Modeling Dynamic Social Networks with Vertex Evolution via Latent Graphical Models

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Abstract

We here consider the problem of modeling network evolution with joint edge and vertex dynamics. It is natural to expect that the accuracy of vertex prediction strongly affect the ability to predict dynamic network evolution accurately. A latent graphical model is here employed to model vertex evolution. This model family can incorporate dependence in vertex co-presence, of the form found in many social settings (e.g., subgroup structure, selective pairing). Recent algorithms for learning latent tree graphical models and their extensions can be efficiently scaled for large graphs. Here, we introduce a novel latent graphical model based approach to the problem of vertex set prediction in dynamic social networks, combining it with a parametric model for covariate effects and a logistic model for edge prediction given the vertex predictions. We apply this approach to both synthetic data and a classic social network data set involving interactions among windsurfers on a Southern California beach. Experiments conducted show a significant improvement in prediction accuracy of the vertex and edge set evolution (about 45% for conditional vertex participation accuracy and 164% for overall edge prediction accuracy) over the existing dynamic network regression approach for modeling vertex co-presence.

Keywords: Social networks, dynamic networks, graphical models, latent variables, conditional random field.

1 Introduction

Over the last several decades there has been an increased interest in modeling and prediction of temporally evolving networks. This is especially relevant in the context of social networks. Examples include forming new organizational alliances, mass convergence of organizations in disasters, the formation of inter-firm networks within new industries, and interpersonal networks under strong external perturbations. Traditionally, network evolution has been studied with a fixed vertex set [e.g., 1, 2, 3, 4, 5]. This is unrealistic in many social and engineering processes e.g., addition and deletion of servers; entry and exit of students in a classroom; online social networks such as twitter friend/follower networks. In this paper, we consider co-evolution of vertex and edge sets in dynamic networks. An important consideration for any model is scalability, especially in the *high-dimensional* or *data-poor* regime. In other words, the number of samples may be far less than the parameters of the model, if we attempt to model all possible interactions between the vertices and edges. Recently, Almquist and Butts [6] introduced a family of simple network models that incorporates logistic models for vertex/edge dynamics (here on referred to as *Dynamic Network Regression*; DNR). However, the pure logistic model, while scalable, has limited ability to capture dependencies in vertex co-presence. Further, [6, 7] demonstrate the importance of obtaining the accurate vertex set predictions, noting that in many cases vertices are associated with covariates that strongly impact the edge structure. For instance, if one is modeling dynam-