Network Science **9** (S1): S1–S3, 2021
doi:10.1017/nws.2021.8

CAMBRIDGE
UNIVERSITY PRESS

SPECIAL ISSUE

Introduction to the special issue on COMPLEX NETWORKS 2019

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This special issue of *Network Science* contains a collection of extended papers from the *8th International Conference on Complex Networks & their Applications (COMPLEX NETWORKS 2019)*. This major international event in network science brings together every year researchers from around the globe. The great diversity of the participants' scientific backgrounds ranges from Finance and Economics, Medicine and Neuroscience, Biology and Earth Sciences, Sociology and Political Science to Mathematics and Computer Science, Physics, and many others, making it a special opportunity to review the current state of the field and formulate new directions.

This edition of the conference took place at the Calouste Gulbenkian Foundation in Lisbon (Portugal) from December 10 to December 12, 2019. It attracted 470 submissions with authors from 58 countries all over the world. After thorough review, 161 papers were selected to be included in the proceedings Cherifi et al. (2020a,b). The conference program also included keynote presentations from Lada Adamic (Facebook, Inc., USA), Reka Albert (Pennsylvania State University, USA), Ulrik Brandes (ETH Zurich, Switzerland), Stefan Thurner (Medical University of Vienna, Austria), Jari Saramki (Aalto University, Finland), and Michalis Vazirgiannis (LIX, cole Polytechnique, France).

Papers invited for this special issue have been selected from the accepted contributions based on relevance to the journal and excellent reviews of the conference version of the papers. The authors were asked to submit an extended version of their conference submission for journal publication in accordance with the customary practice of adding 30% new material. These submissions went through the standard double-blind review process dictated by the journal guidelines. The seven papers accepted to this special issue provide a remarkable sample illustrating the diversity of issues studied in network science research.

In Horn and Nelsen (2020), the authors investigate the celebrated PageRank centrality measure from the point of view of differential geometry. More precisely, they answer the following question: how do variation in teleportation constants influence PageRank scores? Exploiting the relationship between heat flow and PageRank, they develop inequalities that bound a particular "gradient" of PageRank over the graph. Their gradient estimate shows that the PageRank vector smoothes out as the jumping constant changes. This work illustrates a beautiful mathematical theory that connects differential equations, PageRank, and diffusion processes over graphs.

Liu et al. (2020) introduce a convolutional neural network framework and preprocessing techniques to estimate graphlet counts. Exploiting the correlation between the structural graph information and graphlet counts, they propose to predict graphlet count from previously studied graphs coming from a similar distribution with known graphlet counts. Extensive experiments conducted on three types of random graphs (Erdős–Rényi, Barabási–Albert, and geometric) and real-world graphs (biochemistry, collaboration, and social network) for 3,4,5-node graphlet counting show that their framework offer substantial speedup on estimating graphlet counts of new graphs with high accuracy.

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https://doi.org/10.1017/nws.2021.8 Published online by Cambridge University Press

In Molter and Niedermeier (2020), the authors put together the concept of cliques in a temporal graph with that of isolated cliques, defining isolated cliques in temporal graphs. They present a novel method to enumerate cliques in temporal networks with varying degree of isolation. Six variants are given (due to a combination of three different time constraints and two isolation constraints). They propose efficient algorithms for five clique enumeration models and prove worst-case performance bounds for them. Experiments on real-world temporal are promising since new mathematical formalism and efficient algorithms are both needed to advance the field.

In Martin and Niemeyer (2020), the authors investigate how different kinds of mismeasurements affect centrality measures. Robustness is measured by injecting errors through an error mechanism that emulates some possible data errors: edge addition, uniform and degree-proportional edges removal, nodes removal. The robustness index is computed using the Kendall-Rank correlation between the correct and the altered graphs. This index is analyzed for different centrality metrics (degree centrality, PageRank, and eigenvector centrality) computed on various real-world graphs (characterized by different sizes) and two classes of random graphs (Erdős–Rényi and Barabási–Albert). Results show no association between network size and robustness but a high correlation between average degree and robustness. These findings contribute to a better understanding of the interplay of centrality measures and network topology.

In Saucan et al. (2020), the authors introduce several main ideas and curvature estimation definitions, which could be applied to weighted and unweighted graphs and undirected or directed networks. In particular, they extend theoretical relations like the Gauss–Bonnett theorem, which constitute the building block of continuous geometry to the discrete scenario. Furthermore, they study how these notions of curvature apply to hyperbolic embeddings. Finally, they investigate the proposed metric curvature on Erdős–Rényi, Barabási–Albert, and real-world networks. Understanding the geometry underlying real networks is an important research topic, and this paper, explaining the various notions of curvatures with their pros and cons, has strong network application perspectives.

In Antunes et al. (2021), the authors consider the problem of estimating the probability distribution of triangles. To this end, they propose a flexible sampling-based scheme with three sampling designs (without replacement, with replacement, and Bernoulli sampling) motivated by various network access scenarios (full access, restricted access, and streaming edges). Evaluation of the proposed estimation methods on synthetic and real-world networks proves that they are scalable to relatively large networks. As triangles are the most fundamental topological structures of networks, this work is essential for multiple applications such as spam detection, community detection (Orman et al., 2013), etc.

In Wilkerson and Moschoyiannis (2021), the authors investigate critical cascades of the linear threshold model and some of its biologically inspired variations focusing on computational power and learning efficiency. They show that it can compute Logic and universal Logic when replacing the threshold rule with its complement. It can be formulated as a statistical learning model. The training can be done by adjusting its edges. This work that brings together theories of percolation, Boolean Logic, and statistical learning through a basic model paves the way for promising development.

Acknowledgments. Sincere thanks to the contributors. Our most profound appreciation also goes to the reviewers for their expert comments and assistance in timely reviews. Sincere thanks to *Network Science* editorial office for their support. We hope you will enjoy reading this issue as much as we enjoyed putting it together.

Conflict of interest. None

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Cite this article: Cherifi H. and Rocha L. M. (2021). Introduction to the special issue on COMPLEX NETWORKS 2019. *Network Science* **9**, S1–S3. https://doi.org/10.1017/nws.2021.8

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