Chapter 12
Analysis of Multiplex Social Networks Using Nature-Inspired Algorithms

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ABSTRACT

Many real-life social networks are having multiple types of interaction among entities; thus, this organization in networks builds a new scenario called multiplex networks. Community detection, centrality measurements are the trendy area of research in multiplex networks. Community detection means identifying the highly connected groups of nodes in the network. Centrality measures indicate evaluating the importance of a node in a given network. Here, the authors propose their methodologies to compute the eigenvector centrality of nodes to find out the most influential nodes in the network and present their study on finding communities from multiplex networks. They combine a few popular nature-inspired algorithms with multiplex social networks to do the above tasks. The authors' experiments provide a deep insight into the various properties of the multiplex network. They compare the proposed methodologies with several alternative methods and get encouraging and comparable results.

INTRODUCTION

The online social network is one of the prominent and active areas of research. Due to advancement in technologies, it is growing at an exponential rate. For example, there are millions of users on Twitter and Facebook, and this count keeps increasing. A social network is defined as the graph formed by entities or users, which are connected with each other via some relationship. Analysis of social network reveals various information about users behavior. Community detection, centrality measures, and structural holes are the few popular methods used for the social network analysis. The term community means the subset of users from a network, which is highly connected. Community detection implies the identifica-

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tion of such highly correlated subset of users from a given network. The community detection provides a macro level description of the network. Centrality measures mean identification of most influential users of the network, using centrality one can find the status of a node in the network. Centralities find the influential power of nodes in the network. There are various types of centralities defined in network theory such as degree, closeness, eigenvector, Katz, page rank and so on. (Cardillo, Gómez-Gardenes, and Boccaletti, 2013). The basic description of each of these centrality are given as follow:

- Degree centrality is measured as the total count of the connections made by a node with other nodes of the network. In case of directed graphs, compute the in-degree (total incoming connections with other nodes), out-degree (total outgoing connections with other nodes) and total degree (sum of incoming and outgoing connections with other nodes) of a node (L. Leydesdorff, 2009).
- Closeness centrality is given by reciprocal of the sum of the shortest distances made by a node to every other node of the network (Bavelas, A., 1950).
- The relative score of the neighboring nodes gives Eigenvector centrality of a node. This is widely used to find the powerful nodes of the network (Newman, 2014).
- Katz centrality computes the relative degree of impact for a node. The total number of walks between two nodes computes the relative degree of impact (Katz, 1953).
- Page rank centrality was introduced by Google to measure the appearance of web pages according to search made at Google search engine (Jiang, 2016).

Depending on the application, selection of centrality measure is done and applied to find out the importance of the nodes in the network. For example, Page rank (Newman, 2003) centrality measure uses the hyperlink structure of the WWW, and it is used to rank the web pages by their importance.

The concept of structural hole is also performs a significant role for analyzing the behavior of the nodes in social networks. Holes are the nodes, which plays a vital role to setup the communication between two different groups. In a general social network, there exist some closely knitted subgroups or communities of nodes. To such network, some nodes might not be part of any of the subgroup but act as a communicator or bridge between two or more subgroups (Burt, 1992).

Due to progression in technologies, users connected with each other via multiple relationships. For example, one user is connected to other via facebook, twitter, and WhatsApp. These multiple types of connections emerges a new form of the network called multiplex or multilayer network (Kivela, Arenas, Barthelemy, Gleeson, Moreno, and M. Porter, 2014). Analysis of multiplex networks provides authors more considerable results. Such networks provide lots of information about users so as to analyze the users' behavior rigorously and also find much concrete outcomes (Cozzo et al, 2015).

In this book chapter, authors' propose methodologies for finding out the closeness centrality and structural hole nodes from a given multiplexed networks. Authors' work emphases on to find such nodes, which connects two different subgroups of a network and are act as a bridge between two different sub network. Authors' propose the methodology to compute structural holes and centralities by incorporating concepts of nature-inspired algorithms with multiplex social network. There are numerals of approaches exist to find centralities and structural holes in the simplex network, whereas finding these measures in the multiplex network along with nature-inspired algorithms is still untouched (Mittal & Bhatia, 2018) (Noh, 2004) (Boldi and Vigna, 2014) (Lazer et al, 2009).