

Contents

1. Background and motivation	1
2. Spatial point processes	7
2.1. Introduction to spatial point processes	7
2.1.1. Definition and basic properties	7
2.1.2. Intensity	8
2.1.3. Moments	9
2.1.4. Stationarity and isotropy	10
2.2. Complete spatial randomness: The Poisson point process	12
2.3. Clustering and regularity	14
2.4. Inhomogeneity	15
2.5. Spatial point process models	17
2.5.1. Inhomogeneous Poisson point process	17
2.5.2. Cluster processes	18
2.5.3. Cox processes	19
3. Properties of the bomb crater point pattern data	21
3.1. Empty-space function	24
3.2. Nearest-neighbour distance distribution function	27
3.3. J-function	30
3.4. Ripley's K-function	33
3.5. Pair correlation function	39
3.6. Characteristics for inhomogeneous processes	42
4. Methods for constructing high-risk zones	51
4.1. Traditional method	51
4.2. Quantile-based method	54
4.3. Intensity-based method	58
4.3.1. Basic idea	58
4.3.2. Estimation of the intensity function by kernel methods	58
4.3.3. Direct specification of the threshold c	63
4.3.4. Specification of the threshold c via the global failure probability	66
5. Application and evaluation	69
5.1. Model check	69
5.2. Simulation study	73

5.2.1. Setting	73
5.2.2. Results for the bomb crater data	74
5.3. High-risk zones with fixed area	85
5.3.1. Setting	85
5.3.2. Results for the bomb crater data	85
5.4. Properties of the methods for constructing high-risk zones	96
5.5. Application to simulated patterns	99
6. Risk assessment	105
6.1. Simulation procedure based on the estimated intensity function	105
6.2. Results	106
6.3. Bootstrap correction	108
7. Spatial clustering	113
7.1. Sensitivity analysis	113
7.1.1. Simulation procedure based on the intensity	113
7.1.2. Behaviour of the high-risk zones	114
7.2. Fitting cluster models to the bomb crater patterns	118
7.2.1. Summary functions for Thomas and Matérn processes	118
7.2.2. Method of minimum contrast	118
7.2.3. Application to Examples A to F	119
7.2.4. Sensitivity analysis based on Thomas processes	133
7.3. Modelling the intensity of clustered patterns by using a mixture of bivariate normal distributions	137
7.3.1. Model and estimation of model parameters	137
7.3.2. Properties	138
7.3.3. Behaviour of the high-risk zones	144
7.3.4. Constructing high-risk zones based on the mixture intensity	144
8. R package “highriskzone”	147
8.1. Data structure	147
8.2. Determining high-risk zones	149
8.3. Evaluating a single high-risk zone	154
8.4. Evaluating a construction method for high-risk zones	156
9. Discussion	159
9.1. Summary	159
9.2. Outlook	161
A. Incomplete bomb crater patterns	165
A.1. Scenarios	165
A.2. Consequences of incompletely observed bomb crater patterns for simulated examples	167

A.3. Real-data examples	174
B. Definition of guard regions	179
C. Marked point processes	185
D. Consequences of outliers	189
E. Spatially varying probability of non-explosion	193
Bibliography	197