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COMBINATORICS AND NETWORKS FOR DATA ANALYSIS IN COMPLEX SYSTEMS

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Auletta Convegni; IRIB-CNR
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h: 15:00

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ABSTRACT

Many real systems across several fields in the life and social sciences display a multipartite structure, where elements of a given nature only interact with elements of different nature. Combinatorics provides a suitable framework to evaluate the probability of interaction-configurations in these complex systems, under simple assumptions of randomness that fully satisfy systems' constraints. Therefore, combinatorics allows one to filter out (at least part of) the random noise that affects real data of interaction among the elements in the system, and focus the attention on the observed interactions that could not be explained through such a null model. These are the interactions that are worth studying the most, since they are likely the ones that carry most of the relevant information about the emergent structures and the evolutionary properties of the system under investigation. A natural representation of such interactions is through a network, and network theory provides the mathematical toolkit to analyze the aforementioned properties. In this talk, I will go through these concepts by discussing real applications in different areas, such as biology, information science, social sciences, criminology, economics, and finance. In particular, I will discuss the most recent results of my research activity in this context–a method of differential expression analysis (Tumminello et al., Scientific Reports, 2022), an indicator of topic-coherence in the framework of Natural Language Processing (Simonetti et al., Journal of Information Sciences, 2022), alert metrics for the sake of fraud detection in the insurance sector (Tumminello et al., Journal of Risk and Insurance, 2022), an analysis of expenditure patterns of Italian households depending on the status of young-adult children (Lo Verde et al., Social Policies, 2022), and an analysis of mobility patterns of Italian students from the high school to the master degree (Genova et al., Statistical Methods and Applications, 2021).

BIOSKETCH

Michele Tumminello is an associate professor of applied mathematics at the Department of Economics, Business, and Statistics, University of Palermo. He received a PhD in Applied Physics at the University of Palermo in 2007 with a thesis entitled "Development of new methods for the analysis of complex correlation structures with applications to financial markets". He was a postdoctoral fellow at CNR (2007) and at the University of Palermo (2008–2009). From 2010 to 2012, he was a postdoctoral associate at the Department of Social and Decision Sciences, Carnegie Mellon University, Pittsburgh, PA, USA. Back in Italy, he began his research and teaching activities as a researcher at the University of Palermo. He is the author of more than 50 articles published in international journals, mostly concerning complex systems with a multipartite structure. His main research interest is in the development of methods for the empirical analysis of association in complex systems and for the modeling of their evolution, with particular attention to social and economic systems. In particular, he is interested in studying how the heterogeneity of the elements in the system and their interactions at the microscopic level may generate emergent phenomena, such as communities, influence the evolution of the system, and trigger positive feedback mechanisms responsible for "extreme" events, such as the crash of a financial market, pandemics, power-grid failures, etc.