Preface

For more than a decade, complex network analysis has evolved as a methodological paradigm for a multitude of disciplines, including physics, chemistry, biology, geography, sociology, computer science, statistics, media science, and linguistics. Researchers in these fields share an interest in information processing subject to the networking of their corresponding research object, for instance, genes, molecules, individuals, semes, memes, etc. They start with the insight that any of these research objects is *extrinsically* characterized, if not constituted, by its networking with objects of the same provenance. In this way, networks, for example, gene networks, food networks, city networks, networks of words, sentences, texts, or web documents become important research objects in more and more disciplines.

This book, in line with these research developments, presents theoretical and practical results of statistical models of complex networks in the formal sciences, the natural sciences, and the humanities. One of its goals is to advocate and promote combinations of graph-theoretic, information-theoretic, and statistical methods as a way to better understand and characterize real-world networks.

On the one hand, networks appear as paradigmatic objects of approaches throughout the natural and social sciences and the humanities. On the other hand, networks are—irrespective of their disciplinary provenance—known for characteristic distributions of graph-theoretic invariants which affect their robustness and efficiency in information processing. The main goal of this book is to further develop information-theoretic notions and to elaborate statistical models of information processing in such complex networks. In this way, the book includes first steps toward establishing a statistical information theory as a unified basis for complex network analysis across a multitude of scientific disciplines.

The book presents work on the statistics of complex networks together with applications of information theory in a range of disciplines such as quantitative biology, quantitative chemistry, quantitative sociology, and quantitative linguistics. It aims to integrate models of invariants of network topologies and dynamic aspects of information processing in these networks or by means of these networks.

Thus, the book is in support of sharing and elaborating models and methods that may help researchers get insights into complex problems emerging from interdisciplinary reasoning.

The book is divided into two parts: Chaps. 1–4 deal with formal-theoretical issues of network modeling, while Chaps. 5–13 further develop and apply these methods to empirical networks from a wide range of areas. The book starts with a theoretical contribution by *Abbe Mowshowitz* on the entropy of digraphs and infinite graphs. The aim is to provide insights into more complex graph models that go beyond the majority of network models based on finite undirected graphs. The chapter by *Nicolas Bonichon, Cyril Gavoille*, and *Nicolas Hanusse* presents an information-theoretic upper bound of planar graphs by means of the newly introduced notion of well-orderly maps. Such a technique might be useful when studying properties of the very important notion of planar graphs. *Terence Chan* and *Raymond W. Yeung* study a statistical inference problem using network models. *Richard Berkovits, Lukas Jahnke*, and *Jan W. Kantelhardt* examine phase transitions within complex networks that help to examine their structural properties.

The remainder of the book combines the theoretical stance of the first section with an empirical analysis of real networks. *Elena Konstantinova* provides a survey on information-theoretic measures used in chemical graph theory. *Prabhat K. Sahu* and *Shyi-Long Lee* develop a model of chemical graphs by example of molecular networks. Exploring the spectral characteristics of these graphs, they provide a successful classification of chemical graphs.

Biological or, more specifically, ecological networks are dealt with by *Robert E. Ulanowicz* who describes a framework of quantifying patterns of the interaction of networked trophic processes from the point of view of information theory. Ecological networks are also the focus of the chapter of *Linda J. Moniz, James D. Nichols, Jonathan M. Nichols, Evan G. Cooch*, and *Louis M. Pecora*, who provide an approach to modeling the interaction dynamics of ecosystems and their change. A comprehensive view of ontologically disparate networks is given by *Cristian R. Munteanu, J. Dorado, A. Pazos Sierra, F. Prado-Prado, L.G. Pérez-Montoto, S. Vilar, F.M. Ubeira, A. Sanchez-Gonzaléz, M. Cruz-Monteagudo, S. Arrasate, N. Sotomayor, E. Lete, A. Duardo-Sánchez, A. Díaz-López, G. Patlewicz*, and *H. González-Díaz* who use the notion of entropy centrality to compare various systems such as chemical, biological, crime, and legislative networks, thereby showing the interdisciplinary expressiveness of complex network theory.

The book continues with two contributions to linguistic networks: *Alexander Mehler* develops a framework for analyzing the topology of social ontologies as they evolve within Wikipedia and contrasts them with nonsocial, formal ontologies. *Olga Abramov* and *Tatjana Lokot* present a comparative, classificatory study of morphological networks by means of several measures of graph entropy.

Edward B. Allen discusses the measurement of the complexity and error probability of software systems represented as hypergraphs. Finally, in the chapter by *Philippe Blanchard* and *Dimitri Volchenkov*, random walks are studied as a kind of Markov process on graphs that allow insights into the dynamics of networks as diverse as city and trade and exchange networks.

With such a broad field, it is clear that the present book addresses an interdisciplinary readership. It does not simply promote transdisciplinary research. Rather, it is about interdisciplinary research that may be the starting point of developing an overarching network science.

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