FONDAZIONE BRUNO KESSLER
MAGAZINE

Complex Networks: what are and why we need them

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How can we understand real systems? How can we predict what will happen next? Network science gives some answers to that and can help researchers to find a new way to gain insights into different domains.

Making sense of the World is what moves mankind in general, but more specifically it is what have moved more than **40 participants** to the 5th edition of Mediterranean School of Complex Networks. Researchers and students, coming from around the globe, have met in Salina, a pretty island 60 kilometres away from Sicilian north coasts, renown also for being the set of “Il Postino: The Postman”. A place where the inhabitants live in harmony with nature, with a simple life, but where scientists talk about very complex systems. The discussion is particularly concerned with the **mapping of real systems into complex network models**. These are part of a wide amount of subjects such as economics, finance, biology, sociology and many others, so the art of network science has become a very important scientific matter in the last two decades.

Manlio De Domenico, FBK researcher leading the Complex Multilayer Networks Lab, and co-director of the school, can explain us better **what is all about**:

*Facebook, the human brain and transportation infrastructures have something in common. They are **either natural or artificial systems with an intricate architecture of connections that link together people, neurons or geographical areas, respectively**. This type of systems, as many others in biology, social sciences, neuroscience, ecology and engineering, are ubiquitous and better understood within the mathematical and computational framework known as “Network Science”. In the last two decades, Network Science has provided fundamental tools for analysis and modelling of complex systems. This relatively new discipline is intrinsically interdisciplinary and transdisciplinary: it requires physicists, social scientists, biologists and engineers to collaborate together to attack some of the most important problems*

related to society, healthcare and technology, to mention just a few.

For this reason, we have decided to found the Mediterranean School of Complex Networks, with the ultimate goal of gathering together the world leading experts in the field and let them teach Network Science to next-generation scientists from around the world.

And what are the applications?
We have a huge amount of applications, but there is something we are very interested in, especially here in FBK:

- ***Health 1 / Molecular biology:*** *the current trend in the field is to map interactions between biological molecules to complex networks. Regulatory (inhibition/activation) interactions between genes, protein-protein interactions, metabolic reactions, are analyzed through the lens of network science to gain new insights on how phenotypes and human diseases are related to biological processes within the cell. This research advanced our knowledge on pathogenesis of complex diseases such as cancers.*
- ***Health 2 / Epidemiology:*** *together with agent-based models, complex networks are currently used in the most sophisticated approaches for anticipating, and eventually containing, outbreaks of epidemics such as Ebola. In fact, the spreading of transmittable diseases depends on a variety of factors including how humans interact with each other (social networks)*
- ***Social science:*** *network analysis finds its roots in social sciences, where it has been used to identify influencers in social systems and to understand how humans organize in groups and hierarchies. Nowadays, network science is a fundamental tool of computational social science for modelling and analysis of human behaviour, counting on the availability of big data generated by online social networks such as Facebook or Twitter. Used in the correct way, it allows us to recognize fake news from the truth, while used in the wrong way it can lead to manipulate collective attention by microtargeting, such as in the recent Cambridge Analytica scandal. A crucial tool for policy and decision making, where the social structure of a population can be exploited for spreading behaviors (eg policies against bullying or in favor of vaccination: it is a well-known result of network science that, thanks to the very heterogeneous structure of social systems, we need to target a very small fraction of individuals to spread behaviours at the level of the whole population, similarly to what happens to infectious diseases)*

- ***Artificial intelligence:*** *deep neural networks are huge but simple, networks. Only recently network science is approaching this field with the ultimate goal of designing intelligent machines that better resemble the human brain in terms of structure and function.*

What do you expect from the next edition of the Mediterranean School of Complex Networks?

One of the strongest features of our School is that it is unconventional from an academic perspective. Directors and lecturers interact with students within a small environment, provided by the beautiful island of Salina. This feature is what our 194 students have appreciated the most across the five editions since 2014, and what I expect to keep and enhance for the next edition of the School while keeping the standard of scientific excellence of our program and our attendants.

The School is organized by **Fondazione Bruno Kessler**, directed by **Manlio De Domenico** and **Alex Arenas**, full professor of Network Science at University Rovira i Virgili (Tarragona, Spain), and co-organized by **Serafina Agnello**, technologist at FBK.

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