7	Relationships Between Uniform Design and Other Designs	243
13.8	Conclusion	245
	References.....	245
14	Cuscore Statistics: Directed Process Monitoring for Early Problem Detection	
	<i>Harriet B. Nembhard</i>	249
14.1	Background and Evolution of the Cuscore in Control Chart Monitoring.....	250
14.2	Theoretical Development of the Cuscore Chart.....	251
14.3	Cuscores to Monitor for Signals in White Noise	252
14.4	Cuscores to Monitor for Signals in Autocorrelated Data	254
14.5	Cuscores to Monitor for Signals in a Seasonal Process	255
14.6	Cuscores in Process Monitoring and Control	256
14.7	Discussion and Future Work	258
	References.....	260
15	Chain Sampling	
	<i>Raj K. Govindaraju</i>	263
15.1	ChSP-1 Chain Sampling Plan.....	264
15.2	Extended Chain Sampling Plans	265
15.3	Two-Stage Chain Sampling	266
15.4	Modified ChSP-1 Plan.....	268
15.5	Chain Sampling and Deferred Sentencing	269
15.6	Comparison of Chain Sampling with Switching Sampling Systems	272
15.7	Chain Sampling for Variables Inspection	273
15.8	Chain Sampling and CUSUM.....	274
15.9	Other Interesting Extensions	276
15.10	Concluding Remarks	276
	References.....	276
16	Some Statistical Models for the Monitoring of High-Quality Processes	
	<i>Min Xie, Thong N. Goh</i>	281
16.1	Use of Exact Probability Limits	282
16.2	Control Charts Based on Cumulative Count of Conforming Items.....	283
16.3	Generalization of the c -Chart	284
16.4	Control Charts for the Monitoring of Time-Between-Events	286
16.5	Discussion	288
	References.....	289
17	Monitoring Process Variability Using EWMA	
	<i>Philippe Castagliola, Giovanni Celano, Sergio Fichera</i>	291
17.1	Definition and Properties of EWMA Sequences	292
17.2	EWMA Control Charts for Process Position	295
17.3	EWMA Control Charts for Process Dispersion.....	298

17.4	Variable Sampling Interval EWMA Control Charts for Process Dispersion	310
17.5	Conclusions	323
	References	324

18 Multivariate Statistical Process Control Schemes for Controlling a Mean

	<i>Richard A. Johnson, Ruojia Li</i>	327
18.1	Univariate Quality Monitoring Schemes	328
18.2	Multivariate Quality Monitoring Schemes	331
18.3	An Application of the Multivariate Procedures	336
18.4	Comparison of Multivariate Quality Monitoring Methods	337
18.5	Control Charts Based on Principal Components	338
18.6	Difficulties of Time Dependence in the Sequence of Observations	341
	References	344

Part C Reliability Models and Survival Analysis

19 Statistical Survival Analysis with Applications

	<i>Chengjie Xiong, Kejun Zhu, Kai Yu</i>	347
19.1	Sample Size Determination to Compare Mean or Percentile of Two Lifetime Distributions	349
19.2	Analysis of Survival Data from Special Cases of Step-Stress Life Tests	355
	References	365

20 Failure Rates in Heterogeneous Populations

	<i>Maxim Finkelstein, Veronica Esaulova</i>	369
20.1	Mixture Failure Rates and Mixing Distributions	371
20.2	Modeling the Impact of the Environment	377
20.3	Asymptotic Behaviors of Mixture Failure Rates	380
	References	385

21 Proportional Hazards Regression Models

	<i>Wei Wang, Chengcheng Hu</i>	387
21.1	Estimating the Regression Coefficients β	388
21.2	Estimating the Hazard and Survival Functions	389
21.3	Hypothesis Testing	390
21.4	Stratified Cox Model	390
21.5	Time-Dependent Covariates	390
21.6	Goodness-of-Fit and Model Checking	391
21.7	Extension of the Cox Model	393
21.8	Example	394
	References	395

22 Accelerated Life Test Models and Data Analysis

<i>Francis Pascual, William Q. Meeker, Jr., Luis A. Escobar</i>	397
22.1 Accelerated Tests	398
22.2 Life Distributions	400
22.3 Acceleration Models	400
22.4 Analysis of Accelerated Life Test Data	407
22.5 Further Examples	412
22.6 Practical Considerations for Interpreting the Analysis of ALT Data	421
22.7 Other Kinds of ATs	421
22.8 Some Pitfalls of Accelerated Testing	423
22.9 Computer Software for Analyzing ALT Data	424
References.....	425

23 Statistical Approaches to Planning of Accelerated Reliability Testing

<i>Loon C. Tang</i>	427
23.1 Planning Constant-Stress Accelerated Life Tests	428
23.2 Planning Step-Stress ALT (SSALT)	432
23.3 Planning Accelerated Degradation Tests (ADT)	436
23.4 Conclusions.....	439
References.....	440

24 End-to-End (E2E) Testing and Evaluation of High-Assurance Systems

<i>Raymond A. Paul, Wei-Tek Tsai, Yinong Chen, Chun Fan, Zhibin Cao, Hai Huang</i>	443
24.1 History and Evolution of E2E Testing and Evaluation.....	444
24.2 Overview of the Third and Fourth Generations of the E2E T&E	449
24.3 Static Analyses	451
24.4 E2E Distributed Simulation Framework	453
24.5 Policy-Based System Development.....	459
24.6 Dynamic Reliability Evaluation.....	465
24.7 The Fourth Generation of E2E T&E on Service-Oriented Architecture	470
24.8 Conclusion and Summary.....	473
References.....	474

25 Statistical Models in Software Reliability and Operations Research

<i>P.K. Kapur, Amit K. Bardhan</i>	477
25.1 Interdisciplinary Software Reliability Modeling	479
25.2 Release Time of Software	486
25.3 Control Problem	489
25.4 Allocation of Resources in Modular Software.....	491
References.....	495

26 An Experimental Study of Human Factors in Software Reliability Based on a Quality Engineering Approach	
<i>Shigeru Yamada</i>	497
26.1 Design Review and Human Factors	498
26.2 Design-Review Experiment	499
26.3 Analysis of Experimental Results	500
26.4 Investigation of the Analysis Results	501
26.5 Confirmation of Experimental Results	502
26.6 Data Analysis with Classification of Detected Faults	504
References	506
27 Statistical Models for Predicting Reliability of Software Systems in Random Environments	
<i>Hoang Pham, Xiaolin Teng</i>	507
27.1 A Generalized NHPP Software Reliability Model	509
27.2 Generalized Random Field Environment (RFE) Model	510
27.3 RFE Software Reliability Models	511
27.4 Parameter Estimation	513
References	519
 Part D Regression Methods and Data Mining	
28 Measures of Influence and Sensitivity in Linear Regression	
<i>Daniel Peña</i>	523
28.1 The Leverage and Residuals in the Regression Model	524
28.2 Diagnosis for a Single Outlier	525
28.3 Diagnosis for Groups of Outliers	528
28.4 A Statistic for Sensitivity for Large Data Sets	532
28.5 An Example: The Boston Housing Data	533
28.6 Final Remarks	535
References	535
29 Logistic Regression Tree Analysis	
<i>Wei-Yin Loh</i>	537
29.1 Approaches to Model Fitting	538
29.2 Logistic Regression Trees	540
29.3 LOTUS Algorithm	542
29.4 Example with Missing Values	543
29.5 Conclusion	549
References	549
30 Tree-Based Methods and Their Applications	
<i>Nan Lin, Douglas Noe, Xuming He</i>	551
30.1 Overview	552
30.2 Classification and Regression Tree (CART)	555
30.3 Other Single-Tree-Based Methods	561

30.4	Ensemble Trees	565
30.5	Conclusion	568
	References.....	569
31	Image Registration and Unknown Coordinate Systems	
	<i>Ted Chang</i>	571
31.1	Unknown Coordinate Systems and Their Estimation	572
31.2	Least Squares Estimation	575
31.3	Geometry of $\mathcal{O}(p)$ and $\mathcal{SO}(p)$	578
31.4	Statistical Properties of M -Estimates	580
31.5	Diagnostics	587
	References.....	590
32	Statistical Genetics for Genomic Data Analysis	
	<i>Jae K. Lee</i>	591
32.1	False Discovery Rate	592
32.2	Statistical Tests for Genomic Data	593
32.3	Statistical Modeling for Genomic Data	596
32.4	Unsupervised Learning: Clustering	598
32.5	Supervised Learning: Classification	599
	References.....	603
33	Statistical Methodologies for Analyzing Genomic Data	
	<i>Fenghai Duan, Heping Zhang</i>	607
33.1	Second-Level Analysis of Microarray Data	609
33.2	Third-Level Analysis of Microarray Data	611
33.3	Fourth-Level Analysis of Microarray Data	618
33.4	Final Remarks	618
	References.....	619
34	Statistical Methods in Proteomics	
	<i>Weichuan Yu, Baolin Wu, Tao Huang, Xiaoye Li, Kenneth Williams, Hongyu Zhao</i>	623
34.1	Overview.....	623
34.2	MS Data Preprocessing	625
34.3	Feature Selection	628
34.4	Sample Classification	630
34.5	Random Forest: Joint Modelling of Feature Selection and Classification	630
34.6	Protein/Peptide Identification	633
34.7	Conclusion and Perspective	635
	References.....	636
35	Radial Basis Functions for Data Mining	
	<i>Miyoung Shin, Amrit L. Goel</i>	639
35.1	Problem Statement	640
35.2	RBF Model and Parameters	641

35.3	Design Algorithms	642
35.4	Illustrative Example.....	643
35.5	Diabetes Disease Classification	645
35.6	Analysis of Gene Expression Data	647
35.7	Concluding Remarks	648
	References.....	648

36 Data Mining Methods and Applications

	<i>Kwok-Leung Tsui, Victoria Chen, Wei Jiang, Y. Alp Aslandogan</i>	651
36.1	The KDD Process	653
36.2	Handling Data	654
36.3	Data Mining (DM) Models and Algorithms	655
36.4	DM Research and Applications	664
36.5	Concluding Remarks	667
	References.....	667

Part E Modeling and Simulation Methods

37 Bootstrap, Markov Chain and Estimating Function

	<i>Feifang Hu</i>	673
37.1	Overview.....	673
37.2	Classical Bootstrap.....	675
37.3	Bootstrap Based on Estimating Equations.....	678
37.4	Markov Chain Marginal Bootstrap.....	681
37.5	Applications.....	682
37.6	Discussion.....	684
	References.....	684

38 Random Effects

	<i>Yi Li</i>	687
38.1	Overview.....	687
38.2	Linear Mixed Models.....	688
38.3	Generalized Linear Mixed Models	690
38.4	Computing MLEs for GLMMs	692
38.5	Special Topics: Testing Random Effects for Clustered Categorical Data	697
38.6	Discussion.....	701
	References.....	701

39 Cluster Randomized Trials: Design and Analysis

	<i>Mirjam Moerbeek</i>	705
39.1	Cluster Randomized Trials	706
39.2	Multilevel Regression Model and Mixed Effects ANOVA Model	707
39.3	Optimal Allocation of Units	709
39.4	The Effect of Adding Covariates	712
39.5	Robustness Issues.....	713

39.6	Optimal Designs for the Intra-Class Correlation Coefficient	715
39.7	Conclusions and Discussion	717
	References	717
40	A Two-Way Semilinear Model for Normalization and Analysis of Microarray Data	
	<i>Jian Huang, Cun-Hui Zhang</i>	719
40.1	The Two-Way Semilinear Model	720
40.2	Semiparametric M-Estimation in TW-SLM	721
40.3	Extensions of the TW-SLM	724
40.4	Variance Estimation and Inference for β	725
40.5	An Example and Simulation Studies	727
40.6	Theoretical Results	732
40.7	Concluding Remarks	734
	References	734
41	Latent Variable Models for Longitudinal Data with Flexible Measurement Schedule	
	<i>Haiqun Lin</i>	737
41.1	Hierarchical Latent Variable Models for Longitudinal Data	738
41.2	Latent Variable Models for Multidimensional Longitudinal Data	741
41.3	Latent Class Mixed Model for Longitudinal Data	743
41.4	Structural Equation Model with Latent Variables for Longitudinal Data	744
41.5	Concluding Remark: A Unified Multilevel Latent Variable Model	746
	References	747
42	Genetic Algorithms and Their Applications	
	<i>Mitsuo Gen</i>	749
42.1	Foundations of Genetic Algorithms	750
42.2	Combinatorial Optimization Problems	753
42.3	Network Design Problems	757
42.4	Scheduling Problems	761
42.5	Reliability Design Problem	763
42.6	Logistic Network Problems	766
42.7	Location and Allocation Problems	769
	References	772
43	Scan Statistics	
	<i>Joseph Naus</i>	775
43.1	Overview	775
43.2	Temporal Scenarios	776
43.3	Higher Dimensional Scans	784
43.4	Other Scan Statistics	786
	References	788

44 Condition-Based Failure Prediction

<i>Shang-Kuo Yang</i>	791
44.1 Overview	792
44.2 Kalman Filtering	794
44.3 Armature-Controlled DC Motor	796
44.4 Simulation System	797
44.5 Armature-Controlled DC Motor Experiment	801
44.6 Conclusions	804
References	804

45 Statistical Maintenance Modeling for Complex Systems

<i>Wenjian Li, Hoang Pham</i>	807
45.1 General Probabilistic Processes Description	809
45.2 Nonrepairable Degraded Systems Reliability Modeling	810
45.3 Repairable Degraded Systems Modeling	819
45.4 Conclusions and Perspectives	831
45.5 Appendix A	831
45.6 Appendix B	832
References	833

46 Statistical Models on Maintenance

<i>Toshio Nakagawa</i>	835
46.1 Time-Dependent Maintenance	836
46.2 Number-Dependent Maintenance	838
46.3 Amount-Dependent Maintenance	842
46.4 Other Maintenance Models	843
References	847

Part F Applications in Engineering Statistics**47 Risks and Assets Pricing**

<i>Charles S. Tapiero</i>	851
47.1 Risk and Asset Pricing	853
47.2 Rational Expectations, Risk-Neutral Pricing and Asset Pricing	857
47.3 Consumption Capital Asset Price Model and Stochastic Discount Factor	862
47.4 Bonds and Fixed-Income Pricing	865
47.5 Options	872
47.6 Incomplete Markets and Implied Risk-Neutral Distributions	880
References	898

48 Statistical Management and Modeling for Demand of Spare Parts

<i>Emilio Ferrari, Arrigo Pareschi, Alberto Regattieri, Alessandro Persona</i>	905
48.1 The Forecast Problem for Spare Parts	905
48.2 Forecasting Methods	909
48.3 The Applicability of Forecasting Methods to Spare-Parts Demands ...	911

48.4	Prediction of Aircraft Spare Parts: A Case Study	912
48.5	Poisson Models	915
48.6	Models Based on the Binomial Distribution	917
48.7	Extension of the Binomial Model Based on the Total Cost Function ..	920
48.8	Weibull Extension	923
	References.....	928
 49 Arithmetic and Geometric Processes		
	<i>Kit-Nam F. Leung</i>	931
49.1	Two Special Monotone Processes	934
49.2	Testing for Trends.....	936
49.3	Estimating the Parameters.....	938
49.4	Distinguishing a Renewal Process from an AP (or a GP).....	939
49.5	Estimating the Means and Variances	939
49.6	Comparison of Estimators Using Simulation	945
49.7	Real Data Analysis	946
49.8	Optimal Replacement Policies Determined Using Arithmetico-Geometric Processes	947
49.9	Some Conclusions on the Applicability of an AP and/or a GP	950
49.10	Concluding Remarks	951
49.A	Appendix	953
	References.....	954
 50 Six Sigma		
	<i>Fugee Tsung</i>	957
50.1	The DMAIC Methodology	960
50.2	Design for Six Sigma	965
50.3	Six Sigma Case Study	970
50.4	Conclusion	971
	References.....	971
 51 Multivariate Modeling with Copulas and Engineering Applications		
	<i>Jun Yan</i>	973
51.1	Copulas and Multivariate Distributions	974
51.2	Some Commonly Used Copulas	977
51.3	Statistical Inference	981
51.4	Engineering Applications	982
51.5	Conclusion	987
51.A	Appendix.....	987
	References.....	989
 52 Queuing Theory Applications to Communication Systems: Control of Traffic Flows and Load Balancing		
	<i>Panlop Zeephonsekul, Anthony Bedford, James Broberg, Peter Dimopoulos, Zahir Tari</i>	991
52.1	Brief Review of Queueing Theory	994
52.2	Multiple-Priority Dual Queue (MPDQ)	1000

52.3	Distributed Systems and Load Balancing.....	1005
52.4	Active Queue Management for TCP Traffic.....	1012
52.5	Conclusion	1020
	References.....	1020
53	Support Vector Machines for Data Modeling with Software Engineering Applications	
	<i>Hojung Lim, Amrit L. Goel</i>	1023
53.1	Overview.....	1023
53.2	Classification and Prediction in Software Engineering	1024
53.3	Support Vector Machines	1025
53.4	Linearly Separable Patterns.....	1026
53.5	Linear Classifier for Nonseparable Classes	1029
53.6	Nonlinear Classifiers	1029
53.7	SVM Nonlinear Regression	1032
53.8	SVM Hyperparameters	1033
53.9	SVM Flow Chart.....	1033
53.10	Module Classification.....	1034
53.11	Effort Prediction	1035
53.12	Concluding Remarks	1036
	References.....	1036
54	Optimal System Design	
	<i>Suprasad V. Amari</i>	1039
54.1	Optimal System Design	1039
54.2	Cost-Effective Designs.....	1047
54.3	Optimal Design Algorithms.....	1051
54.4	Hybrid Optimization Algorithms	1055
	References.....	1063
	Acknowledgements	1065
	About the Authors	1067
	Detailed Contents	1085
	Subject Index	1113

List of Tables

Part A Fundamental Statistics and Its Applications

1 Basic Statistical Concepts

Table 1.1	Results from a twelve-component life duration test.....	6
Table 1.2	Main rotor blade data	22
Table 1.3	Successive inter-failure times (in s) for a real-time command system	25
Table 1.4	Sample observations for each cell boundary	26
Table 1.5	Confidence limits for θ	29
Table 1.6	Cumulative areas under the standard normal distribution	43
Table 1.7	Percentage points for the t -distribution ($t_{\alpha,r}$).....	44
Table 1.8	Percentage points for the F -distribution $F_{0.05, \nu_2/\nu_1}$	45
Table 1.9	Percentage points for the χ^2 distribution.....	46
Table 1.10	Critical values $d_{n,\alpha}$ for the Kolmogorov–Smirnov test	47

2 Statistical Reliability with Applications

Table 2.1	Common lifetime distributions used in reliability data analysis.....	52
Table 2.2	Minimum cut sets and path sets for the systems in Fig. 2.3	57

3 Weibull Distributions and Their Applications

Table 3.1	Data set of failure test (data set 2)	74
Table 3.2	A sample of reliability applications.....	75
Table 3.3	A sample of other applications	76

6 Prediction Intervals for Reliability Growth Models with Small Sample Sizes

Table 6.1	Values of the mean of the distribution of R	118
Table 6.2	Values of the median of the distribution of R	118
Table 6.3	Percentiles of the distribution of R	119
Table 6.4	Predictions of fault detection times based on model	120
Table 6.5	Expected faults remaining undetected.....	120
Table 6.6	Probability of having detected all faults	121
Table 6.7	Observed ratios.....	121
Table 6.8	Prediction errors.....	122

9 Modeling and Analyzing Yield, Burn-In and Reliability for Semiconductor Manufacturing: Overview

Table 9.1	Industry sales expectations for IC devices.....	154
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Part B Process Monitoring and Improvement

11 Statistical Methods for Product and Process Improvement

Table 11.1	Noise factor levels for optimum combination	210
Table 11.2	Comparison of results from different methods	211

12 Robust Optimization in Quality Engineering

Table 12.1	2^2 factorial design for paper helicopter example	217
Table 12.2	Experiments along the path of steepest ascent	217
Table 12.3	Central composite design for paper helicopter example	217
Table 12.4	Comparison of performance responses using canonical and robust optimization approaches (true optimal performance: -19.6)	226
Table 12.5	Comparison of performance responses using canonical, robust, and weighted robust optimization	226

13 Uniform Design and Its Industrial Applications

Table 13.1	Experiment for the production yield y	232
Table 13.2	ANOVA for a linear model	232
Table 13.3	ANOVA for a second-degree model	233
Table 13.4	ANOVA for a centered second-degree model	233
Table 13.5	The set up and the results of the accelerated stress test	233
Table 13.6	ANOVA for an inverse responsive model	234
Table 13.7	Experiment for the robot arm example	235
Table 13.8	A design in $\mathcal{U}(6; 3^2 \times 2)$	237
Table 13.9	Construction of UD in $S_{a,b}^{3-1}$	242

15 Chain Sampling

Table 15.1	ChSP-1 plans indexed by AQL and LQL ($\alpha = 0.05$, $\beta = 0.10$) for fraction nonconforming inspection	265
Table 15.2	Limits for deciding unsatisfactory variables plans	274

16 Some Statistical Models for the Monitoring of High-Quality Processes

Table 16.1	A set of defect count data	285
------------	----------------------------------	-----

17 Monitoring Process Variability Using EWMA

Table 17.1	Standard-deviation $\sigma(\tilde{Z})$ of the normal $(0, 1)$ sample median, for $n \in \{3, 5, \dots, 25\}$	296
Table 17.2	Optimal couples (λ^*, K^*) and optimal ARL^* of the EWMA- $\bar{X}$ (<i>half top</i>) and EWMA- $\bar{X}$ (<i>half bottom</i>) control charts, for $\tau \in \{0.1, 0.2, \dots, 2\}$, $n \in \{1, 3, 5, 7, 9\}$ and $ARL_0 = 370.4$	297
Table 17.3	Constants $A_{S^2}(n)$, $B_{S^2}(n)$, $C_{S^2}(n)$, Y_0 , $E(T_k)$, $\sigma(T_k)$, $\gamma_3(T_k)$ and $\gamma_4(T_k)$ for the EWMA- S^2 control chart, for $n \in \{3, \dots, 15\}$	300
Table 17.4	Optimal couples (λ^*, K^*) and optimal ARL^* for the EWMA- S^2 control chart, for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{3, 5, 7, 9\}$ and $ARL_0 = 370.4$	300

Table 17.5	Constants $A_S(n)$, $B_S(n)$, $C_S(n)$, Y_0 , $E(T_k)$, $\sigma(T_k)$, $\gamma_3(T_k)$ and $\gamma_4(T_k)$ for the EWMA- S control chart, for $n \in \{3, \dots, 15\}$	304
Table 17.6	Optimal couples (λ^*, K^*) and optimal ARL^* for the EWMA- S control chart, for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{3, 5, 7, 9\}$ and $ARL_0 = 370.4$	306
Table 17.7	Expectation $E(R)$, variance $V(R)$ and skewness coefficient $\gamma_3(R)$ of R	307
Table 17.8	Constants $A_R(n)$, $B_R(n)$, $C_R(n)$, Y_0 , $E(T_k)$, $\sigma(T_k)$, $\gamma_3(T_k)$ and $\gamma_4(T_k)$ for the EWMA- R control chart, for $n \in \{3, \dots, 15\}$	307
Table 17.9	Optimal couples (λ^*, K^*) and optimal ARL^* for the EWMA- R control chart, for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{3, 5, 7, 9\}$ and $ARL_0 = 370.4$	309
Table 17.10	Optimal out-of-control ATS^* of the VSI EWMA- S^2 for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{3, 5\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	311
Table 17.11	Optimal out-of-control ATS^* of the VSI EWMA- S^2 for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{7, 9\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	312
Table 17.12	Optimal h_L^* values of the VSI EWMA- S^2 for $n \in \{3, 5, 7, 9\}$, $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	313
Table 17.13	Optimal couples (λ^*, K^*) of the VSI EWMA- S^2 for $n \in \{3, 5\}$, $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	314
Table 17.14	Optimal couples (λ^*, K^*) of the VSI EWMA- S^2 for $n \in \{7, 9\}$, $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	315
Table 17.15	Subgroup number, sampling interval (h_5 or h_L), total elapsed time from the start of the simulation and statistics S_k^2 , T_k and Y_k	317
Table 17.16	Optimal out-of-control ATS^* of the VSI EWMA- R for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{3, 5\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	318
Table 17.17	Optimal out-of-control ATS^* of the VSI EWMA- R for $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $n \in \{7, 9\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	319
Table 17.18	Optimal h_L^* values of the VSI EWMA- R for $n \in \{3, 5, 7, 9\}$, $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	320
Table 17.19	Optimal couples (λ^*, K^*) of the VSI EWMA- R for $n \in \{3, 5\}$, $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	321
Table 17.20	Optimal couples (λ^*, K^*) of the VSI EWMA- R for $n \in \{7, 9\}$, $\tau \in \{0.6, 0.7, 0.8, 0.9, 0.95, 1.05, 1.1, 1.2, \dots, 2\}$, $h_5 \in \{0.1, 0.5\}$, $W = \{0.1, 0.3, 0.6, 0.9\}$, $ATS_0 = 370.4$	322

**18 Multivariate Statistical Process Control Schemes
for Controlling a Mean**

Table 18.1	ARL comparison with bivariate normal data (uncorrelated)	337
Table 18.2	ARL comparison with bivariate normal data (correlated)	338
Table 18.3	Eigenvectors and eigenvalues from the 30 stable observations	340
Table 18.4	Probability of false alarms when the process is in control. Normal populations and X-bar chart	342
Table 18.5	The estimated ARL for Page's CUSUM when the process is in control. Normal populations	342
Table 18.6	The h value to get in-control ARL ≈ 200 , $k = 0.5$. Page's CUSUM	342
Table 18.7	The estimate in-control ARL using Crosier's multivariate scheme	343

Part C Reliability Models and Survival Analysis

19 Statistical Survival Analysis with Applications

Table 19.1	Sample size per group based on the method of <i>Rubinstein</i> , et al. [19.18] $\alpha = 5\%$, $\beta = 20\%$	352
Table 19.2	Sample size per group based on the method of <i>Freedman</i> [19.22] (Weibull distribution with a shape parameter 1.5 assumed) $\alpha = 5\%$, $\beta = 20\%$	353
Table 19.3	Sample size per group based on (19.8); The lognormal case $\alpha = 5\%$, $\beta = 20\%$, $\sigma = 0.8$	353
Table 19.4	Sample size per group based on (19.8); the Weibull case $\alpha = 5\%$, $\beta = 20\%$, $\sigma = 0.8$	353
Table 19.5	Step-stress pattern after step 4	360
Table 19.6	Count data	360
Table 19.7	Parameter estimates	360
Table 19.8	Percentiles of S_3 and S_5	364

21 Proportional Hazards Regression Models

Table 21.1	Data table for the example	393
Table 21.2	Model fitting result	394

22 Accelerated Life Test Models and Data Analysis

Table 22.1	GAB insulation data	403
Table 22.2	GAB insulation data. Weibull ML estimates for each voltage stress	409
Table 22.3	GAB insulation data. ML estimates for the inverse power relationship Weibull regression model	409
Table 22.4	GAB insulation data. Quantiles ML estimates at 120 V/mm	412
Table 22.5	IC device data	412
Table 22.6	IC device data. Lognormal ML estimates for each temperature	414
Table 22.7	IC device data. ML estimates for the Arrhenius lognormal regression model	414

Table 22.8	Laminate panel data. ML estimates for the inverse power relationship lognormal regression model	415
Table 22.9	LED device subset data. ML estimates for the lognormal regression models (22.12) and (22.13)	417
Table 22.10	Spring fatigue data. ML estimates for the Weibull regression model	419
Table 22.11	Spring fatigue data. Quantiles ML estimates at (20 mil, 600 °F) for the Old and New processing methods	420
23 Statistical Approaches to Planning of Accelerated Reliability Testing		
Table 23.1	A summary of the characteristics of literature on optimal design of SSALT	432
24 End-to-End (E2E) Testing and Evaluation of High-Assurance Systems		
Table 24.1	Evolution of E2E T&E techniques	445
Table 24.2	Automatically generated code example	457
Table 24.3	Examples of obligation policies	461
Table 24.4	Examples of specifying system constraints	463
Table 24.5	Policy registration	464
Table 24.6	Reliability definition of ACDATE entities	467
Table 24.7	The most reliable services and their forecast	469
Table 24.8	ANOVA significance analysis	469
Table 24.9	Cooperative versus traditional ontology	472
25 Statistical Models in Software Reliability and Operations Research		
Table 25.1	Fitting of testing effort data	485
Table 25.2	Parameter estimation of the SRGM	485
Table 25.3	Estimation result on DS-3	486
Table 25.4	Release-time problems	489
26 An Experimental Study of Human Factors in Software Reliability Based on a Quality Engineering Approach		
Table 26.1	Controllable factors in the design-review experiment	499
Table 26.3	Controllable factors in the design-review experiment	500
Table 26.2	Input and output tables for the two kinds of error	500
Table 26.4	The result of analysis of variance using the SNR	502
Table 26.5	The comparison of SNR and standard error rates	503
Table 26.6	The optimal and worst levels of design review	503
Table 26.7	The SNRs in the optimal levels for the selected inducers	503
Table 26.8	The comparison of SNRs and standard error rates between the optimal levels for the selected inducers	503
Table 26.9	The orthogonal array $L_{18}(2^1 \times 3^7)$ with assigned human factors and experimental data	504
Table 26.10	The result of analysis of variance (descriptive-design faults) ..	505

Table 26.11	The result of analysis of variance (symbolic–design faults).....	505
Table 26.12	The result of analysis of variance by taking account of correlation among inside and outside factors	505

27 Statistical Models for Predicting Reliability of Software Systems in Random Environments

Table 27.1	Summary of NHPP software reliability models	508
Table 27.2	Normalized cumulative failures and times during software testing	513
Table 27.3	Normalized cumulative failures and their times in operation	513
Table 27.4	MLE solutions for the γ -RFE model	514
Table 27.5	MLE solutions for the β -RFE model	514
Table 27.6	The mean–value functions for both RFEs models	515
Table 27.7	MLEs and fitness comparisons	518

Part D Regression Methods and Data Mining

28 Measures of Influence and Sensitivity in Linear Regression

Table 28.1	Three sets of data which differ in one observation	527
Table 28.2	Some statistics for the three regressions fitted to the data in Table 28.1	527
Table 28.3	A simulated set of data	531
Table 28.4	Eigen–analysis of the influence matrix for the data from Table 28.3. The eigenvectors and eigenvalues are shown	531
Table 28.5	Values of the t statistics for testing each point as an outlier ...	531
Table 28.6	Eigenvalues of the sensitivity matrix for the data from Table 28.3.....	532

29 Logistic Regression Tree Analysis

Table 29.1	Indicator variable coding for the species variable S	539
Table 29.2	Predictor variables in the crash–test dataset. Angular variables $crbang$, $pdof$, and $impang$ are measured in degrees clockwise (from -179 to 180) with 0 being straight ahead	544
Table 29.3	Split at node 7 of the tree in Fig. 29.8	546
Table 29.4	Split at node 9 of the tree in Fig. 29.8.....	547

30 Tree–Based Methods and Their Applications

Table 30.1	Electronic mail characteristics	552
Table 30.2	Seismic rehabilitation cost–estimator variables	553
Table 30.3	Characteristics of CPUs	559
Table 30.4	Comparison of tree–based algorithms.....	564
Table 30.5	Data–mining software for tree–based methods.....	565

31 Image Registration and Unknown Coordinate Systems	
Table 31.1 12 digitized locations on the left and right hand	573
Table 31.2 Calculation of residual lengths for data from Table 31.1	583
32 Statistical Genetics for Genomic Data Analysis	
Table 32.1 Outcomes when testing m hypotheses	593
Table 32.2 Classification results of the classification rules and the corresponding gene model.....	603
33 Statistical Methodologies for Analyzing Genomic Data	
Table 33.1 The numbers of genes belonging to the intersects of the five k -means clusters and the 13 PMC clusters.....	614
35 Radial Basis Functions for Data Mining	
Table 35.1 Dataset for illustrative example	643
Table 35.2 Data description for the diabetes example.....	645
Table 35.3 RBF models for the diabetes example	646
Table 35.4 Selected models and error values for the diabetes example....	647
Table 35.5 Classification results for the cancer gene example	647
Part E Modeling and Simulation Methods	
37 Bootstrap, Markov Chain and Estimating Function	
Table 37.1 Minimum L_q distance estimator ($q = 1.5$). Simulated coverage probabilities and average confidence intervals (fixed design) .	683
39 Cluster Randomized Trials: Design and Analysis	
Table 39.1 Values for the mixed effects ANOVA model.....	708
Table 39.2 Changes in the variance components due to the inclusion of a covariate	713
Table 39.3 Assumptions about the intra-class correlation coefficient, with associated power with 86 groups and required number of groups for a power level of 0.9	714
Table 39.4 Empirical type I error rate α and power $1 - \beta$ for the standard design and re-estimation design for three values of the prior ρ . The true $\rho = 0.05$	715
40 A Two-Way Semilinear Model for Normalization and Analysis of Microarray Data	
Table 40.1 Simulation results for model 1. $10\,000 \times$ Summary of MSE. The true normalization curve is the horizontal line at 0. The expression levels of up- and down-regulated genes are symmetric: $\alpha_1 = \alpha_2$, where $\alpha_1 + \alpha_2 = \alpha$	731
Table 40.2 Simulation results for model 2. $10\,000 \times$ Summary of MSE. The true normalization curve is the horizontal line at 0. But the percentages of up- and down-regulated genes are different: $\alpha_1 = 3\alpha_2$, where $\alpha_1 + \alpha_2 = \alpha$	731

Table 40.3	Simulation results for model 3. 10 000 × Summary of MSE. There are nonlinear and intensity-dependent dye biases. The expression levels of up- and down-regulated genes are symmetric: $\alpha_1 = \alpha_2$, where $\alpha_1 + \alpha_2 = \alpha$	731
Table 40.4	Simulation results for model 4. 10 000 × Summary of MSE. There are nonlinear and intensity-dependent dye biases. The percentages of up- and down-regulated genes are different: $\alpha_1 = 3\alpha_2$, where $\alpha_1 + \alpha_2 = \alpha$	731
42 Genetic Algorithms and Their Applications		
Table 42.1	Failure modes and probabilities in each subsystem	764
Table 42.2	Coordinates of Cooper and Rosing's example	770
Table 42.3	Comparison results of Cooper and Rosing's example	770
44 Condition-Based Failure Prediction		
Table 44.1	Mean values, standard deviations, and variances for different T	803
45 Statistical Maintenance Modeling for Complex Systems		
Table 45.1	Optimal values I and L	824
Table 45.2	The effect of L on P_c for $I = 37.5$	825
Table 45.3	Nelder–Mead algorithm results	830
Table 45.4	The effect of (L_1, L_2) on P_p for a given inspection sequence ...	830
Table 45.5	The effect of the inspection sequence on P_p for fixed PM values	830
46 Statistical Models on Maintenance		
Table 46.1	Optimum T^* , N^* for $T = 1$ and percentile T_p when $F(t) = 1 - \exp(-t/100)^2$	839
Table 46.2	Optimum replacement number K^* , failed element number N^* , and the expected costs $C_1(K^*)$ and $C_2(N^*)$	847
Part F Applications in Engineering Statistics		
47 Risks and Assets Pricing		
Table 47.1	Comparison of the log-normal and bi-log-normal model	890
48 Statistical Management and Modeling for Demand of Spare Parts		
Table 48.1	A summary of selected forecasting methods	907
Table 48.2	Classification of forecasting methods, corresponding testing ground and applications	909
Table 48.3	Summary of the better forecasting methods	911
Table 48.4	Comparison among some methods	913
Table 48.5	Ranking based on performance evaluation (MAD)	914
Table 48.6	Example of N evaluation for a specific item (code 0X931: pin for fork gear levers)	918

Table 48.7	LS % and minimum cost related to $T_s d$ and $Rt/(C_m d)$ — no. of employments $n = 5$	921
Table 48.8	LS % and minimum cost related to $T_s d$ and $Rt/(C_m d)$ — no. of employments $n = 15$	921
Table 48.9	Optimization of T_s for fixed number of spare parts N	922

49 Arithmetic and Geometric Processes

Table 49.1	Recommended estimators for μ_{A_1} and $\sigma_{A_1}^2$	945
Table 49.2	Recommended estimators for μ_{G_1} and $\sigma_{G_1}^2$	945
Table 49.3	Recommended estimators for $\mu_{\bar{A}_1}$ and $\sigma_{\bar{A}_1}^2$, and $\mu_{\bar{G}_1}$ and $\sigma_{\bar{G}_1}^2$..	946
Table 49.4	Estimated values of common difference and ratio, and means for the 6LXB engine	950
Table 49.5	Estimated values of common difference and ratio, and means for the Benz gearbox	950
Table 49.6	Summary of useful results of both AP and GP processes	951

50 Six Sigma

Table 50.1	Final yield for different sigma levels in multistage processes ..	958
Table 50.2	Number of Six Sigma black belts certified by the American Society for Quality (ASQ) internationally (ASQ record up to April, 2002)	959

51 Multivariate Modeling with Copulas and Engineering Applications

Table 51.1	Some one-parameter (α) Archimedean copulas	980
Table 51.2	Comparison of T^2 percentiles when the true copula is normal and when the true copula is Clayton with various Kendall's τ . The percentiles under Clayton copulas are obtained from 100 000 simulations	984
Table 51.3	IFM fit for all the margins using normal and gamma distributions, both parameterized by mean and standard deviation. Presented results are log-likelihood (Loglik), estimated mean, and estimated standard deviation (StdDev) for each margin under each model	985
Table 51.4	IFM and CML fit for single-parameter normal copulas with dispersion structures: AR(1), exchangeable, and Toeplitz	986
Table 51.5	Maximum-likelihood results for the disk error-rate data. Parameter estimates, standard errors and log-likelihood are provided for both the multivariate normal model and the multivariate gamma model with a normal copula. The second entry of each cell is the corresponding standard error	986

52 Queuing Theory Applications to Communication Systems: Control of Traffic Flows and Load Balancing

Table 52.1	Some heavy-tail distributions	1016
Table 52.2	Scheduling variables	1016
Table 52.3	DPRQ parameters	1018

Table 52.4	States of the DPRQ	1019
53 Support Vector Machines for Data Modeling with Software Engineering Applications		
Table 53.1	Data points for the illustrative example	1028
Table 53.2	Three common inner-product kernels	1030
Table 53.4	Classification results	1034
Table 53.3	List of metrics from NASA database	1034
Table 53.5	Performance of effort prediction models.....	1036
54 Optimal System Design		
Table 54.1	Exhaustive search results	1052
Table 54.2	Dynamic programming solution.....	1054
Table 54.3	Parameters for a series system	1059
Table 54.4	Parameters for optimization of a series system	1059
Table 54.5	Parameters for a hypothetical reliability block diagram	1060
Table 54.6	Parameters for the optimization of a hypothetical reliability block diagram	1060
Table 54.7	Parameters for a bridge network	1062

List of Abbreviations

A

ABC	approximated bootstrap confidence
ACK	acknowledgment
ADDT	accelerated destructive degradation tests
ADI	average inter-demand interval
ADT	accelerated degradation test
AF	acceleration factor
AGP	arithmetico-geometric process
ALM	accelerated life model
ALT	accelerated life testing
AMA	arithmetic moving-average
ANN	artificial neural networks
ANOVA	analysis of variations
AP	arithmetic process
APC	automatic process control
AQL	acceptable quality level
AQM	active queue management
AR	autoregressive process
ARI	adjusted Rand index
ARL	average run length
ARMA	autoregressive and moving average
ARMDT	accelerated repeated measures degradation tests
ARRSES	adaptive response rate single-exponential smoothing
ART	accelerated reliability
ASN	average sample number
ASQ	American Society for Quality
ATI	average total inspection
AUC	area under the receiver operating characteristics curve
AW	additive Winter

B

BIB	burn-in board
BIR	built-in reliability
BLAST	Berkeley lazy abstraction software verification tool
BLUP	best linear unbiased predictor
BM	binomial model
BVE	bivariate exponential

C

CART	classification and regression tree
CBFQ	credit-based fair queueing
CBQ	class-based queues
CCD	central composite design
CDF	cumulative distribution function

CE	classification error
CF	characteristic function
CFE	Cauchy functional equation
CFR	call for fire
CHAID	chi-square automatic interaction detection
CID	collision-induced dissociation
CIM	cluster-image map
CLT	central limit theorem
CM	corrective maintenance
CML	canonical maximum likelihood
CMW	combination warranty
CNM	customer needs mapping
COPQ	cost of poor quality
COT	cumulative sum of T
cPLP	capacitated plant location problem
CRC	cumulative results criterion
CRUISE	classification rule with unbiased interaction selection and estimation
CS-CQ	cycle stealing with central queue
CS-ID	cycle stealing with immediate dispatch
CSALT	constant-stress accelerated life test
CSS	conditional single-sampling
CTQ	critical-to-quality
CUSUM	cumulative sum
CV	coefficient of variance
CV	cross-validation
CVP	critical value pruning
CX	cycle crossover
Cdf	cumulative distribution function
Cuscore	cumulative score
Cusum	cumulative sum

D

DBI	dynamic burn-in
DBSCAN	Density-based clustering
DCCDI	define, customer concept, design, and implement
DES	double-exponential smoothing
df	degrees of freedom
DFM	design for manufacturability
DFR	decreasing failure rate
DFR	design for reliability
DFSS	design for Six Sigma
DFY	design for yield
DLBI	die-level burn-in
DLBT	die-level burn-in and testing
DM	Data mining
DMADV	define, measure, analyze, design and verify
DMAIC	define, measure, analyze, improve, and control

DMAICT	define, measure, analyze, improve, control and technology transfer
DOE	design of experiments
DP	dynamic programming
DP	design parameters
DPMO	defects per million opportunities
DQ	dual-queue
DQLT	dual queue length threshold
DRD	dynamic robust design
DRR	deficit round-robin
DSSP	dependent stage sampling plan
DUT	device under test
DWC	discounted warranty cost
DoD	Department of Defense

E

EBD	equivalent business days
EBP	error-based pruning
EDWC	expected discounted warranty cost
EF	estimating function
EM	expectation maximization
EOQ	economic order quantity
EOS	electrical-over-stress
EQL	expected quality loss
ES	exponential smoothing
ESC	expected scrap cost
ESD	electrostatic discharge
ETC	expected total cost
EWC	expected warranty cost
EWMA	exponentially weighted moving average
EWMAST	exponentially weighted moving average chart for stationary processes

F

FCFS	first-come first-served
FDR	false discovery rate
FIR	fast initial response
FMEA	failure modes and effects analysis
FR	failure rate
FR	functional requirements
FRPW	free repair warranty
FRW	free replacement warranty
FSI	fixed sampling interval
FSW	full-service warranty
FTP	file transfer protocol
FWER	family-wise error rate

G

GA	genetic algorithms
GAB	generator armature bars
GAM	generalized additive model
GAOT	genetic algorithm optimization toolbox
GEE	generalized estimating equation

GERT	graphical evaluation and review technique
GLM	general linear model
GLM	generalized linear model
GLMM	generalized linear mixed model
GLRT	generalized likelihood ratio test
GP	geometric process
GUIDE	generalized, unbiased interaction detection and estimation

H

HALT	highly accelerated life tests
HCF	highest class first
HDL	high-density lipoprotein
HEM	heterogeneous error model
HEM	hybrid evolutionary method
HLA/RTI	high level architecture/runtime infrastructure
HPP	homogeneous Poisson process
HR	human resource
HTTP	hypertext transfer protocol

I

IC	inspection cost
ICOV	identify, characterize, optimize, verify
IDOV	identify, design, optimize, validate
IETF	internet engineering task force
IFM	inference functions for margins
IFR	increasing failure rate
i.i.d.	of independent and identically distributed
iid	independent identically distributed
IM	improvement maintenance
IT	information technology

K

KDD	knowledge discovery in databases
KGD	known good dies
KNN	<i>k</i> -nearest neighbors

L

LAC	lack of anticipation condition
LCEM	linear cumulative exposure model
LCF	lowest class first
LCL	lower control limits
LDA	linear discriminant analysis
LED	light emitting device
LIFO	last-in first-out
LLF	least loaded first
LLP	log-linear process
LMP	lack-of-memory property
LOC	lines of code
LOF	lack-of-fit
LPE	local pooled error

LQL	limiting quality level
LR	logistic regression
LSL	lower specification limit
LTi	low-turnaround-index
LTP	linear transportation problem

M

MAD	mean absolute deviation
MAD	median absolute deviation
MAPE	mean absolute percentage error
MARS	multivariate adaptive regression splines
MART	multiple additive regression tree
MC/DC	modified condition/decision coverage
MCF	minimum-cost-flow problem
MCMB	Markov chain marginal bootstrap
MCNR	Monte Carlo Newton–Raphson
MCS	Monte Carlo simulation
MCUSUM	multivariate cumulative sum
MDMSP	multidimensional mixed sampling plans
MDS	multiple dependent (deferred) state
MEP	minimum error pruning
MEWMA	multivariate exponentially weighted moving average
MGF	moment generating function
MILP	mixed integer linear programming model
ML	maximum-likelihood
MLDT	mean logistic delay time
MLE	maximum likelihood estimation
MME	method of moment estimates
MMSE	minimum mean squared error
MOLAP	multidimensional OLAP
MPDQ	multiple-priority dual queues
MPP	marked point process
MPP	multistage process planning
MRL	mean residual life
MS	mass spectrometry
MSA	measurement system analysis
MSE	mean square errors
MST	minimum spanning tree
MTBF	mean time before failure
MTBR	mean time between replacement
MTEF	marginal testing effort function
mTP	multiobjective transportation problem
MTS	Mahalanobis–Taguchi system
MTTF	mean time to failure
MTTR	mean time to repair
MVN	multivariate normal
MW	multiplicative Winter
MiPP	misclassification penalized posterior

N

NBM	nonoverlapping batch means
NHPP	nonhomogeneous Poisson process
NLP	nonlinear programming

NN	nearest neighbor
NPC	nutritional prevention of cancer
NTB	nominal-the-best case
NUD	new, unique, and difficult

O

OBM	overlapping batch means
OC	operating characteristic
OLAP	online analytical processing
OX	order crossover

P

PAR	phased array radar
PCB	printed circuit board
PDF	probability density function
pdf	probability density function
PEP	pessimistic error pruning
pFDR	proposed positive FDR
PH	proportional hazards
PID	proportional-integral-derivative
PLBI	package-level burn-in
PM	preventive maintenance
PMC	probabilistic model-based clustering
PMX	partial-mapped crossover
POF	physics-of-failure
PQL	penalized quasi-likelihood
PRM	probabilistic rational model
PRW	pro-rata warranty
PV	process variable

Q

QCQP	quadratically constrained quadratic programming
QDA	quadratic discriminant analysis
QFD	quality function deployment
QML	qualified manufacturing line
QSS	quick-switching sampling
QUEST	quick, unbiased and efficient statistical tree
QoS	quality of service

R

RBF	radial basis function
RCL	rate conservation law
RCLW	repair-cost-limit warranty
RD	Robust design
RED	random early-detection queue
REP	reduced error pruning
RF	random forest
RGS	repetitive group sampling
RIO	RED in/out
RNLW	repair-number-limit warranty

RP renewal process
RPC remote procedure call
RPN priority number
RPN risk priority number
RSM response surface method
RSM response surface methodology
RSM response surface models
RTLW repair-time-limit warranty
RV random variable

S

SA simulated annealing
SAFT scale-accelerated failure-time
SAM significance analysis of microarray
SAR split and recombine
SBI steady-state or static burn-in
SCC special-cause charts
SCFQ as self-clocked fair queueing
SCM supply-chain management
s.d. standard deviation
SDLC software development life cycle
SDP semidefinite program
SE standard errors
SEM structural equation models
SES single-exponential smoothing
SEV standard smallest extreme value
SF survival function
SIMEX simulation extrapolation
SIPOC suppliers, inputs, process, outputs and customer

SIRO service in random order
SMD surface-mount devices
SMT surface-mount technology
SNR signal-to-noise ratios
SOAP simple object access protocol
SOF special operations forces
SOM self-organizing maps
SOM self-organizing (feature) map
SPC statistical process control
SQL structured query language
SRGM software reliability growth models
SRM seasonal regression model
SSBB Six Sigma black belts
SSE sum of squared errors
SSM surface-to-surface missile
STS standardized time series

SVM support vector machine
SoS system of systems

T

TAAF test, analyse and fix
TAES forecasting time series data that have a linear trend
TCP transmission control protocol
TCP/IP transmission control protocol/internet protocol
TDBI test during burn-in
TDF temperature differential factor
TQM total quality management
TS tracking signal
TSP traveling-salesman problem

U

UBM unified batch mean
UCL upper control limits
UML unified modeling language
USL upper specification limit

V

VOC voice of customer
VSI variable sampling intervals
VaR value at risk

W

WBM weighted batch mean
WLBI wafer-level burn-in
WLBT wafer-level burn-in and testing
WLR wafer-level reliability
WPP Weibull probability plot
WRED weighted RED
WRR weighted round-robin
WSDL web services description language

X

XML extensible markup language

Y

Y2K year 2000