Complex Networks: Theory, Methods, and Applications

Lake Como School of Advanced Studies - May 16-20, 2022

Complex networks: Theory, Methods, and Applications (6th edition)
Villa del Grumello, Como, Italy, May 16-20, 2022

Many real systems can be modeled as networks, where the elements of the system are nodes and interactions between elements are edges. An even larger set of systems can be modeled using **dynamical processes on networks**, which are in turn affected by the dynamics. Networks thus represent the backbone of many **complex systems**, and their theoretical and computational analysis makes it possible to gain insights into numerous applications. **Networks permeate almost every conceivable discipline** —including sociology, transportation, economics and finance, biology, and myriad others — and the study of "network science" has thus become a crucial component of modern scientific education.

The school "**Complex Networks: Theory, Methods, and Applications**" offers a succinct education in network science. It is open to all aspiring scholars in any area of science or engineering who wish to study networks of any kind (whether theoretical or applied), and it is especially addressed to **doctoral students** and **young postdoctoral scholars**. The aim of the school is to deepen into both theoretical developments and applications in targeted fields.

This is the **6th edition** of the school: click here to visit the website of the **5th edition** (2019).

Download the leaflet (pdf) of the school.

Sponsored by

Italian Society for Chaos and Complexity
www.sicc-it.org

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Lecturers

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Inria and Brain and Spine Institute, Paris
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Program

(last updated May 13, 2022)

[time zone UTC+2 – check your time lag at https://www.timeanddate.com/time/zone/italy]

Monday, 16 May, morning (9.30-12.30)
Introduction to complex networks **(Sales-Pardo)**: In this introductory lecture, I will talk about general properties of networks. We will look into diferent kinds of networks and how to characterize the structure of these networks. We will also make a walk in the history of the analysis of the large-scale structure of networks.

Monday, 16 May, afternoon (14.30-17.30)
Science informing COVID-19 policies (remote session: **Vittoria Colizza, Yamir Moreno, Niel Hens, Jacco Wallinga, Alessia Melegaro**): Through experiences from different countries, the session will explore how science helped shaping policies to manage COVID-19 pandemic, addressing issues of timing, reliability, communication, academic research, and existing gaps.

Tuesday, 17 May, morning (9.30-12.30)
Inference for complex networks **(Sales-Pardo)**: I will introduce the ideas behind probability theory and how these probabilistic approaches can help us extract knowledge from data. In particular, I will focus on the use of Baysian inference approaches to the problems of extracting the large-scale structure of complex networks, the problem of predicting missing data and the problem of network reconstruction.

Tuesday, 17 May, afternoon
no lectures

Wednesday, 18 May, morning (9.30-12.30)
Computational social science **(Lehmann)**: As harddrives have gotten less and less expensive and database software ubiquitous over the past two decades, humanity has collected more data about human behavior than ever before. These new datasets hold the promise of new discoveries about the principles and patterns that govern and shape human choices and actions – a data driven social science. With a starting point in my own research, I discuss advances over the past ten years, covering networks, human mobility, sleep, and social media. The lecture also addresses methodological developments.

Wednesday, 18 May, afternoon (14.30-17.30)
Computational human dynamics **(Karsai)**: Human actions and interactions appear neither deterministic nor completely random for an external observer. They are driven by several confounding factors like personal decisions and preferences, inter-personal influence, or impulses arriving from the environment just to mention a few. Consequently, their characterization, modeling and understanding have to consider simultaneously their stochastic but correlated nature, which can be conveniently approached by computational methods. Early simulation studies of human dynamics focused on the mechanistic modeling of emergent social phenomena like the social structure or any collective process taking place on it. Multivariate statistical models have been also developed to identify correlations and causal patterns in the temporal sequence of decisions, mobility, or adoption patterns of individuals or groups. However, the recent availability of large digitally behavioral datasets radically changed this landscape and opened up novel opportunities for the application and development of computational methods borrowed from statistical learning and artificial intelligence. This lead researcher to achieve better understanding of human behavior, and to build predictive models with ever seen precision about processes driven by the many aspects of human dynamics. In this lecture we are going to discuss examples regarding these aspects of computational human dynamics. We will identify some ways human dynamical data can be collected and will introduce several computational models, built on mechanistic or statistical learning conventions, to describe human dynamics at the individual, group and collective level. More precisely, we will discuss the characterization and potential explanations of bursty patterns of individual dynamics; we will focus on temporal networks and their different ways of modeling and representations; and we will see how statistical learning methods can be use to infer characteristics of individuals like their language usage or socioeconomic status.

Wednesday, 18 May, evening (20.00)
social dinner

Thursday, 19 May, morning (9.30-12.30)
short talks by students: click for the schedule of the short talk session

Thursday, 19 May, afternoon
no lectures

Friday, 20 May, morning (9.30-12.30)
Biological networks **(Pržulj)**: Dealing with complex "omic" data is computationally intractable. Hence, we must develop methods for extracting new biomedical knowledge from them. In this lecture, we will present new computational methods from our lab to address these challenges. Our new computational methods uncover the patterns in molecular networks and in the multi-scale network organization indicative of biological function, translating the information hidden in the network topology into biomedical knowledge. Also, we introduce a versatile data fusion (integration) framework to address key challenges in precision medicine: better patient stratification, prediction of driver genes in cancer, and re-purposing of approved drugs to particular patients and patient groups. Our new methods stem from novel network science approaches coupled with machine learning, such as graph-regularized non-negative matrix tri-factorization. We utilize our new methodologies for performing other related tasks, including uncovering new cancer mechanisms and disease re-classification from modern, heterogeneous molecular level data, inferring new Gene Ontology relationships, and aligning multiple molecular networks.

Friday 20 May, afternoon (14.30-17.30)
Brain networks **(De Vico Fallani)**: In the last decades, network science has become essential for studying complex interconnected systems. Combined with neuroimaging, network science has allowed to visualize brain connectivity patterns and quantify their key organizational properties. Within this expanding multidisciplinary field many issues remain open, from how modeling temporally dynamic brain networks to how integrating information from multimodal connectivity. In this presentation, I will focus on these challenges and discuss the potential impact through a selection of results obtained in human neuroscience.

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Organizing Committee

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Application

To ensure distancing, only **a limited number of qualified and selected students will be admitted ONSITE**; other students will be allowed to attend the school **ONLINE** (Zoom platform).

In compliance with the regulation currently in force (*November 2021*), the school will be open to

- **30 students onsite** (please check the Covid19-related rules for admission). Registration fee: **500 euro** (VAT 22% included). The fee covers: all lectures; course material; wi-fi connections; lunches and coffee breaks; social dinner.

- **Up to 90 students online**. Registration fee: **250 euro** (VAT 22% included). The fee covers: remote access to all lectures; course material.

HOW TO APPLY: Prospective participants have to fill out and **submit the form** below, and **upload a 1-page letter** (pdf) organized as follows:

- name, department/university, current position (PhD student, postdoc, other)
- educational background
- research activity and interests
- motivations for participating in the school

Please note that **any page after the first one** will be automatically deleted.

PREREQUISITES: Basic notions and metrics on complex networks are required to be able to follow the entire course.

SELECTION CRITERIA: In addition to applicant quality, the Organizing Committee will consider a number of features including: the coherence of the motivation with the aim and scope of the school, the potential benefit for the student's research, the timeliness for the development of the student's career. Preference will be given to applicants not participating in the previous edition (2019) of the school.

The school is especially addressed to **doctoral students** and **young postdoctoral scholars**. A very limited number of **senior students** (e.g., assistant/associate/full professors) can be admitted, if they provide strong and convincing motivation in their application letter.

SHORT TALKS: Participants who intend to give a short talk (4 minutes) on **Thursday, May 19,** should declare it in the **application form** (see below) and provide a **title** and a list of **keywords** (from 3 to 5). As there will be room for no more than 25 talks, in case of a larger number of proposals the Organizing Committee will select on the basis of the potential interest to the audience, the coherence with the aim and scope of the school, and the diversification of topics.

Deadlines

• Student application: **February 20, 2022** *(firm deadline)*
• Notification of acceptance: **March 14, 2022**
• Registration (only accepted students): **March 28, 2022**

SICC fee reduction

Members of the Italian Society for Chaos and Complexity (SICC) are entitled for a discount of 50 euros on the admission fee. After the notification of acceptance, please contact Carlo Piccardi (carlo.piccardi@polimi.it) to inform about your membership.

APPLICATION FORM

The application form for Complex networks: theory, methods, and applications (6th edition) is currently closed.

For information, please contact the Organizing Secretariat (Ms. Alessandra Cazzaniga – email: alessandra.cazzaniga@fondazionealessandrovolta.it) .

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Venue and Accommodation

The School is housed in **Villa del Grumello,** Como, which is set in a park over Como lake.

How to get there

Click here for information on how to reach Como

Villa del Grumello is 20 min on foot from Como city center – you can also take a bus, lines 6 and 11 (bus stop: "Como Via Regina Piscine Villa Olmo", just after "Villa Olmo").

From the main Train Station (Como S. Giovanni), the nearest bus stop to catch line 6 and 11 is "Piazzale Rocchetto".

Click here for a map

Accommodation

PLEASE NOTE: All available rooms at the guesthouse of Villa del Grumello and Hotel Engadina have been booked.

It is possible to ask for accommodation in shared rooms @Ostello Bello Como at a discount rate. Please contact the hostel directly @ booking.como@ostellobello.com with your booking request. Please specify you are a student of Fondazione Alessandro Volta, otherwise it will not be possible to benefit of the affilated rate.

The hostel will possibly keep students of the school in the same rooms. This offer is subject to availability.

IMPORTANT NOTICE for all school lecturers and attendees:

We have been informed that someone tried to contact school speakers and attendees offering travel arrangements (hotel and flight booking) on behalf of the school secretariat, asking for credit card details in order to proceed.

***THIS IS A FRAUD**: these agencies are by no means authorized by the school.*

In case of doubt do not hesitate to contact the school secretariat (see page Contacts).

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Contacts

For enquiries about the **scientific aspects of the school**, please contact Carlo Piccardi (carlo.piccardi@polimi.it) or any other member of the Organizing Committee.

For enquiries about the **venue** of the school, **travel**, **accommodation**, and **application** procedure, please contact Alessandra Cazzaniga (alessandra.cazzaniga@fondazionealessandrovolta.it) at Fondazione Alessandro Volta, Como.