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Quantifying multiple social relationships based on a multiplex stochastic block model

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

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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

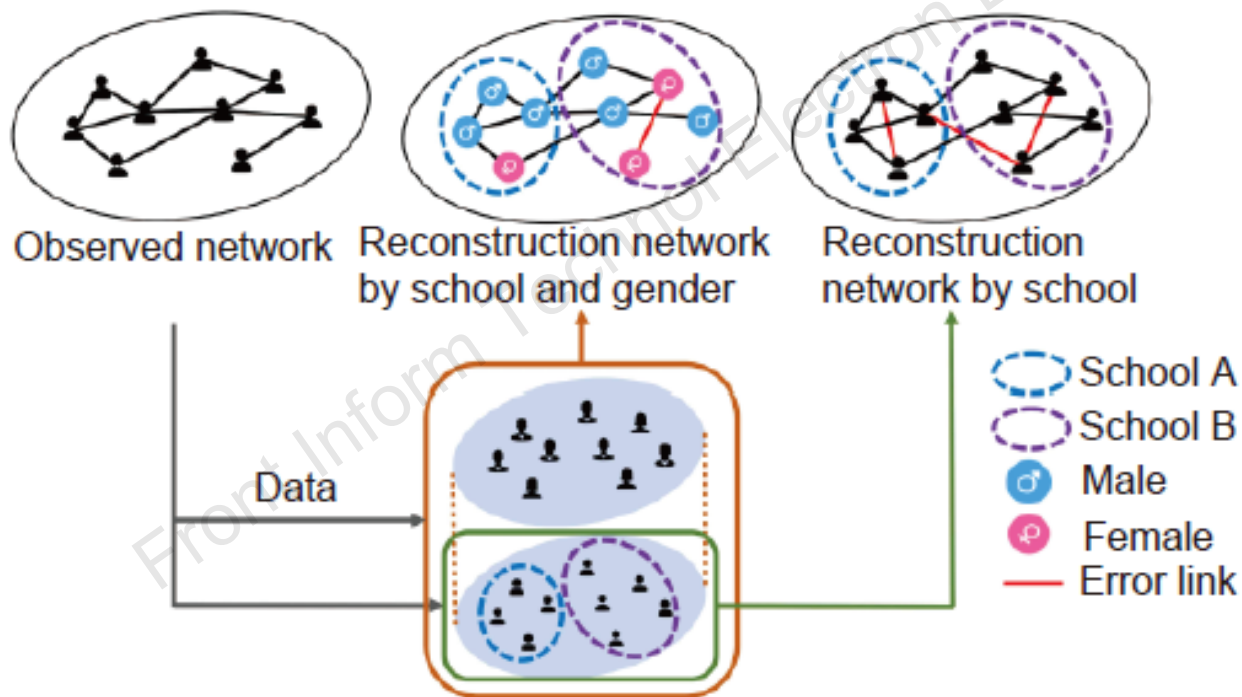


Fig. 1 An intuitive illustration of our method by adding a layer to improve model precision

Method (Cont'd)

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

$$Q_f^* = \operatorname{argmin}_{Q_f} \left| 2^K - 1 - \frac{Q_f(Q_f + 1)}{2} \right|$$

where K is the number of layers.

Major results

Test results of our method and baselines

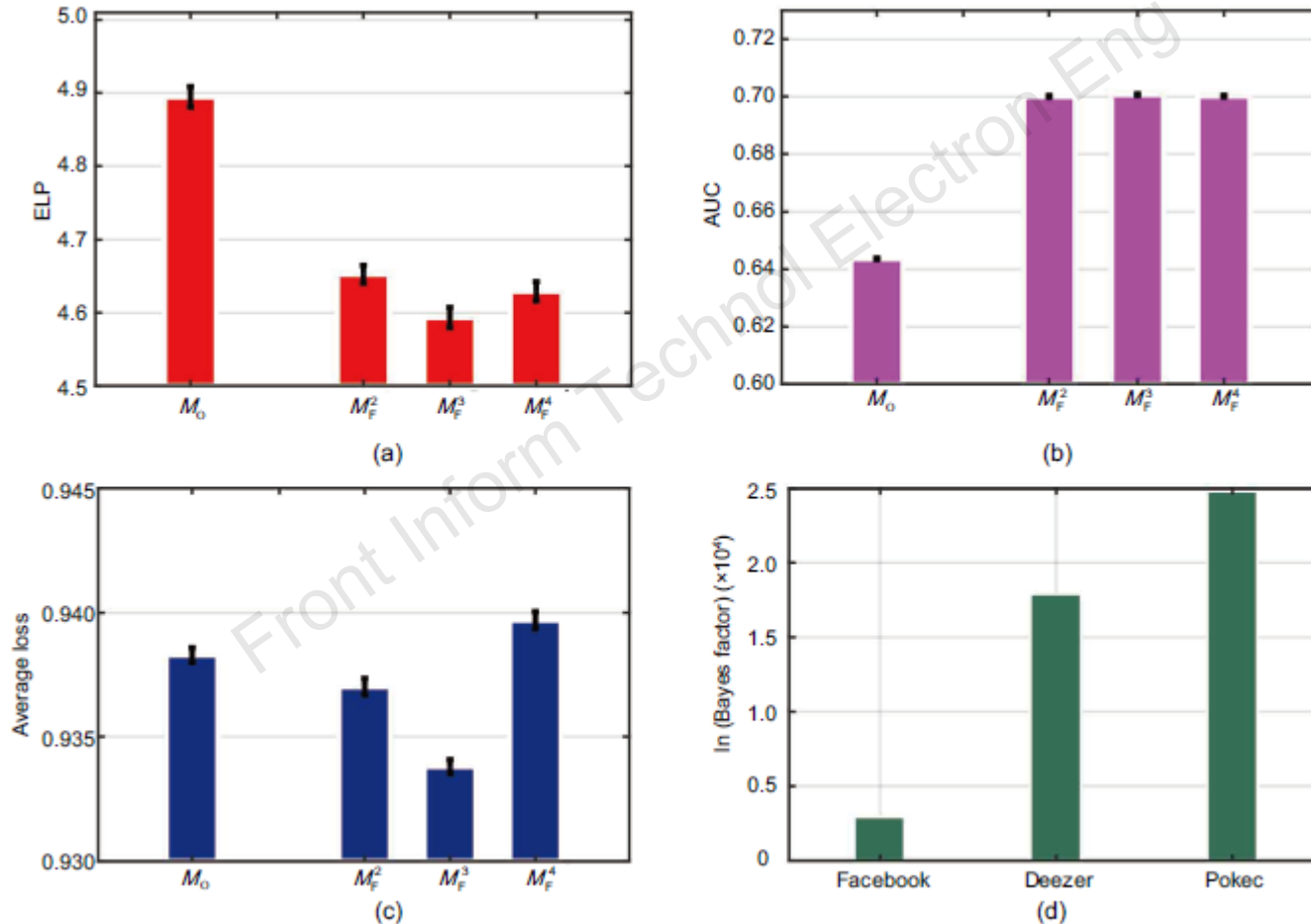


Fig. 2 Simulation results of the error of link probability (ELP) (a), AUC (b), average loss (c), and Bayes factors of different models (d)

Conclusions

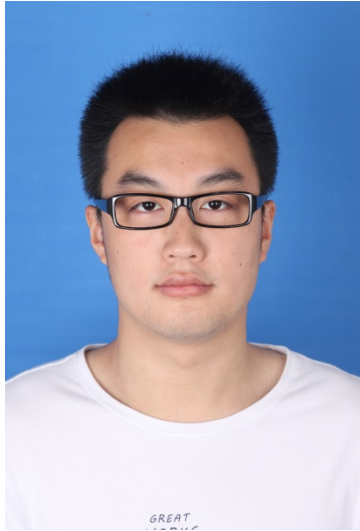
1. A multiplex stochastic block model was proposed by observing the OR-aggregation of a multiplex network, where blocks are determined by natural annotations of nodes.
2. A method to improve the precision was proposed for estimating parameters in the multiplex stochastic block model with its aggregation.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



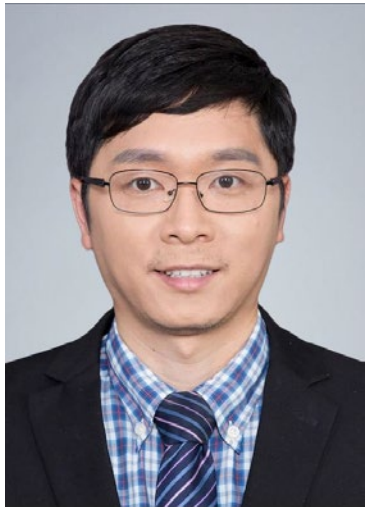
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