COMPLEX NETWORKS: THEORY, METHODS, AND APPLICATIONS

Lake Como School of Advanced Studies - May 14-18, 2018

Home

Complex networks: theory, methods, and applications (4th edition)
Villa del Grumello, Como, Italy, 14-18 May 2018

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 **4th edition** of the school: click here to visit the website of the **3rd edition** (2017).

Download the leaflet (pdf) of the school.

Sponsored by

COMPLEX SYSTEMS SOCIETY

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Application

The School will be open to 50 qualified and selected students.

Registration fee: **500 euro,** VAT 22% included.
The fee covers all lectures; course material; wi-fi connections; lunches and coffee breaks; social dinner.

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** 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 (2017) of the school.

SHORT TALKS: Participants who intend to give a short talk (4 minutes) on **Wednesday 16, afternoon**, 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 25-30 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 18, 2018**
• Notification of acceptance: **March 12, 2018**
• Registration (only accepted students): **March 26, 2018**

CSS-TSS fee waivers

The Complex Systems Society (CSS), in the framework of the Thematic School Support (TSS) Program 2018, grants 2 fee waivers to support the attendance of PhD students and Junior Post Doctoral researchers who are members of the CSS.

Prospective participants who are eligible for the TSS grant should accompany their application (see the form below) with an email to the Organizing Committee (Carlo Piccardi, carlo.piccardi@polimi.it) requiring the fee waiver, providing evidence of their eligibility (academic status and CSS membership, holding at the application deadline, February 18, 2018) and motivations for their request. The acceptance will be notified together with the admission to the school (March 12, 2018).

APPLICATION FORM

The application form for Complex networks: theory, methods, and applications (4th edition) is currently closed.

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

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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.

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Lecturers

Albert-László Barabási
Center of Complex Networks Research, Northeastern University, and Division of Network Medicine, Harvard University
barabasi.com

Stefano Battiston
University of Zurich
www.bf.uzh.ch/cms/de/battiston.stefano.html

Ulrik Brandes
Department of Humanities, Social and Political Sciences, ETH Zurich

Vittoria Colizza
Inserm & Université Pierre et Marie Curie, Paris, and ISI Foundation, Turin
www.epicx-lab.com/vittoria-colizza

Puck Rombach
Complex Systems Center, University of Vermont
www.uvm.edu/~mrombach/

Alessandro Vespignani
Northeastern University
www.mobs-lab.org/alessandro-vespignani.html

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Organizing Committee

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Program

(updated February 15, 2018)

Monday, 14 May, morning (9.30-12.30)
Network Science: From Structure to Control **(Barabasi)**: Systems as diverse as the world wide web, Internet or the cell are described by highly interconnected networks with amazingly complex topology. Recent studies indicate that these networks are the result of self-organizing processes governed by simple but generic laws, resulting in architectural features that makes them much more similar to each other than one would have expected by chance. I will discuss the order characterizing our interconnected world and its implications to network robustness, and control. Indeed, while control theory offers mathematical tools to steer engineered and natural systems towards a desired state, we lack a framework to control complex self-organized systems. I will discuss a recently developed analytical framework to study the controllability of an arbitrary complex directed network, identifying the set of driver nodes whose time-dependent control can guide the system's dynamics.

Monday, 14 May, afternoon (14.30-17.30)
Mesoscale Analysis of Networks **(Rombach)**: Mesoscale structures are structures that are not apparent either at the local scale of nodes and edges or at the global scale of summary statistics. They are computationally harder to detect than local or global structure, but can provide considerable insight into the topological positioning of nodes. The two most widely studied examples are community structure and core-periphery structure. We will review detection methods for these two structures. We will take a detailed look at the use of random graphs with certain global properties as null models. Based on global properties of our network, what mesoscale structure (and how much of it) do we expect?

Tuesday, 15 May, morning (9.30-12.30)
Taming Complexity: Controlling Networks **(Barabasi)**: The ultimate proof of our understanding of biological or technological systems is reflected in our ability to control them. While control theory offers mathematical tools to steer engineered and natural systems towards a desired state, we lack a framework to control complex self-organized systems. Here we develop analytical tools to study the controllability of an arbitrary complex directed network, identifying the set of driver nodes whose time-dependent control can guide the system's entire dynamics. We apply these tools to several real networks, finding that the number of driver nodes is determined mainly by the network's degree distribution. We show that sparse inhomogeneous networks, which emerge in many real complex systems, are the most difficult to control, but dense and homogeneous networks can be controlled via a few driver nodes. Counter-intuitively, we find that in both model and real systems the driver nodes tend to avoid the hubs.

Tuesday, 15 May, afternoon
no lectures

Wednesday, 16 May, morning (9.30-12.30)
Centrality in Networks **(Brandes)**: Centrality is a central concept in network analysis, and variations are termed status, prominence, importance, etc. Traditionally, it is operationalized via indices that assign numerical scores to the nodes such that higher values indicate higher centrality. We will review and analyze important indices, derive general principles, and thus arrive at a framework with much wider applicability. When does an index represent a centrality? Degree, closeness, betweenness, eigenvector centrality. Neighborhood inclusion, threshold graphs, positional dominance. Indirect relations, network positions, centrality in temporal and multivariate networks. Testing hypotheses about centrality.

Wednesday, 16 May, afternoon (14.30-17.30)
short talks by students (see page Application)

Wednesday, 16 May, evening (20.00)
social dinner

Thursday, 17 May, morning (9.30-12.30)
Contagion in Networks/1 – Financial Systems **(Battiston)**: Understanding the dynamics of contagion in financial networks is crucial to design a financial system that is more stable, that does not increase inequality in our society, and that is more aligned with the financing needs of combating climate change in a low-carbon economy. Ten years after the 2008 global financial crisis it is now widely accepted that the financial system is best described as a complex network. Yet, differently for other domains of complex networks, economic agents make decisions based on their own expectations on the future, including being rescued if they become interconnected enough to be considered systemically important. For these reasons, the endogenous dynamics of systemic risk in the financial system is far from being fully understood from a scientific perspective, and it is currently not adequately addressed by policy. Throughout this lecture, students will learn the main theoretical notions to understand network models of financial contagion. During the practical exercises with provided software tools, the students will also have the opportunity to carry out simple stress-test exercises on real financial networks.

Thursday, 17 May, afternoon
no lectures

Friday, 18 May, morning (9.30-12.30)
Contagion in Networks/2 – Network Epidemiology **(Vespignani)**: At the core of epidemic modeling approaches is the structure of human interactions, mobility and contacts patterns that finds its best representation in the form of networks. Recent years have witnessed the development of data driven models of infectious diseases rooted in the combination of large–scale data mining techniques, computational approaches and mathematical modeling. These models are defined by the network describing the coupling among individuals and/or populations, along with the intensity of the coupling. In this lecture I will introduce the basic theoretical concepts and tools needed for the analysis of contagion processes taking place on networks. I will review the effect of contact patterns in the spreading of infectious diseases, and show how they manifest in simulated data from realistic models and real-world epidemics. I will also illustrate how networks at different scales are at the core of predictive modeling approaches and forecast to epidemics. Finally I will discuss basic modeling difference emerging from the description of biological and social contagion phenomena.

Friday, 18 May, afternoon (14.30-17.30)
Contagion in Networks/3 – Epidemic Threshold in Structured Host Populations **(Colizza)**: Our understanding of infectious diseases prevention and control is rooted in the theory of host population transmission dynamics. Contacts between hosts (along which transmission can occur) and contacts between populations of hosts (along which spatial diffusion can take place) drive the epidemiology of infectious diseases, determining if and how quickly they spread, and who gets infected. Mathematical epidemiology has made great progress in this area in the last decades, moving from approximations where every host is in contact with anyone else with equal probability (i.e. the homogeneous mixing assumptions) to frameworks where patterns of contacts between hosts or population of hosts are explicitly accounted for through networks, made of nodes representing hosts/populations of hosts and connections representing potential transmission/diffusion links. This lecture will focus on (i) spatial epidemic spread, through the introduction of metapopulation network models with mobility/migration coupling between host populations, and (ii) disease spread when host-to-host contacts evolve in time, through the introduction of temporal networks. Using different techniques and approximations, we will explore how the structure of the host population affects its vulnerability to infectious disease epidemics, by means of the epidemic threshold, a central parameter in epidemiology indicating the critical conditions for the epidemic to occur.

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Protetto: Registration

Il contenuto è protetto da password. Per visualizzarlo inserisci di seguito la password:

Password: Invio

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

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.

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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

Villa del Grumello has a **guest house** ("foresteria") with 19 beds in 2- or 4-bed rooms. The rate is **33 euros(*)** per night (breakfast not included; a kitchen for self preparing breakfast is available). Please notice that **only shared accommodation with other students is allowed** (no accompanying persons).

A few rooms have been blocked in 3-star **hotels in Como**, with rates ranging from 75 to 120 euros per night (breakfast included).

The **School Secretariat** will take care of the accommodation of the accepted students who have accomplished the payment of the fee, and who have filled out and sent a suitable accommodation form before April 3rd, 2018.

UPDATE! 21 March 2018 – Please note: the guesthouse is already fully booked. If you are looking for a low price accommodation, we suggest you the youth hostel OSTELLO BELLO (https://ostellobello.com/it/ostello/ostello-bello-como-lake/; email: booking.como@ostellobello.com) prices from EUR 36,90 per night and person (shared dorms). The hostel is 15 minutes on foot from Villa del Grumello.