Contents

Preface V

List of Contributors XV

Part I Basic Notions and Manipulation of Spatial Point Processes

Fundamentals of Point Process Statistics
Dietrich Stoyan 3
1 Basic Notions of the Theory of Spatial Point Processes 3
2 Marked Point Processes 5
3 The Second-order Moment Measure 6
4 Introduction to Statistics for Planar Point Processes 9
5 The Homogeneous Poisson Point Process 17
6 Other Point Processes Models 20
References 21

Modelling Spatial Point Patterns in R
Adrian Baddeley, Rolf Turner 23
1 Introduction 23
2 The spatstat Package 23
2.1 Scope 24
2.2 Data Types in spatstat 24
3 Data Analysis in spatstat 25
3.1 Data Input 25
3.2 Initial Inspection of Data 26
3.3 Exploratory Data Analysis 27
4 Point Process Models 27
4.1 Formulation of Models 28
4.2 Scope of Models 29
4.3 Model-fitting Algorithm 29

5 Model-fitting in spatstat 30
5.1 Overview 30
5.2 Spatial Trend Terms 31
5.3 Interaction Terms 32
6 Fitted Models 33
6.1 Interpretation of Fitted Coefficients 34
6.2 Invalid Models 35
6.3 Predicting and Plotting a Fitted Model 36
7 Models with Covariates 37
7.1 Covariates in a List of Images 38
7.2 Covariates in a Data Frame 40
8 Fitting Models to Multitype Point Patterns 41
8.1 Conditional Intensity 41
8.2 Multitype Models 42
9 Irregular Parameters 44
10 Model Validation 45
10.1 Residuals and Diagnostics 46
10.2 Formal Inference 46
11 Harkness-Isham Ants' Nests Data 50
11.1 Description of Data 50
11.2 Exploratory Analysis 51
11.3 Modelling 54
11.4 Formal Inference 57
11.5 Incorporation of Covariates 59
12 The Queensland Copper Data 62
12.1 Data and Previous Analyses 62
12.2 Analysis 63
12.3 North-South Effect 69
References 70

Part II Theoretical and Methodological Advances in Spatial Point Processes

Strong Markov Property of Poisson Processes and Slivnyak Formula
Sergei Zuyev 77
1 Filtrations and Stopping Sets 77
2 Slivnyak Theorem for Locally Defined Processes 81
References 84

Bayesian Analysis of Markov Point Processes
Kasper K. Berthelsen, Jesper Møller 85
1 Introduction 85
2 Auxiliary Variable Method 88
3 The Strauss Process 89

3.1 Specification of Auxiliary Point Processes 89
3.2 Results for the Auxiliary Variable Method 91
4 Concluding Remarks 93
References 96

Statistics for Locally Scaled Point Processes
Michaela Prokešová, Ute Hahn, Eva B. Vedel Jensen 99
1 Introduction 99
2 Locally Scaled Point Processes 101
3 Simultaneous Maximum (Pseudo)likelihood Estimation of Scaling Function and Template Parameters 104
4 Two Step Maximum Likelihood Estimation of Scaling Parameters Prior to Template Parameters 106
4.1 Estimation of Scaling Parameters, Using the Poisson Likelihood 107
4.2 Statistical Properties of $\widehat{\theta}_0$ 109
4.3 Estimation of the Template Parameters 110
5 Simulation Study 111
6 Two Step Inference Where Scaling Function Is Estimated Using Other (non ML) Methods 114
7 Model Validation 115
7.1 The K-function 116
7.2 The Q^2 Statistic 117
8 Data Analysis 118
References 122

Nonparametric Testing of Distribution Functions in Germ-grain Models
Zbyněk Pawlas, Lothar Heinrich 125
1 Introduction 125
2 Empirical Distribution Functions 127
3 Weak Convergence of an Empirical Multiparameter Process 128
4 Centres of Pores in a Ceramic Coating 129
5 Conclusion 132
References 133

Principal Component Analysis for Spatial Point Processes – Assessing the Appropriateness of the Approach in an Ecological Context
Janine Illian, Erica Benson, John Crawford, Harry Staines 135
1 Introduction 135
2 Methods 136
2.1 Functional Data Analysis 136
2.2 Functional Principal Component Analysis of Second-Order Summary Statistics 137
3 Feasibility Study 138
4 Erroneous Data 140

4.1 Inaccurate Location . . . 142
4.2 Data Collected on a Grid . . . 142
4.3 Wrong Species Recorded . . . 144
5 Application . . . 146
6 Discussion . . . 148
References . . . 149

Part III Practical Applications of Spatial Point Processes

On Modelling of Refractory Castables by Marked Gibbs and Gibbsian-like Processes
Felix Ballani . . . 153
1 Introduction . . . 153
2 The Data . . . 154
2.1 Production and Data Extraction . . . 155
2.2 Statistics . . . 155
3 The Stationary Marked Gibbs Process . . . 157
4 The Random-Shift Model . . . 159
4.1 Definition . . . 159
4.2 Simulation . . . 160
4.3 Fitting . . . 162
5 Further Models . . . 164
5.1 Dense Random Packings . . . 164
5.2 The Ordered RSA Model . . . 164
6 Conclusions . . . 165
References . . . 165

Source Detection in an Outbreak of Legionnaire's Disease
Miguel A. Martínez-Beneito, Juan J. Abellán, Antonio López-Quílez, Hermelinda Vanaclocha, Óscar Zurriaga, Guillermo Jorques, José Fenollar . . . 169
1 Introduction . . . 169
2 Case Study Description . . . 170
3 Methods . . . 172
4 Results . . . 176
5 Discussion . . . 177
References . . . 181

Doctors' Prescribing Patterns in the Midi-Pyrénées rRegion of France: Point-process Aggregation
Noel A.C. Cressie, Olivier Perrin, Christine Thomas-Agnan . . . 183
1 Introduction . . . 183
2 Spatial Regression Model . . . 185
3 Weighted Regression Analysis . . . 188
4 Weighted Spatial Regression Analysis . . . 191

5 Discussion and conclusions 194
References 195

Strain-typing Transmissible Spongiform Encephalopathies Using Replicated Spatial Data
Simon Webster, Peter J. Diggle, Helen E. Clough, Robert B. Green, Nigel P. French 197
1 Introduction 197
2 Data Collection 199
2.1 Sample Material 199
2.2 Extraction of Data from the Sample Material 201
3 Methods 202
3.1 Vacuole Counts 202
3.2 Vacuole Sizes 203
3.3 Spatial Distribution 203
4 Results 206
4.1 Vacuole Counts 206
4.2 Vacuole Sizes 208
4.3 Spatial Distribution of Vacuoles 210
5 Discussion 212
References 213

Modelling the Bivariate Spatial Distribution of Amacrine Cells
Peter J. Diggle, Stephen J. Eglen, John B. Troy 215
1 Introduction 215
1.1 Biological Background 215
2 Pairwise Interaction Point Processes 218
2.1 Univariate Pairwise Interaction Point Processes 218
2.2 Bivariate Pairwise Interaction Point Processes 221
3 Monte Carlo Likelihood Inference 222
4 Analysis of the Amacrines Data 223
4.1 Exploratory Analysis 223
4.2 Structural Hypotheses for the Amacrines Data 225
4.3 Non-parametric Estimation 225
4.4 Univariate Parametric Analysis 226
4.5 Bivariate Analysis 228
5 Conclusions 230
5.1 Statistical Summary 230
5.2 Biological Implications 230
References 232

Analysis of Spatial Point Patterns in Microscopic and Macroscopic Biological Image Data
Frank Fleischer, Michael Beil, Marian Kazda, Volker Schmidt 235
1 Introduction 235
1.1 Analysis of Centromeric Heterochromatin Structures 236
1.2 Planar Sections of Root Systems in Tree Stands 237
1.3 Detection of Structural Differences 238
2 Image Data 238
2.1 NB4 Cell Nuclei 238
2.2 Profile Walls 239
3 Statistical Methods and Results 241
3.1 3D Point Patterns of Chromocenters in NB4 Cells 241
3.2 2D Point Patterns in Planar Sections of Root Systems 244
3.3 Model Fitting for the Root Data 247
4 Discussion 250
4.1 NB4 Cell Nuclei 250
4.2 Planar Sections of Root Systems 252
References 257

Spatial Marked Point Patterns for Herd Dispersion in a Savanna Wildlife Herbivore Community in Kenya
Alfred Stein, Nick Georgiadis 261
1 Introduction 261
2 Materials and Methods 262
2.1 Distribution Data 262
2.2 Measures of Dispersion 264
3 Results 266
3.1 Spatial Point Patterns 266
4 Discussion 269
5 Conclusions 271
References 272

Diagnostic Analysis of Space-Time Branching Processes for Earthquakes
Jiancang Zhuang, Yosihiko Ogata, David Vere-Jones 275
1 Introduction 275
2 The Space-time ETAS Model 276
3 Data and Preliminary Results 280
4 Residual Analysis for the Whole Process 282
5 Verifying Stationarity of the Background 284
6 Verifying Formulation of Branching Structures by Stochastic Reconstruction 286
7 Conclusion 289
References 290

Assessing Spatial Point Process Models Using Weighted K-functions: Analysis of California Earthquakes
Alejandro Veen, Frederic Paik Schoenberg 293
1 Introduction 293
2 The Weighted K-function 294
2.1 Ripley's K-function and Variants 294
2.2 Definition and Distribution of the Weighted K-function 295
3 Application 298
3.1 Data Set 298
3.2 Analysis 299
4 Concluding Remarks 303
References 304