Accepted Manuscript

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PII: S0378-4371(18)30654-X
DOI: https://doi.org/10.1016/j.physa.2018.05.101
Reference: PHYSA 19641

To appear in: *Physica A*

Received date : 15 November 2017
Revised date : 12 April 2018

Please cite this article as: L. Pan, H. Shao, M. Mesbahi, D. Li, Y. Xi, Structural balance of multiplex signed networks: A distributed data-driven approach, *Physica A* (2018), https://doi.org/10.1016/j.physa.2018.05.101

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Structural Balance of Multiplex Signed Networks: A Distributed Data-driven Approach

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Abstract

This paper examines the data-driven verification of structural balance of multiplex networks by utilizing the dataset generated by the bipartite consensus dynamics adopted by each node in the network. To this end, some necessary and sufficient conditions for the structural balance of multiplex signed networks from a graph-theoretic perspective has been provided. It is also shown that a multiplex signed network is structurally balanced if and only if its related compressed network is structurally balanced. Built on the proposed theoretical results and dynamic mode decomposition technique, a distributed data-driven approach is proposed for verification of the structural balance of large-scale multiplex signed networks without relying on the explicit knowledge on network topology.

Keywords: Signed networks, structural balance, multiplex networks, bipartite consensus, dynamic mode decomposition.

Introduction

Consensus dynamics on complex networks plays an important role in disciplines such as opinion dynamics, diffusion processes on networks, and distributed algorithms [12, 14, 11, 20]. The functionality of networks such as consensus, relies on the interplay of component-wise dynamical behaviors and the topology of inter-component interactions, where the latter is abstracted in terms of a graph. The classical consensus theory mainly concentrates on networks where the interactions between neighboring nodes are cooperative; however, in complex networks antagonistic interactions can also exist. A graph admitting the coexistence of both positive and negative signs is referred to as a signed graph or signed network [9]. Allowing signs on edges in a graph allows modeling relationships such as friend/foe, cooperation/competition, and attraction/repulsion, etc. For instance, a repulsive force is necessary for scenarios such as collision avoidance and mitigation of undesirable synchronization. Furthermore, a signed network can be an optimal solution to the fast consensus

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[1]This work is supported by the National Science Foundation of China (Grant No.61433002, 61521063, 61333009, 61473317,61590924) and in part by U.S. Office of Naval Research grant N00014-12-1-1002.
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