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# JOINT MODELING OF CHANGE-POINT IDENTIFICATION AND DEPENDENT DYNAMIC COMMUNITY DETECTION

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*Abstract:* The field of dynamic network analysis has recently seen a surge of interest in community detection and evolution. However, existing methods for dynamic community detection do not consider dependencies between edges, which could lead to a loss of information when detecting community structures. In this study, we investigate the problem of identifying a change-point with abrupt changes in the community structure of a network. To do so, we propose an approximate likelihood approach for the change-point estimator and for identifying node membership that integrates marginal information and dependencies of network connectivities. We propose an expectation-maximization-type algorithm that maximizes the approximate likelihood jointly over change-point and community membership evolution. From a theoretical viewpoint, we establish estimation consistency under the regularity condition, and show that the proposed estimators achieve a higher convergence rate than those of their marginal likelihood counterparts, which do not incorporate dependencies between edges. We demonstrate the validity of the proposed method by applying it to the ADHD-200 data set to detect brain functional community changes over time.

*Key words and phrases:* Change-point detection, community detection, dynamic network, stochastic block model.

## 1. Introduction

Network data analysis has become an important tool for studying relationships and associations among subjects. In this study, we develop community detection for dynamic network data. Traditional network analysis assumes that network connectivities are independent and identically distributed (i.i.d.), and that networks are static over time. However, in practice, these assumptions fail when dynamic changes of sequential observed network data occur over time, such as in social networks, political networks, trading networks, brain networks, biological networks, among others.

Most existing dynamic networks do not use the latent community structure, mainly using the Gaussian graphic model to analyze the conditional correlation between variables. To deal with a time-varying graphical structure, typical assumptions for the covariance matrix require that the precision matrices either

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