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Markov-modulated Hawkes Process with Marks

Abstract

A main branch of earthquake forecasting attempts to identify statistical patterns in the occurrence of earthquakes. These patterns can be temporal, such as the Omori law for aftershocks or, more generally, spatio-temporal. Some formulations include magnitude as well. Hidden Markov models have observable variables, in this case the earthquakes, controlled by an unobservable state, which encapsulates the required pattern information. We have developed two new types of continuous-time hidden Markov models; a Markov modulated Hawkes process with marks for magnitude, and a spatiotemporal version of this. These are used to investigate long-term seismicity, using the entire earthquake record in a selected region to identify hidden states correlated with subsequent large earthquakes. A hybrid estimation procedure for the parameters of the models is derived by combining the Expectation Maximization algorithm and direct maximization of the log likelihood. The models are applied to earthquake catalogs from two regions in different tectonic environments, the Middle America Trench and Northern California. The features of the seismicity captured by the models for the two catalogues are compared.

This is joint work with Ting Wang, University of Otago