Multichain Hidden Markov and Semi-Markov Models: Formalization, Inference, and Applications

Peyrard N., Bacave H., Durand J.-B., Franc A., Plancade S., Sabbadin R.

Hidden Markov Models (HMMs) and Hidden Semi-Markov Models (HSMMs) are widely used statistical models for studying dynamic processes that cannot be observed directly or governed by a hidden layer. In many applications, particularly those involving spatial data, the hidden chain and the observed time series are multidimensional, exhibiting structured dependencies between variables at time t and variables at time t+1. In this talk, we introduce the framework of multichain HMMs, which provides a unified approach to existing models in the literature and also allows for their generalization. We demonstrate the utility of these models in ecological dynamics modeling. We then discuss inference for multichain HMMs within the context of the Expectation-Maximization (EM) algorithm. We explain why exact inference remains tractable for certain structures of multichain HMMs, while it is computationally intractable for others. Finally, we consider an extension to the semi-Markov case and propose the first rigorous definition of a multichain HSMM.