THE UNIVERSITY OF CHICAGO | DEPARTMENT OF STATISTICS

# PhD Dissertation Proposal Presentation

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## "Scalable Nonnegative Tensor Decomposition Models for Latent Structure Discovery in Large Complex Networks"

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### Abstract

High-dimensional complex networks in physical, social, and biological systems often exhibit sparse interactions governed by some underlying latent structure. Nonnegative matrix and tensor factorization methods have proven to be useful for identifying this structure due to their parts-based representation. This proposal presents a family of novel nonnegative tensor decomposition methods for latent structure discovery. The first approach investigates temporal, multilayer relational data taking the form "sender i sends action a to receiver j at time t". I extend the Bayesian Poisson Tucker Decomposition to handle the computational curse of dimensionality in Tucker's core tensor, which scales exponentially in the number of modes. By introducing a novel prior that serves as a "computational budget", I develop an algorithm for exact posterior inference via Gibbs sampling which substantially reduces inference time. The second method tackles latent structure discovery in hypergraph, or higher-order network data. In this setting, the data arises as a series of tensors with increasing order. I develop a symmetric, low-rank approach to tractably perform inference in a shared Tucker decomposition setting and implement an efficient expectation-maximization algorithm for parameter estimation. The method allows for recovery of a spectrum of mesoscale structure, capturing diverse forms of community interaction. The third method connects latent variable models (such as the topic model and stochastic block model) and Poisson nonnegative tensor factorization to provide a general, GPU-accelerated algorithm for nonnegative tensor factorization. The coupling allows practitioners to specify problem-specific desiderata while maintaining simplicity and computational efficiency. This work motivates extensions to incorporate additional information where available, such as in settings with multiview, hierarchical, or dynamic structure.

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