

Estimation of Multivariate Discrete Hawkes Processes: Application to Incident Monitoring

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Abstract

Hawkes processes are a class of self-exciting point processes that are used to model complex phenomena. While most applications of Hawkes processes assume that event data occurs in continuous-time, the less-studied discrete-time version of the process is more appropriate in some situations. In this work, we develop methodology for the efficient implementation of discrete Hawkes processes. We achieve this by developing algorithms which take only constant time complexity to evaluate the log-likelihood function and its gradient via maintaining additional data structures which take a constant space. We extend these methods to a particular form of a marked discrete multivariate Hawkes process which we use to model the occurrences of violent events within a forensic psychiatric hospital. A prominent feature of our problem, captured by a mark in our process, is the presence of an alarm system which can be heard throughout the hospital. An alarm is sounded when an event is particularly violent in nature and warrants a call for assistance from other members of staff. We conduct a detailed analysis showing that such a variant of the Hawkes process manages to perform very well in terms of predictive power. Finally, we interpret our findings.