NETWORK SCIENCE IN COMPUTER ENGINEERING AND INFORMATION TECHNOLOGY

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Abstract

Since the beginning of the new Millennia, we have witnessed the emergence of the New Science of Complex Networks, which encompasses multiple elements from physics, mathematics, and computer science. Specifically, Complex Networks describe the structure and behavior of complex systems that can be modelled as graphs, namely mathematical structures consisting of objects, nodes, or vertices, which are connected by lines, links, or edges. As opposed to conventional graph theory, complex networks have many nodes (up to several millions) and complex irregular interconnection topology. The field of Complex Networks bridges the gap between complexity and algorithmic models, which in turn pave the way for innovative computer applications in fields such as biology, medicine, economy, social sciences, or physics.

The overarching field of Information Technology includes various approaches where computer algorithms and applications are used for the advancement of biology, medicine, pharmacology, or social physics. Indeed, the last decade has witnessed significant progress in personalized or precision medicine, based on big data techniques and computer technologies such as Complex Network Analysis, Machine Learning (including Deep Learning). Moreover, the advance in social system physics has gain a lot of momentum since the global dissemination of Online Social Networks.

Our approach to using complex networks in information technology is twofold. First, we propose new computer-based models for simulating the dynamics of opinion is social networks. Further, we validate our tolerance-based opinion diffusion model against social behavior detected in real-world data from Twitter, Facebook and Yelp. We also analyze and confirm our hypotheses by providing a comprehensive probabilistic interpretation of our tolerance-based computational model. Second, we apply a dual complex network clustering, which relies on both modularity classes and force directed network layouts, to advance the fields of network medicine and network pharmacology. In the case of network medicine, we cluster networks of Obstructive Sleep Apnea Syndrome patients, to generate patient phenotypes that can be effectively used for managing patients according to precision medicine principles. In the case of network pharmacology, we use our dual clustering methodology to extract pharmaceutical properties for available drugs, only from information on drug-drug interactions. To this end, we build a drug-drug interaction network and process it, by algorithmically defining functional drug communities; analyzing the generated drug communities leads to recovering previous drug repositioning examples, as well as to proposing new important repositionings.

Our future research will focus on applying complex networks in computer engineering. As such, we provide an extensive overview on how network analysis can be used to optimize multi-core communication in Network-on-Chip (NoC) systems. Indeed, our initial assessment proves that – from a conceptual standpoint – fractal topologies can provide a low power, reliable and performant communication infrastructure for NoCs.

The ful abstract at:
http://www.upt.ro/img/files/2016-2017/abilitare/udrescu/Rezumat_teza_abilitare_en_Udrescu.pdf

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