DOCTORAL THESIS

Model-free tests for isotropy, equal distribution and random superposition in spatial point pattern analysis

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Abstract

This thesis introduces three new model-free tests for isotropy, equal distribution and random superposition in non-rectangular windows respectively. For isotropy, a bootstrap-type test is proposed. The corresponding test statistic assesses the discrepancy between the uniform distribution and the empirical normalised reduced second-order moment measure of a sector of fixed radius with increasing central angle. The null distribution of the discrepancy is then estimated by stochastic reconstruction, which generates bootstrap-type samples of point patterns that resemble the spatial structure of the given pattern. The new test is applicable for small sample sizes and is shown to have more robust powers to different choices of user-chosen parameter when compared with the asymptotic χ^2-test by Guan et al. (2006) in our simulation. For equal distribution, a model-free asymptotic test is introduced. The proposed test statistic compares the discrepancy between the empirical second-order product densities of the observed point patterns at some pre-chosen lag vectors. Under certain mild moment conditions and a weak dependence assumption, the limiting null distribution of the test statistic is the χ^2-distribution. Simulation results show that the new test is more powerful than the permutation test by Hahn (2012) for comparing point patterns with similar structures but different distributions. The new test for random superposition is a modification of the toroidal shift test by Lotwick and Silverman (1982). The idea is to extrapolate the pattern observed in a non-rectangular window to a larger rectangular region by the stochastic reconstruction so that the toroidal shift test can be applied. Simulation results show that the powers of the test applied to patterns with extrapolated points are remarkably higher than those of the test applied to the largest inscribed rectangular windows, with only slightly increased type I error rates. Real data sets are used to illustrate the advantages of the tests developed in this thesis over the existing tests in the literature.

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