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Analysis of Marked Point Patterns with Spatial and Non-spatial Covariate Information

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The analysis of spatial point process data has historically been plagued by computational difficulties. Likelihoods feature intractable integrals that require approximation. This problem is exacerbated when such models are incorporated in a fully hierarchical framework, since this nests the integrals within a Markov chain Monte Carlo (MCMC) algorithm. We extend customary spatial point pattern analysis in the context of a log-Gaussian Cox process model to accommodate spatially referenced covariates, individual-level risk factors, and individual-level covariates of interest that mark the process. We also use multivariate process realizations to capture dependence among the intensity surfaces across the marks. We illustrate using a collection of breast cancer case locations collected over the mostly rural northern part of the state of Minnesota that are marked by their treatment selection, mastectomy or breast conserving surgery ("lumpectomy"), which is less disfiguring but requires 6 weeks of follow-up radiation therapy. The key substantive covariate (driving distance to the nearest radiation treatment facility) is spatially referenced, but other important covariates (notably age and stage) are not. Our approach facilitates mapping and boundary analysis ("wombling") of the marginal log-relative intensity surfaces for the two treatment options, and resolves the issue of whether women who face long driving distances are significantly more likely to opt for mastectomy while still accounting for all sources of spatial and nonspatial variability in the data.