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Quantifying multiple social relationships based on a multiplex stochastic block model

Key words: Social network; Multiplex network; Stochastic block model

Corresponding author: Shibo HE
E-mail: s18he@zju.edu.cn
ORCID: https://orcid.org/0000-0002-1505-6766

Motivation

1. Online social networks (OSNs) have attracted great attention recently, while the observed structure of an OSN is the aggregation of multiple social relationships.
2. In addition to the edges (friendships) in OSNs, the annotations that describe the attributes (e.g., gender and occupation) of nodes are available.
3. Typically, a node in an OSN has various attributes, which means multiple roles.

Main idea

1. Multiple social ties can be more accurately captured by a multiplex network.
2. Assuming that each layer of a multiplex network is described by a single stochastic block model (SBM), a multiplex network forms a multiplex SBM (MSBM).
3. Because the original multiplex network has a high degree of freedom, an independent functional layer can be added to cover the degree of freedom.

Method

1. The model precision is improved using maximum likelihood estimation, where the precision is defined by the cross entropy of parameters between the data and model.
2. The optimal block number of the added layer is theoretically provided.
3. Empirical results verify the effectiveness of the proposed method using four measures, i.e., error of link probability, cross entropy, area under the receiver operating characteristic curve, and Bayes factor.

Method (Cont'd)

A schematic of adding a functional layer

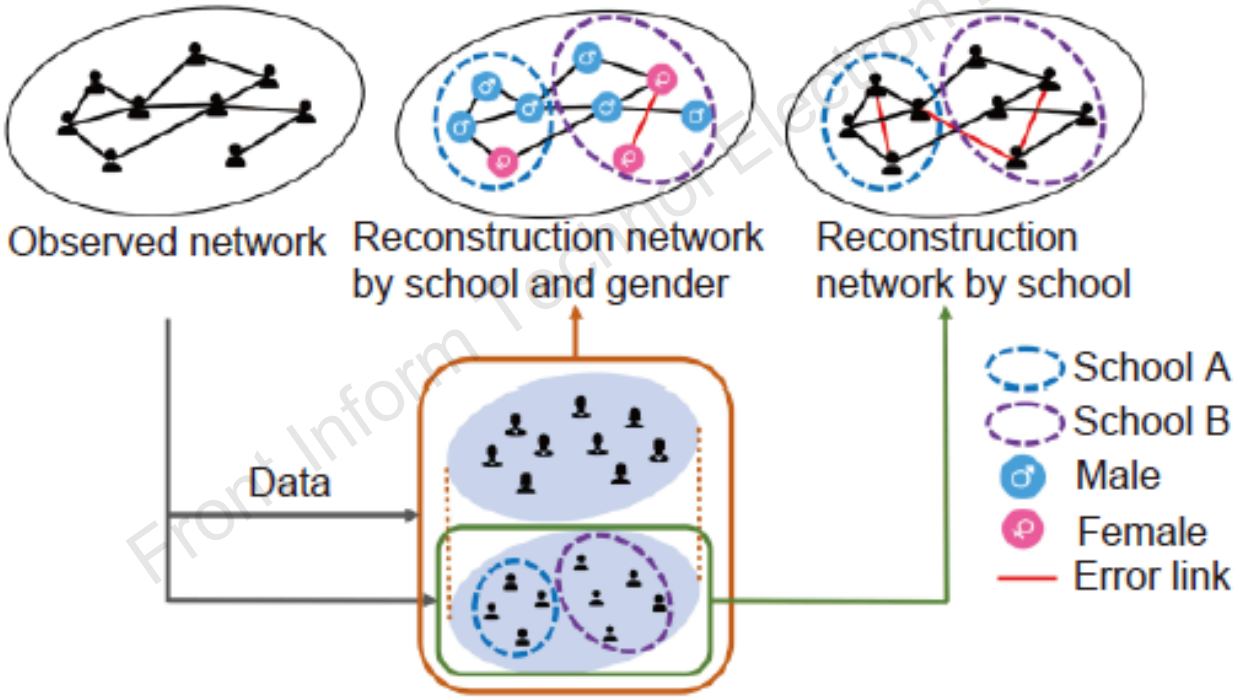


Fig. 1 An intuitive illustration of our method by adding a layer to improve model precision

Method (Cont'd)

1. Mathematical analysis indicates that the optimal number of blocks Q_f^* of the constructed functional layer can be obtained by

$$Q_{\mathrm{f}}^* = \underset{Q_{\mathrm{f}}}{\operatorname{argmin}} \left| 2^K - 1 - \frac{Q_{\mathrm{f}}(Q_{\mathrm{f}}+1)}{2} \right|$$

where K is the number of layers.

Major results

Test results of our method and baselines

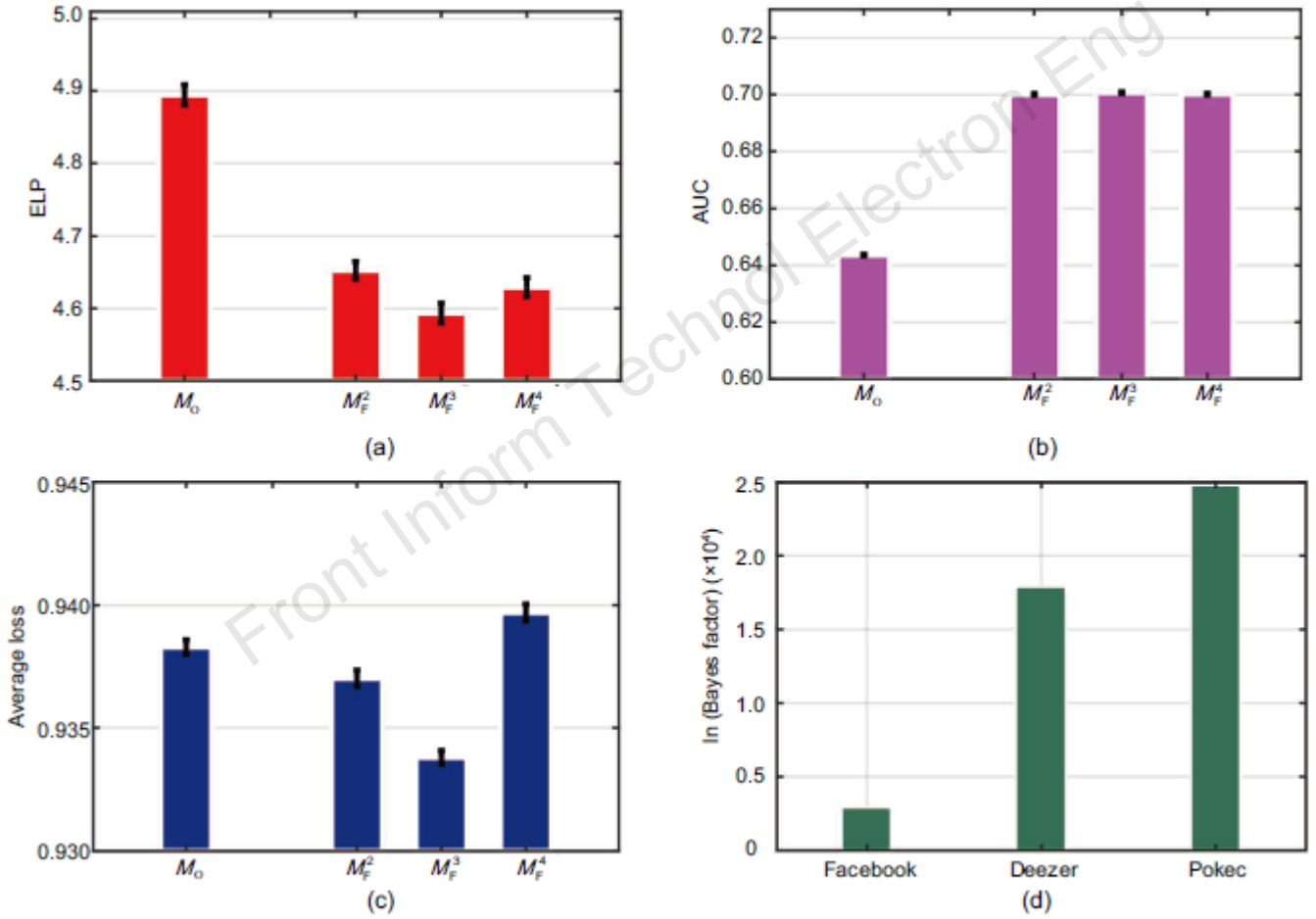


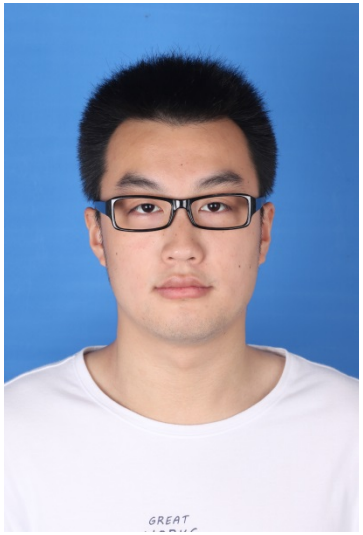
Fig. 2 Simulation results of the error of link probability (ELP) (a), AUC (b), average loss (c), and Bayes factors of different models (d)

Conclusions

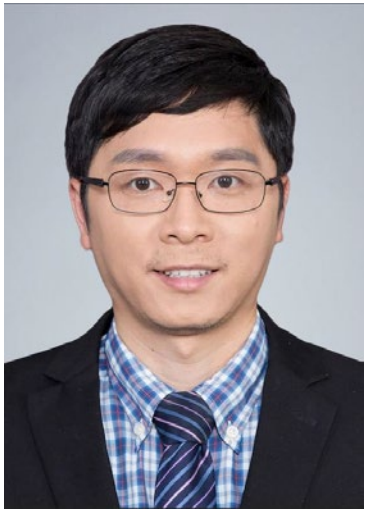
1. A multiplex stochastic block model was proposed by observing the OR-aggregation of a multiplex network, where blocks are determined by natural annotations of nodes.
2. A method to improve the precision was proposed for estimating parameters in the multiplex stochastic block model with its aggregation.
3. Theoretical analysis for adding an independent functional layer was verified by empirical results.

Mincheng WU is a PhD candidate with the group of Networked Sensing and Control (NeSC) in the State Key Lab of Industrial Control Technology, Zhejiang University, Hangzhou, China. During 2014–2016, he was with the School of Mathematical Sciences, Zhejiang University, and he received his BS degree in Mathematics from the College of Mathematics and Computer Science, Zhejiang Normal University in 2014. His research interests include structural analysis, link prediction, and statistical inference in multilayer networks.

Zhen LI is a PhD candidate at Zhejiang University. He received his BS degree from Zhejiang University in 2020. His research interests include network science and cognitive psychology.



Cunqi SHAO received his BS degree in Department of Mathematics, Zhejiang University in 2018. He is currently a PhD candidate with the College of Control Science and Engineering, Zhejiang University. His research interests include network science, community detection, and network propagation.



Shibo HE is currently a professor with the NeSC group, Zhejiang University. He received his BS degree from Northeast Petroleum University, China in 2006 and his MS degree from Zhejiang University in 2008, both in mathematics. He received his PhD degree in Control Science and Engineering from Zhejiang University in 2012. During 2010–2011, he was a visiting scholar at the ECE Department, University of Waterloo, Canada. He was an associate research scientist during Mar. 2014–May 2014 in Arizona State University, USA, where he was a postdoc research scholar during May 2012–Feb. 2014.