COMPLEX NETWORKS

COMPLEX NETWORKS 2023

THE 12TH INTERNATIONAL CONFERENCE ON COMPLEX NETWORKS AND THEIR APPLICATIONS

28 - 30 November, 2023
Menton, France

BOOK OF ABSTRACTS

COMPLEX NETWORKS 2023
The 12th International Conference on Complex Networks & Their Applications
28 - 30 November, 2023 Menton, France
Published by the International Conference on Complex Networks & Their Applications

Editors

Hocine Cherifi
University of Burgundy, France

Luis Mateus Rocha
Binghamton University, USA

Chantal Cherifi
University of Lyon, France

Murat Donduran
Yildiz Technical University, Turkey

COMPLEX NETWORKS 2023
e-mail: hocine.cherifi@u-bourgogne.fr

ISBN: 978-2-9557050-7-0

AISM: A Novel Method for Node Importance Ranking in Complex Networks

Haotian Xie[1] and Chen Zhang[1]

Faculty of Arts and Sciences, Beijing Normal University, No.18, Jinfeng Road, Tangjiawan, Zhuhai City, Guangdong Province, 519087, P.R.China
haotianxie@mail.bnu.edu.cn

1 Introduction

The elucidation of nodal significance stands as a cardinal conundrum within the realm of intricate network scrutiny. It seeks to discern a subset of nodes that wield paramount influence over the very fabric and functionality of the network. This quandary finds application across a multitude of domains, encompassing the diffusion of information, the orchestration of epidemiological control, the propagation of viral marketing, the safeguarding of network security, and the honing of network optimization. Nevertheless, the task of node importance delineation assumes a guise of formidable complexity. This complexity emanates from the inherent divergence in roles and contributions exhibited by distinct nodes across disparate scenarios and contexts. Thus, an imperative imperative manifests itself – the creation of a holistic and efficacious methodology, capacious enough to assess node importance through a kaleidoscopic array of perspectives and criteria. Within this discourse, we posit an innovative modus operandi for the ranking of node importance within complex networks. This proposition is founded upon the bedrock of adversarial interpretive structural modeling (AISM), which, in its essence, harmonizes a panoply of centrality metrics within a coherent framework, thus effectuating the acquisition of intricate, non-linear interconnections that interlink nodes [6].

In the annals of extant methodologies for the classification of node importance, resides an approach predicated on the precepts of network centrality metrics. These metrics, in quantifying the worth of nodes, draw succor from their topological attributes, encompassing the likes of degree centrality (DC) [1], closeness centrality (CC) [1], betweenness centrality (BC) [9], eigenvector centrality (EC) [7], H-index [5], VoteRank [8] and K-shell [2]. Nonetheless, these metrics are not without their limitations and deficiencies. A case in point is the partiality of degree centrality, ensnared within the confines of localized node information, relinquishing a disdainful disregard for their holistic sway. Likewise, proximity and intermediacy centrality stand ensnared in the tendrils of labyrinthine computational intricacy, while also demonstrating susceptibility to the ebb and flow of network dimensions and densities. In a similar vein, eigenvector centrality is predisposed to inflate the significance of nodes entwined with well-connected peers. The fissures in this framework extend to k-shell decomposition, wherein nodes with disparate diffusive potentials may be draped in the same cloak of importance. Moreover, these centrality yardsticks, by their very nature, are inclined to incongruences and incommensurability, thereby complicating their seamless integration within a unified edifice.

To surmount these formidable challenges, we proffer an avant-garde methodology for the hierarchical valuation of nodal significance, grounded in the paradigm of AISM. AISM, an intricate system of structural modeling, encapsulates the very essence of adversarial dynamics inherent in the domain of generative adversarial networks (GANs), and seamlessly melds this concept with the venerable classical interpretive structural model (ISM) [4]. ISM orchestrates the metamorphosis of nebulous and inadequately articulated cognitive models of intricate systems into lucid, meticulously delineated models that serve myriad purposes. AISM extends the domain of ISM, unfurling a duet of archetypes – a generator and a discriminator – engaged in a symphony of adversarial harmony. The generator aspires to conjure forth an exemplary interpretive structural model, one that aggrandizes the stratum of nodal importance scores, whilst the discriminator strives to discern, with acuity, the contrived model from its authentic network counterpart, thus attenuating the preeminence of the node scores. Through this intricate choreography of adversarial interplay, AISM achieves erudition in the labyrinthine tapestry of non-linear interrelationships among nodes, all the while embracing a multifaceted vista for the evaluation of their eminence across an array of discerning criteria and dimensions.

The main contributions of this paper are as follows:

1. We propose a novel method for node importance ranking based on AISM, which can effectively integrate multiple centrality measures into a unified framework and learn the complex and nonlinear relationships among nodes.
2. We design an algorithm to implement AISM based on GANs, which can optimize the interpretive structure model and the node importance scores through an adversarial learning process.
3. We conduct extensive experiments on Facebook, a real-world networks to evaluate the performance of AISM and compare it with several state-of-the-art methods. The results show that AISM can achieve better accuracy and robustness than the existing methods.

2 Results

The crucible for validating the AISM algorithm resides within the realm of SIR models. The mettle of assorted algorithms finds appraisal in the crucible of the ultimate contagion scope within the Facebook network [3], across a spectrum of diverse inaugural dissemination magnitudes. The pinnacle quotient of nascent seed nodes is meticulously capped at 0.03. The contagion coefficient, denoted as β, stands augmented to 1.5 times its minimal counterpart, denoted as β_{min}, thereby imbuing it with a heightened propensity. The average final infection size $F(tc)$ of each algorithm is shown in Fig. 1, where the *x*-axis denotes the different initial seed node ratios p and the *y*-axis denotes the final infection size under each ratio. Moreover, we also use time-step experiments to verify the propagation size and propagation rate of seed nodes selected by different algorithms. The results of $F(t)$ over time are shown in Fig. 2, which gives a comparison plot of the infection size of the different algorithms. *x*-axis is the time step and *y*-axis denotes the infection size $F(t)$ at time t. These results are averaged from 1000 experiments.

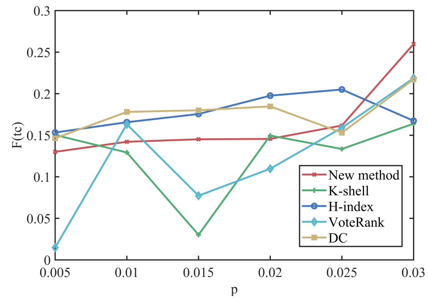

Fig. 1. Infection scale with different initial node ratios in Facebook networks.

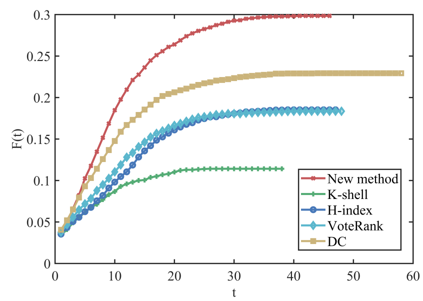

Fig. 2. Comparison of infection scale in Facebook networks.

Summary. We have unveiled an innovative paradigm for the hierarchy-based appraisal of nodal significance within intricate networks, hinging upon the foundation of AISM. This methodology adeptly harmonizes an ensemble of centrality metrics, thus assimilating diverse aspects of node prominence and comprehending intricate, non-linear nodal interconnections. Our approach has been subjected to rigorous benchmarking, where it stands juxtaposed with prevailing methodologies across an array of networks and metrics. The results corroborate that our methodology espouses heightened precision and robustness. Nonetheless, it is imperative to acknowledge that our approach is not devoid of limitations and challenges, which necessitate attention in forthcoming endeavours. Among these are the judicious selection and amalgamation of centrality metrics, the sustenance of stability and diversity within AISM, and the broadening of the horizons to encompass a plethora of network typologies and tasks.

References

1. Bródka, P., Skibicki, K., Kazienko, P., Musiał, K.: A degree centrality in multi-layered social network. In: 2011 international conference on computational aspects of social networks (CASoN). pp. 237–242. IEEE (2011)

2. Kitsak, M., Gallos, L.K., Havlin, S., Liljeros, F., Muchnik, L., Stanley, H.E., Makse, H.A.: Identification of influential spreaders in complex networks. Nature physics 6(11), 888–893 (2010)
3. Leskovec, J., Mcauley, J.: Learning to discover social circles in ego networks. Advances in neural information processing systems 25 (2012)
4. Li, Y., Tan, Y., Pu, Y., Zhu, Y., Xie, H.: Exploring the drivers of green supply chain management in the chinese electronics industry: Evidence from a gdematel–aism approach. Cleaner Logistics and Supply Chain p. 100110 (2023)
5. Pastor-Satorras, R., Castellano, C.: Topological structure and the h index in complex networks. Physical Review E 95(2), 022301 (2017)
6. Xie, H., Li, Y., Pu, Y., Zhang, C., Huang, J.: Airline service quality ranking based on combined topsis-vikor-aism framework. arXiv e-prints pp. arXiv–2212 (2022)
7. Xu, Y., Feng, Z., Qi, X.: Signless-laplacian eigenvector centrality: A novel vital nodes identification method for complex networks. Pattern Recognition Letters 148, 7–14 (2021)
8. Zhang, J.X., Chen, D.B., Dong, Q., Zhao, Z.D.: Identifying a set of influential spreaders in complex networks. Scientific reports 6(1), 27823 (2016)
9. Zhang, J., Luo, Y.: Degree centrality, betweenness centrality, and closeness centrality in social network. In: 2017 2nd international conference on modelling, simulation and applied mathematics (MSAM2017). pp. 300–303. Atlantis press (2017)

The 12th International Conference on Complex Networks and Their Applications
November 28 - 30, 2023 - Menton, France

9 782955 705070

www.complexnetworks.org