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Fast estimation of multivariate spatiotemporal Hawkes processes and network reconstruction

Baichuan Yuan[1] · **Frederic P. Schoenberg**[2] · **Andrea L. Bertozzi**[1]

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Abstract

We present a fast, accurate estimation method for multivariate Hawkes self-exciting point processes widely used in seismology, criminology, finance and other areas. There are two major ingredients. The first is an analytic derivation of exact maximum likelihood estimates of the nonparametric triggering density. We develop this for the multivariate case and add regularization to improve stability and robustness. The second is a moment-based method for the background rate and triggering matrix estimation, which is extended here for the spatiotemporal case. Our method combines them together in an efficient way, and we prove the consistency of this new approach. Extensive numerical experiments, with synthetic data and real-world social network data, show that our method improves the accuracy, scalability and computational efficiency of prevailing estimation approaches. Moreover, it greatly boosts the performance of Hawkes process-based models on social network reconstruction and helps to understand the spatiotemporal triggering dynamics over social media.

Keywords Nonparametric estimation · L_2 regularization · Point processes · Social network · Cumulants

Fast estimation of Hawkes processes.

✉ Frederic P. Schoenberg
frederic@stat.ucla.edu

[1] Department of Mathematics, University of California, Los Angeles, 7619D Math-Science Building, Los Angeles, CA 90095-1555, USA

[2] Department of Statistics, University of California, 8142, Math-Science Building, Los Angeles, CA 90095-1554, USA