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VARIATIONAL INFERENCE FOR LATENT SPACE MODELS FOR DYNAMIC NETWORKS

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Abstract: Latent space models are popular for analyzing dynamic network data. We propose a variational approach to estimate the model parameters and the latent positions of the nodes in the network. The proposed approach is much faster than Markov chain Monte Carlo algorithms, and is able to handle large networks. Theoretical properties of the variational Bayes risk of the proposed procedure are provided. We apply the variational method with the latent space model to simulated and real data to demonstrate its performance.

Key words and phrases: Bayes risk, dynamic network, latent space model, variational inference.

1. Introduction

Network data analysis has become an increasingly important research topic in various scientific disciplines in recent years. Most existing work on network data focuses on static networks, which means the inference is based on a static list of nodes and edges in an observed network at a given point in time (see Goldenberg et al. (2010) for a survey). However, the network structures of real-world systems are often time varying, or dynamic, in nature, with the set of nodes or the set of edges, or both, evolving over time. In this study, we focus on a time series of observed networks with the same set of nodes and a sequence of sets of edges observed at multiple time points. Analyzing such networks is crucial to understanding their dynamic aspect, such as how social relations and structures, gene-protein interactions, and co-authorship patterns evolve over time.

Many models for dynamic networks have been proposed in the literature. Some are extensions of existing static network models, including the dynamic versions of the stochastic blockmodel (SBM) (Yang et al. (2011); Xu and Hero (2014); Xu, Kliger and Hero III (2014); Xu (2015); Matias and Miele (2017)), degree-corrected stochastic blockmodel (Wilson, Stevens and Woodall (2019)), mixed-membership stochastic blockmodel (MMSB) (Fu, Song and Xing (2009);

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