Catania, Sicily 25 June - 02 July 2022

VII MEDITERRANEAN SCHOOL OF COMPLEX NETWORKS

MSCx networks

VII MEDITERRANEAN SCHOOL OF COMPLEX NETWORKS

In the last decade, network theory has been revealed to be a perfect instrument to model the structure of complex systems and the dynamical process they are involved into. The wide variety of applications to social sciences, technological networks, biology, transportation and economic, to cite just only some of them, showed that network theory is suitable to provide new insights into many problems.

Given the success of the Sixth Edition in 2019 of the Mediterranean School of Complex Networks, we call for applications to the Seventh Edition in 2022.

SCHOOL DIRECTORS:

Alex Arenas (URV)
Vincenza Carchiolo (UNICT)
Manlio De Domenico (UNIPD)
Mattia Frasca (UNICT)
Giuseppe Mangioni (UNICT)

ORGANIZERS:

Vincenza Carchiolo (UNICT)
Manlio De Domenico (UNIPD)

LOCAL ORGANIZERS:

Serafina Agnello
Riccardo Gallotti (FBK)

UNIVERSITAT ROVIRA i VIRGILI

FONDAZIONE BRUNO KESSLER

PRIZES AND FELLOWSHIPS

The School will award two prizes:

- to one attendant, for the participant talk,
- to one lecturer, for the best lecture.

PhD students and Junior Post Doctoral researchers (no more than two years from their PhD completion) who are members of the CSS (cssociety.org/home) are eligible to get a fellowship covering the School fee and the participation to social events.

We granted two fellowships.

COMPLEX SYSTEMS SOCIETY

LECTURERS

FABRIZIO DE VICO FALLANI

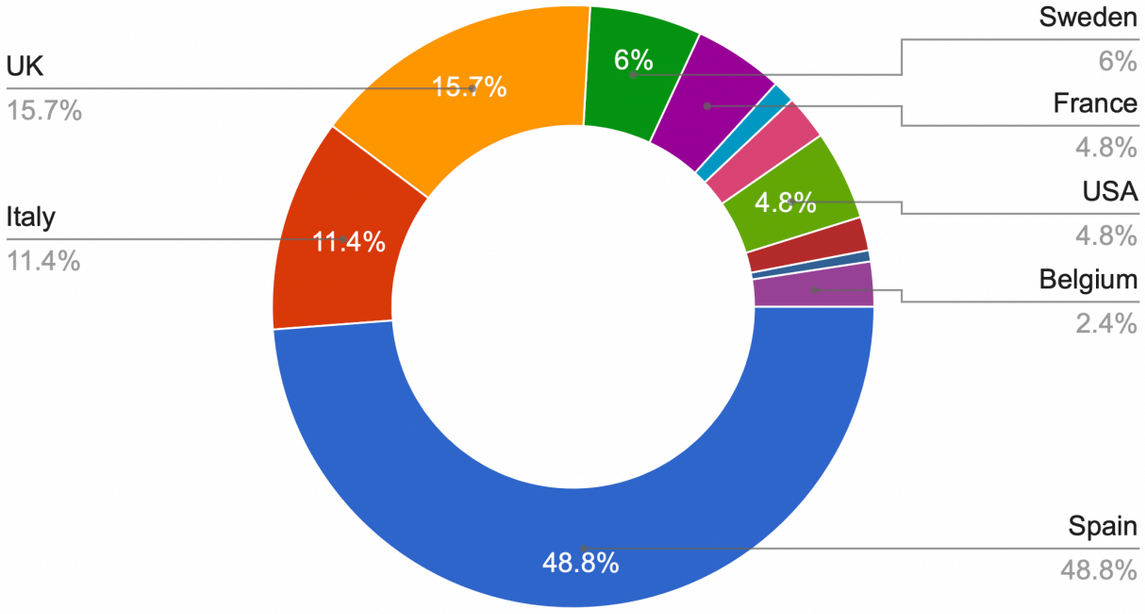
(INRIA, France)

JESUS GOMEZ-GARDEÑES

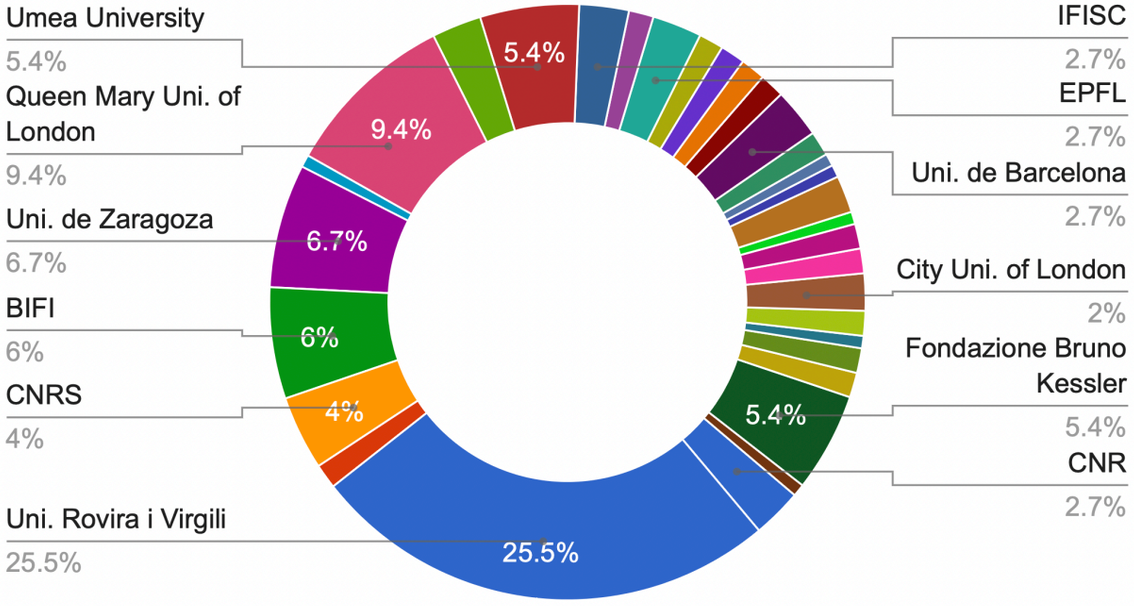
(Universidad de Zaragoza, Spain)

ROGER GUIMERÀ

(Universitat Rovira i Virgili, Spain)



Lecturers by country of all editions



Lecturers by institutions of all editions

SPEAKERS

ANDREA BARONCHELLI

(City University of London and The Alan Turing Institute, UK)

CLARA GRANELL

(URV, Spain)

KYRIAKI KALIMERI

(ISI Turin, Italy)

ROSARIO MANTEGNA

(University of Palermo, Italy)

TUTORIAL SPEAKERS

MARCO GRASSIA

(Università degli studi di Catania, Italy)

VALENTINA GAMBUZZA

(Università degli studi di Catania, Italy)

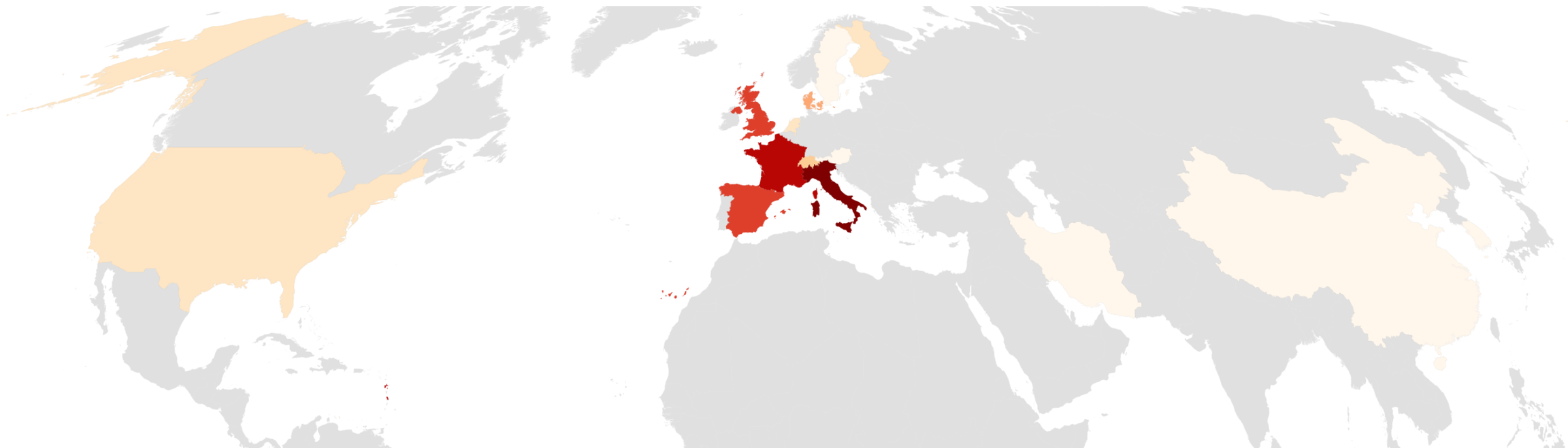
STUDENTS

Name	Affiliation
Akke Mats Houben	University of Barcelona
Alberto Amaduzzi	University of Bologna
Alessandra Corso	University of Catania
Alexis Bénichou	Institut Pasteur
Andrea Radici	INRAE
Antoine Huchet	La Rochelle University
Antoine Vendeville	University College London
Cinzia Tomaselli	University of Catania
Diana Veronica Luna Gonzalez	Stockholm University
Eric Dignum	University of Amsterdam
Giulia Fischetti	Ca' Foscari University of Venice
Giulio Burgio	University of Rovira i Virgili
Giulio Colombini	University of Bologna
Hae Seong Lee	Sungkyunkwan University
Irene Ferri	University of Barcelona
Jacques Bara	University of Warwick
Jasper van der Kolk	University of Barcelona
Johanna Einsiedler	University of Copenhagen
Juliana Gonzalez-Astudillo	ARAMIS lab

Name	Affiliation
Katharina Ledebur	Complexity Science Hub Vienna
Lasse Mohr	Technical University of Denmark
Louis Boucherie	DTU
Marta Zava	Bocconi University
Mathilde Josserand	Laboratoire Dynamique du Langage
Mattia Mattei	University of Rovira i Virgili
Niall Rodgers	University of Birmingham
Peter Møllgaard	Technical University of Denmark
Piergiorgio Castioni	University of Rovira i Virgili
Quintino Francesco Lotito	University of Trento
Sebastiano Bontorin	Fondazione Bruno Kessler
Shahbaz Chaudhry	University of Warwick
Shriya Nagpal	Cornell University
Silja Sormunen	Aalto University
Silvia Rognone	Queen Mary University of London
Vito Dichio	Sorbonne University
Xue Xia	ETH Zurich
Yizhou Wan	University of Cambridge
Yu Gao	University of Zürich

ONLINE STUDENTS

Name	Affiliation
Alberto Ceria	TU Delft
Ali Yassin	Université de Bourgogne
Cristina Llopis-Belenguer	ETH Zurich
Maisha Islam Sejunti	State University of New York at Buffalo
Razieh Masoumi	Shahid Beheshti University
Xin-Ya Zhang	Tongji University
Zhiren Huang	Department of Computer Science, Aalto University



Map colored by the number of applications to the VII edition

PROGRAM

	26 June	27 June	28 June	29 June	30 June	1 July
9:00	**OPENING** Giuseppe Mangioni	**SESSION I - PART I** Roger Guimerà	**SESSION II - PART I** Fabrizio De Vico Fallani	**SESSION III - PART I** Jesus Gomez-Gardeñes	**SEMINARS I** Clara Granell	**SEMINARS III** Rosario Mantegna
10:00	**INDIVIDUAL PRESENTATIONS**					
10:30	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**
11:00	**PROJECT GROUP AND CHALLENGE**	**SESSION I - PART II** Roger Guimerà	**SESSION II - PART II** Fabrizio De Vico Fallani	**SESSION III - PART II** Jesus Gomez-Gardeñes	**SEMINARS II** Andrea Baronchelli	**SEMINARS IV** Kyriaki Kalimeri
12:30	**BREAK**	**BREAK**	**BREAK**	**BREAK**	**BREAK**	**BREAK**
15:00				**ETNA VOLCANO TOUR**		
16:00	**WARM UP I** Valentina Gambuzza	**STUDENT TALKS I**	**STUDENT TALKS III**		**PROJECTS TIME**	**PROJECT PRESENTATIONS**
17:00	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**		**COFFEE BREAK**	**COFFEE BREAK**
17:30	**WARM UP II** Marco Grassia	**STUDENT TALKS II**	**STUDENT TALKS IV**		**PROJECTS TIME**	**AWARD AND CLOSING CERIMONIES**
18:30					**BREAK**	
20:00					**SOCIAL DINNER**	

SESSION

SESSION I

FROM NETWORK INFERENCE TO THE DISCOVERY OF EQUATIONS FROM DATA

Roger Guimerà

Network inference is the process of extracting information from network data; some typical problems in network inference include link prediction or the discovery of network communities. Although there exist heuristic methods to solve these problems, methods based on the formulation of generative models and the rigorous use of probability theory are often preferable. In the first part of this lecture we will describe these approaches to network inference, starting from general concepts of Bayesian model selection. In the second part of the lecture, we will discuss how we can use similar approaches to a seemingly unrelated problem, namely the problem of learning closed-form mathematical models from data.

SESSION II

NETWORK SCIENCE FOR UNDERSTANDING BRAIN COMPLEXITY

Fabrizio 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 to filter connectivity information to how to model temporally dynamic brain networks and integrate 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.

SESSION III

SPREADING PROCESSES ON NETWORKS

Jesus Gomez-Gardeñes

In this lecture we will address a topic that has advanced enormously in recent decades thanks to the contribution of network science: the modeling of the impact that social behavior has on the onset of an epidemic or on the spread of information. We will begin by reviewing the building blocks of spreading processes, compartmental models, and the derivation of the basic reproductive number. From there, we will progressively add ingredients aimed at capturing the actual patterns of connectivity (networks) and mobility (metapopulations) observed in our society. Finally, after analyzing the behavior of these models from a theoretical point of view, we will address their application in theoretical epidemiology and the design of non-pharmacological containment strategies, i.e. those that act by changing our social behavior or taking advantage of it to mitigate or suppress pathogen transmission.

SEMINARS

SEMINARS I

COMMUNITY DETECTION

Clara Granell (URV, Spain)

Community detection is an important problem that consists on grasping the intrinsic topological structures of networked data, without any previous knowledge about the size or number of groups to be found. This is of utmost importance in exploratory data analysis, specially in experimental fields like biology, chemistry, and many others. The main difficulty that scientists face when trying to do community analysis relies on finding the appropriate definitions and algorithms for each problem at hand. Nowadays, a myriad of methods are available, and some are even embedded in network analysis tools, making it easy for scientists to apply the most popular community algorithm right away, but also hiding the whole community detection process in a black box. In this lecture we will review community detection from its very definition, considering the advantages and drawbacks of the most popular approaches, in hopes to build a grounded knowledge about this problem so that every scientist is able to critically choose the appropriate solution for his problem.

SEMINARS II

SELF-ORGANISATION IN THE BLOCKCHAIN ECOSYSTEM

Andrea Baronchelli (City University of London and The Alan Turing Institute)

The scientific paper "Bitcoin: A Peer-to-Peer Electronic Cash System" by Satoshi Nakamoto, published in 2008, started a socio-economic revolution which is still unfolding under our eyes. Today, cryptocurrencies alone have a market capitalisation of 1.7 billion Euros, the governments of 60+ countries are experimenting with central bank digital currencies and the NFT are deeply transforming such diverse sectors as the art market, the gaming industry, the fashion industry, the music business and even the real estate market. In this talk, after introducing key concepts upon which the blockchain ecosystem is unfolding, we will discuss some recent results that help us make sense of the self-organisation taking place at all levels of this revolution, including the development, usage, market and governance of cryptocurrencies and NFTs.

SEMINARS III

STATISTICALLY VALIDATED NETWORKS IN FINANCE

Rosario Mantegna (University of Palermo, Italy)

We present an overview of statistically validated networks, i.e., event or relationship networks where a subset of links and edges are selected according to a statistical test of a null hypothesis. We present two case studies. In the first case study [1], we investigate daily trading decisions of individual investors. We construct the time-evolution of statistically validated networks of investors, and we obtain clusters of investors—and their time evolution— which are characterized by similar trading profiles. Our empirical observations show the presence of an ecology of groups of investors characterized by different attributes and by various investment styles over many years. In the second case study [2], we consider the trading networks occurring in a venue of a financial market with a state-of-the-art technological infrastructure. These studies detect a sizable increase in both the number and persistence of networked relationships occurring between market members in most recent years and show how technological and regulatory innovations affect the networked nature of markets.

SEMINARS IV

DATA FOR GOOD

Kyriaki Kalimeri (ISI Turin, Italy)

Every field has data. We use data everyday to extract knowledge, interpret the world around us, and make decisions. “Data for Good” is an emerging discipline where data is used to address societal challenges, bringing humanistic perspectives as—not after—new science and technology are invented. The research questions in this area are often more complex than those proposed in computer science since cultural, moral, and other human factors are entangled within the phenomena under investigation. The data employed to answer those questions entail the same complexity with sparsity and data biases issues to require the combination of data originating from a wide range of sources to depict a more concrete view of the problem. Finally, the unambiguous measures of validity, to which we are accustomed to in computer science, are rare, and when present, they are only partial evidence in support of a broader argument. Careful observation, critical abilities, and collaboration with practitioners with in-depth field knowledge are crucial elements for successfully introducing AI in addressing societal challenges.

WARM UP

WARM UP I

BRIEF INTRODUCTION TO COMPLEX NETWORKS

Valentina Gambuzza (Università degli studi di Catania)

The aim of this tutorial is to briefly recall some features of complex networks. We will start from basic definitions useful to understand the structure of a network and how they characterize the different models. We will go through the most important models used to build up networks with different features and finally we will discuss some applications of complex networks.

WARM UP II

NETWORK ANALYSIS WITH PYTHON

Marco Grassia (Università degli studi di Catania)

Python is the most widely used programming language in data analysis. In this warmup, we will introduce the most popular and powerful libraries for Network Science (i.e., graph-tool, NetworkX), for data analysis and visualization (Matplotlib, NumPy, SciPy, Pandas, Seaborn), and for Deep Learning on graphs (PyTorch Geometric).

STUDENT TALKS I

NETWORK NEUROSCIENCE & SEMANTIC NETWORKS

27 JUNE

I

INTERPLAY OF EXTERNAL NOISE AND ANISOTROPIC CONNECTIVITY ON THE DYNAMICS OF NEURONAL NETWORKS

Akke Mats Houben

In vitro cultured neurons are a unique model to study the dynamics of complex networks of active elements, providing access to both the connectivity and activity of single neurons. Using opto-genetics it becomes possible to administer external perturbations, and by using micro-fabricated obstacles it is possible to manipulate the connectivity structure of the neuronal network. All this enables to study the interplay between connectivity and external inputs, and their combined effect on network dynamics.
In this talk I will present results on the combined effects of external noise level and degree of connectivity anisotrophy on the dynamics of neuronal cultures and the propagation of input patterns.

II

NETWORK MOTIFS AND THE COMPRESSIBILITY OF NEURAL CONNECTOMES

Alexis Bénichou

Physical and functional constraints on biological networks lead to particular topological patterns across multiple scales. A particular type of higher-order network feature that has received considerable interest are network motifs—statistically regular subgraphs. These may implement fundamental logical or computational circuits and have thus be referred to as “building blocks of complex networks”. Their well defined structures and small sizes furthermore means that their function is amenable to testing in synthetic and natural biological experiments.
I will present a methodology for motif mining based on lossless network compression using subgraph contractions. This provides an alternative definition of motif significance, which guarantees more robust statistical tests while conveniently avoiding random graph sampling. The minimum description length principle allows us to select the most significant set of motifs and other network features in terms of their combined compression of the network. Our approach thus overcomes fundamental statistical problems in classic census-based motif analysis, namely their inability to account for correlations between different motifs and to select the most appropriate null model when this is not known beforehand. I will discuss how the approach can be applied to perform comparative connectomics, by evaluating the connectomes’ compressiblity and comparing their circuit motifs.

III

SYNCHRONISATION PHENOMENA IN COMPLEX NEURONAL NETWORKS

Giulio Colombini

The phenomenon of neural synchronisation, a simultaneous and repeated firing of clusters of neurons, underlies many physiological functions and pathological manifestations. Neural synchronisation, as a general phenomenon, can be approached theoretically in the framework of Dynamical Systems on Graphs. We consider complex networks of FitzHugh-Nagumo model neurons using delay differential equations and different network structures. We study the stability of the synchronous state when one removes links from the network, so to obtain a bipartite network. Considering the case of neurons that produce a fixed amount of neurotransmitter, a self-consistent approach is formulated and its limitations are explored. The predictivity of the Mean Field Approach is then tested on the different random network models, and the results are discussed in terms of the original network properties.

IV

EFFECT OF PRIOR KNOWLEDGE ON VOCABULARY LEARNING

Hae Seong Lee

Finding a word meaning in a dictionary often requires recursive searches for words presented in words' definitions. If the learner's prior knowledge is limited, the learner will often encounter an outbreak of search. The process of recursive search can be understood as an epidemic spreading on a Lexical network. We consider three states of words: Unknown, Found, and Known states correspond to Susceptible, Infective, and Removed states in the SIR model. We define the core vocabulary as the minimal group of pre-immunized words preventing the search outbreak efficiently. We apply vaccination strategies to the Korean lexical network based on the Korean Standard Dictionary. We test vaccination strategies pre-immunizing a given fraction of words with the highest in/out-degree, betweenness centrality, and the random vaccination strategy. We report that pre-immunization of words with high betweenness centrality leads to more efficient core vocabulary than other strategies we have considered.

V

SPATIAL LATERALIZATION IN MOTOR BRAIN NETWORKS

Juliana González Astudillo

It is well known that the motor cortex is principally involved in controlling the contralateral side of the body. Recent neuroimaging studies demonstrated that brain connectivity can reveal this lateralization during motor-related tasks. In our work, we explored the dual contribution of brain network topology and space in modelling motor-related mental states through functional lateralization. Specifically, we introduced new metrics to quantify segregation and integration within and between the hemispheres, and we showed that they are highly relevant features for decoding a motor-imagery mental task. In a machine learning scenario, these network properties not only give high values of classification accuracy, but they also have the advantage of being neurophysiologically interpretable, compared to state-of-the-art approaches that are instead blind to the underlying mechanism.

VI

CRITICAL DRIFT IN A NEURO-INSPIRED ADAPTIVE NETWORK

Silja Sormunen

It has been postulated that the brain operates in a self-organized critical state that brings multiple benefits, such as optimal sensitivity to input. Thus far, self-organized criticality has typically been depicted as a one-dimensional process, where one parameter is tuned to a critical value. However, the number of adjustable parameters in the brain is vast, and hence critical states can be expected to occupy a high-dimensional manifold inside a high-dimensional parameter space. In our project, we have shown that adaptation rules inspired by homeostatic plasticity drive a neuro-inspired network to drift on a critical manifold, where the system is poised between inactivity and persistent activity. During the drift, global network parameters continue to change while the system remains at criticality. This opens up the possibility of new phenomena such as high-codimension multi-way criticality and persistent parametric dynamics in the critical state.

STUDENT TALKS II

SPATIAL NETWORKS & NETWORK EPIDEMIOLOGY

27 JUNE

I

QUANTITATIVE MEASURES FOR THE INDIVIDUAL HUMAN TRAJECTORIES DURING THE COVID PANDEMIC

Alberto Amaduzzi

The onset of the Covid pandemic in 2020 and the associated Mobility restrictions and lockdowns are an unprecedented event that revealed the tight interaction between mobility and disease spreading. At the same time, they also represent a natural experiment that allow us to test the robustness of individual mobility patterns to these shocks. In this work, we have analyzed a large dataset of GPS trajectories produced by smartphone apps during the period January-September 2020, including over 180,000 trajectories of people living in Massachusetts and moving across the whole U.S.A. In particular, we have calculated how the shape of the distribution of single trajectory's observables such as displacement length and radius of gyration change during three different periods, before, during and after restrictions. Our results provide quantitative measures for the evolution individual human trajectories during the pandemic that would allow for improved modeling of the impact of mobility to disease spreading.

II

BENEFITS AND COSTS OF NETWORK-BASED COOPERATIVE PLANT EPIDEMIC SURVEILLANCE

Andrea Radici

Airborne plant pathogens, such as Puccinia graminis, fungal causal agent of stem rust of wheat, create a network of continental epidemic connections due to air-masses spore dissemination through a globally distributed host. Although the recent emergence and rapid diffusion of new virulent strains brought this disease back to the scientific stage after decades, surveillance strategies are still struggling to face this pathogen because of its long-distance dispersal mechanism. In this work, we developed a network-inspired surveillance strategy coupling air-masses trajectories simulations with biophysical layers describing local infection dynamics. Furthermore, we evaluated how non-cooperative national-based strategies may impacts on surveillance objectives. We found that the high density of the epidemic network allows to identify a circumscribed set of sentinels to efficacy surveil great part of worldwide wheat producing regions, while national-based strategies generally decrease surveillance performance - with few exceptions.

III

CRITICAL BEHAVIOR IN INTERDEPENDENT SPATIAL SPREADING PROCESSES WITH DISTINCT CHARACTERISTIC TIME SCALES

Piergiorgio Castioni

The spread of an infectious disease is well approximated by metapopulation networks connected by human mobility flow and upon which an epidemiological model is defined. In order to account for travel restrictions or cancellation we introduce a model with a parameter that explicitly indicates the ratio between the time scales of the intervening processes. We study the critical properties of the epidemic process and its dependence on such a parameter. We find that the critical threshold separating the absorbing state from the active state depends on the scale parameter and exhibits a critical behavior itself: a metacritical point – a critical value in the curve of critical points – reflected in the behavior of the attack rate measured for a wide range of empirical metapopulation systems. Our results establish a non-trivial critical behavior between temporal scales of reaction (epidemic spread) and diffusion (human mobility) processes.

IV

DYNAMICAL NETWORK ANALYSIS OF EXTREME SPACE WEATHER EVENTS

Shahbaz Chaudhry

Extreme space-weather events known as geomagnetic storms can have severe impacts on technological systems, on the ground and in space, including damage to satellites and power blackouts in severe cases. Quantitative understanding of the non-linear magnetospheric system during storms/sub-storms is important as our reliance on space based systems increases. We build dynamical corelation networks for storms using looking at standing wave modes along field lines known as Pc waves. We use data from >100 ground-based magnetometers, obtained from the SuperMAG collaboration. Using recently released 1s high time resolution data it is possible to capture more dynamical detail of the magnetosphere during storms and substorms.

V

CHARACTERISING STRUCTURES EMERGED FROM RANDOM COLOURING PROCESSES ON A SPATIAL NETWORK

Silvia Rognone

The use of labels to represent physical quantities on networks is tied up with the need to understand and quantify the presence of heterogeneity in the distribution of the variable of interest. In the case of spatial networks, the presence of spatial constraints could lead to the emergence of structures when a specific colouring process is implemented. In this work, we characterise spatial structures that emerge from a random colouring process on a lattice. We provide a dynamical random growth model to reproduce the structures and we measure some structural quantities making a comparison with a well-known growth model, the EGM, used as control. Then, we propose the exit time as a tool for the characterization of these spatial motifs. We show the analysis in a real-case scenario, characterising the spatial patterns of root cells of some plants and looking at their resilience in terms of two types of attacks.

VI

FLOQUET THEORY FOR SPREADING DYNAMICS OVER PERIODICALLY SWITCHING NETWORKS online

Maisha Islam, Sejunti

In this work, we formulate and analyze metapopulation susceptible-infected-susceptible (SIS) epidemic models over periodically switching temporal networks. By applying Floquet theory ---a framework that extends the theory of linear systems to the setting of time-varying periodic systems---we characterize the epidemic threshold and growth/decay rates in terms of a Floquet multiplier of a system's monodromy matrix. We apply our theoretical techniques to explore curfew strategies that balance human mobility and risk to infection. We also investigate Parrando's Paradox for this context, whereby we find that supercritical epidemics could mistakenly be predicted to be subcritical if one neglects that the system is inherently temporal and periodic.

VII

MOBILITY SIGNATURES: A TOOL FOR CHARACTERIZING CITIES USING INTERCITY MOBILITY FLOWS online

Zhiren Huang

Understanding the patterns of human mobility between cities has various applications from transport engineering to spatial modeling of the spreading of contagious diseases. We adopt a city-centric, data-driven perspective to quantify such patterns and introduce the mobility signature as a tool for understanding how a city is embedded in the wider mobility network. We demonstrate the potential of the mobility signature approach through two applications that build on mobile-phone-based data from Finland. First, we use mobility signatures to show that the well-known radiation model is more accurate for mobility flows associated with larger Finnish cities, while the traditional gravity model appears a better fit for less populated areas. Second, we illustrate how the pandemic disrupted the mobility patterns in Finland in the spring of 2020. These two cases demonstrate the ability of the mobility signatures to capture features of mobility flows that are harder to extract using more traditional methods.

STUDENT TALKS III

STATISTICAL PHYSICS OF NETWORKS

28 JUNE

I

A GEOMETRY-INDUCED TOPOLOGICAL PHASE TRANSITION IN RANDOM GRAPHS

Jasper van der Kolk

Clustering – the tendency for neighbors of nodes to be connected – quantifies the coupling of a complex network to its latent metric space. In random geometric graphs, clustering undergoes a continuous phase transition, separating a phase with finite clustering from a regime where clustering vanishes in the thermodynamic limit. We prove this geometric-to-nongeometric phase transition to be topological in nature, with anomalous features such as diverging entropy as well as atypical finite size scaling behavior of clustering. Moreover, a slow decay of clustering in the nongeometric phase implies that some real networks with relatively high levels of clustering may be better described in this regime.

II

DYNAMIC NETWORK EMBEDDINGS

Louis Boucherie

How can we develop and utilize large scale dynamic network embeddings to enable a human understanding of the structure of complex systems and forecast their future behaviors ? While many other methods are able to analyze a network's past behavior, the strength of the methods developed here, is the ability to accurately forecast and scale to very large datasets. Further, as we compare the predicted behavior with the empirical development, we can pinpoint parts of the network exhibiting 'unexpected behavior'. This unexpected behavior could be anomalies, or truly novel developments driven by factors exogenous to the system. We use this general strategy to analyze two key areas in this project: i) dynamics of knowledge production, ii) prediction of information propagation and detection of filter bubbles.

III

INFLUENCE OF NETWORK HIERARCHY, DIRECTIONALITY ON STRUCTURE, FUNCTION OF DIRECTED COMPLEX NETWORKS

Niall Rodgers

Many real-world networks have directed interactions such as food-webs, social networks, neural networks and trade networks. These real world networks display hierarchical organisation and global directionality. This can be studied by a recent network analysis tool, inspired by ecology, called Trophic Analysis. This talk will explain how it can be used to understand the topology of a network. As well as how hierarchically organisation and global directionality can be used to interpret and control the dynamics of complex networks. In particular how the performance of Hopfield-like networks can be affected by hierarchy and how many structural properties of networks such as the spectral radius or strong connectivity can be shaped by the hierarchical organisation.

IV

HIGHER-ORDER MOTIF ANALYSIS IN HYPERGRAPHS

Quintino Francesco Lotito

A deluge of new data on real-world networks suggests that interactions among system units are not limited to pairs, but often involve a higher number of nodes. To encode higher-order interactions, richer mathematical frameworks such as hypergraphs are needed, where hyperedges describe interactions among an arbitrary number of nodes. In this talk, we investigate higher-order motifs, small connected subgraphs in which vertices may be linked by interactions of any order, and propose an efficient algorithm to extract higher-order motif profiles from empirical data. We identify different families of hypergraphs, characterized by distinct connectivity patterns at the local scale. Finally, we study the nested structure of hyperedges and provide evidence of structural reinforcement, a mechanism that associates higher strengths of higher-order interactions for the nodes that interact more at the pairwise level. We highlight the informative power of higher-order motifs, providing a principled way to extract higher-order fingerprints in hypergraphs at the network microscale.

V

MULTI-PATHWAYS TEMPORAL DISTANCE UNRAVELS THE HIDDEN GEOMETRY OF NETWORK-DRIVEN PROCESSES

Sebastiano Bontorin

Network-based interactions are widely adopted to model the behavior of technological and natural systems, where understanding information flow between nodes is of paramount importance in predicting its functioning. As different dynamic processes give rise to profoundly different, and apparently random, perturbation patterns on top of the same topology of connections, the interplay between network connectivity and the dynamics on top of it has been the focus of recent studies. The identification of dynamical regimes and predictive observables via scaling laws sheds light over signal propagation in complex systems, and overcomes the paradigm of information flow being solely dependent on network topology. In this paper we perform a path-driven analysis of perturbation propagation on steady-state systems, establishing the relevant paths for information transfer given the exponential decay of correlations. We exploit known scaling laws to define a new multi-pathways temporal distance between nodes that predicts propagation times and improves over the existing definition. We validate these measures on synthetic models, simulating dynamical processes pertaining to different regimes, measuring the goodness in predicting empirical arrival times. This measure fully predicts the time of arrival of a perturbation and naturally encodes the concerted behavior of the ensemble of paths connecting two nodes in conveying propagation. The dynamics induces a latent geometry in which the signal propagation resembles the traveling wave solution of reaction-diffusion systems.

VI

DESIGNING ROBUST NETWORKS OF COUPLED PHASE-OSCILLATORS

Shriya Nagpal

Assuming a complex network of coupled phase-oscillators with global synchronized frequencies, we consider a vulnerability measure that quantifies how much a small perturbation to a phase-oscillator's natural frequency impacts the system's global synchronized frequencies. In particular, we leverage this measure by proposing a mathematical framework for designing robust networks of coupled phase-oscillators; Given a fixed complex network topology with specific governing dynamics, our frameworks finds an optimal allocation of edge weights that minimizes the vulnerability measure(s) at the node(s) for which we expect small perturbations to occur. We specify our mathematical model to high voltage grids where each node corresponds to a voltage phase angle associated with a bus and two nodes are connected by an edge if there exists a transmission line that connects the busses in the physical system. The ability for voltage phase-oscillators' to maintain synchronization is imperative to the grid's health and functionality.

VII

AN EVOLUTIONARY MASTER-EQUATION FOR GRAPH'S EDGE DYNAMICS

Vito Dichio

A number of natural systems' dynamics can be thought to arise at their most fundamental level by two opposing forces: the need to explore the configuration space (entropic driver) and at the same time the need to select optimal state(s) i.e. functional states. In order to study their interplay, we draw analogies from known models of population genetics and propose a new statistical framework: it is designed for network data and based on a mutation-selection Master Equation. By defining an appropriate state space and a fitness function on it, the latter can be studied to understand the forward dynamics of given systems both analytically and numerically. What we propose is a statistical environment within which to ask questions about the network's edge dynamics, rather than a model for anything in particular: we show applications to problems of increasing complexity involving random graphs, Barabási-Albert graphs and experimental network data.

STUDENT TALKS IV

SOCIAL & ECOLOGICAL NETWORKS

28 JUNE

I

FIGHTING POLITICAL ECHO CHAMBERS VIA CONTENT RECOMMENDATION: METHOD AND APPLICATION TO THE 2017 FRENCH PRESIDENTIAL ELECTIONS

Antoine Vendeville

Online social platforms have become central in the political debate. In this context, the existence of echo chambers is a problem of primary relevance. These clusters of like-minded individuals tend to reinforce prior beliefs, elicit animosity towards others and aggravate the spread of misinformation. We observe this phenomenon on a Twitter dataset related to the 2017 French presidential elections and propose a method to tackle it via algorithmic recommendations. We use a quadratic program to find optimal recommendations that maximise the diversity of content users are exposed to, while still accounting for their preferences. The method is based on a theoretical model that describes the flow of content throughout the platform. We show that the model provides good approximations of empirical measures and demonstrate the efficacy of the optimisation algorithm at mitigating the echo chamber effect on the dataset.

II

SOCIAL NETWORKS IN THE COMPUTATIONAL MODELLING OF SCHOOL SEGREGATION

Eric Dignum

In this talk I will briefly present two ways we used networks in the context of school segregation. After a brief introduction of the project, a model of friendship formation and its implications for within-school segregation are discussed. This is followed by presenting the results combining an Agent-Based Model with a parental social network together with school quality perceptions and its influence on school choice and resulting segregation.

III

INVESTIGATING PEER EFFECTS IN UNIVERSITY STUDENT FRIENDSHIP NETWORKS

Johanna Einsiedler

Using a dataset containing bluetooth phone data of 800 university students in Denmark, I try to investigate whether we can see see different types of friendship networks emerging and how these relate to university performance, behavior and later life outcomes.

IV

THE EVOLUTION AND STRUCTURE OF FAMILY NETWORKS

Lasse Mohr

Most social network systems are characterized by temporal links. Therefore, dynamic networks should not just be seen a natural extension of static networks, but as a cornerstone of social complex systems. However, the field of temporal social networks have not found its ''scale-free degree distribution'' yet - very common structures that calls for analytical explanations. If such structures are to be found, they call for more systematic large-scale studies of empirical temporal networks. In this project, we construct and analyze a temporal family network of the entire population of Denmark - a country with over 5.8 million inhabitants. We investigate the emergence of giant-connected components and meso-scale structures and investigate how homophily influence their development.

V

BOW-TIE STRUCTURES OF TWITTER DISCURSIVE COMMUNITIES

Mattia Mattei

A bow-tie structure is a simple division of the nodes of a directed network consisting in 3 main sectors: SCC (main Strongly Connected Component), IN and OUT (set of nodes not included in SCC that, respectively, can access and are accessible to nodes in the SCC). In the analysis of Twitter debate, the recent literature focused on discursive communities, i.e. clusters of accounts interacting among themselves via retweets. We studied discursive communities in 8 different thematic Twitter data sets in various languages. Surprisingly, we observed that almost all discursive communities therein display a bow-tie structure during political or societal debates. We furthermore analysed the quality of the content created in the various sectors: it turns out that content with the lowest quality is the ones produced and shared in SCC. In the present paper, we correlate the presence of an infodemic to a peculiar network structure, i.e. a OUT-dominant bow-tie.

VI

HOST-PARASITE NETWORKS ARE AFFECTED BY SAMPLING ISSUES online

Cristina Llopis-Belenguer

Host-parasite interactions compose networks present in all ecosystems. To study empirical host-parasite complex networks, researchers obtain representative samples of the interactions. Acquiring representative samples is difficult because not all species are easy to sample or to identify. Sampling issues virtually affect all host-parasite network studies. Two main sampling issues affect our interpretation of host-parasite networks: host sampling completeness (failure to capture the full range of interactions of a host species) and parasite taxonomic resolution (failure in identifying parasite species correctly). This study assesses the influences of reduced host sampling completeness and parasite taxonomic resolution on four commonly-used descriptors of host-parasite networks: modularity, nestedness, connectance and specialisation. Both sampling issues had an additive effect. The descriptors differed in sensitivity, but all were sensitive to low taxonomic resolution. Researchers should extract conclusions from under-sampled networks or those with a low taxonomic resolution. Our study will improve our understanding host-parasite dynamics in ecosystems.

LOCATION

The School will take place in **"Hotel Nettuno"**
(Viale Ruggero di Lauria, 121- 95127 Catania - CT Sicilia).

The fee includes accommodation in a sigle room with bathroom, available from June 25 2022 to July 1 (night) included.
Attendants who wish to arrive before, or leave after, these dates should arrange for other accommodation on their own.

Breakfast is offered by the school.

Participants should arrange for lunch and dinners by their own. However, they can have a typical Sicilian lunch and dinner in the hotel at a special price of € 25.

Some refreshments will be available during the morning sessions and are included in the fee.

How to get to "Hotel Nettuno":
Located in Viale Ruggero di Lauria 121, about 9 km away from the "Vincenzo Bellini" Fontanarossa Airport, it is possible to reach it quickly once landed.

At the exit of the airport you will find **Alibus**, a shuttle that will take you to the Catania railway station where you have to take **Bus 448**.

The attendants can purchase the ticket on board.

to Hotel Nettuno, Viale Ruggero di Lauria, 121, 95...

Walk
About 6 min, 450 m

7:50 PM **Capolinea ALIBUS**

ALIB Giovanni XXIII Stazione Centrale
20 min (4 stops)

8:10 PM
8:25 PM **Stazione Centrale**

448 Harris Messina
34 min (26 stops)

8:59 PM **Alagona Nettuno Est**

Walk
About 3 min, 250 m

9:02 PM **Hotel Nettuno**
Viale Ruggero di Lauria, 121, 95127
Catania CT

For more informations: Alibus https://www.amts.ct.it/alibus. Hotel Nettuno https://www.hotel-nettuno.it

MAP OF CATANIA AIRPORT

ETNA VOLCANO TOUR

Location: south side of Etna

Altitude: 2000 Meters

Duration: from 15:00 to 22:00

Difficulty: medium-easy

Etna represents a natural, terrestrial scientific laboratory, and its volcanic zones and intense eruptions have been observed and talked about since Antiquity.

This evening excursion on Etna will allow you to admire the magnificent colors of the evening in the splendid setting of the extinct craters of the volcano!

Mount Etna volcano in Sicily

Requirements

It is strongly recommended not to participate in the excursions to people who are not in good health, especially those ones suffering from cardiorespiratory diseases.

Recommended equipment

We remind you to wear closed and sturdy shoes (sports or trekking) with thick socks, and to bring a winter-like jacket because the temperature at high altitude can be lower, especially at night (about 5-7 °C).

For more informations

https://lovingsicilia.it/vulcano-etna-sicilia/crateri-silvestri-rifugio-sapienza/

https://sicilia-etna.it/vulcano-etna/passeggiate-sull-etna/passeggiata-crateri-silvestri/

https://www.youtube.com/watch?v=FM1dj0s9Ghk

The relationship between Etna and Man

The volcano, apparently so hostile to settlements, has always offered a variety of resources that seem designed specifically for human needs since prehistoric times. Etna makes its entry into the literature thanks to the Greeks with the eruption of 475 BC. Pindaro is described it in the mythical image of Typhoeus or Typhon. A giant who wandered in the volcanic areas, which, imprisoned by Zeus under the weight of the volcano, spat fire from his eyes and nostrils. With time, the myths and legends ended, but the eruptions continued to leave their traces and to modify the volcano. But if you are wondering why do people live close to active volcanoes, you should know that the main reason is the rich volcanic soil. The region has been intensively cultivated for centuries. The land is planted with vines, vegetables and flowers. Every square foot of this rich soil is used.

SOCIAL DINNER

Location: Museo Diocesano di Catania

Duration: From 20:00 to 23:00

Meeting point: Piazza Duomo at 20:00
(the transfer is self-organized by the attendant)

How to get to "Piazza Duomo": Bus **534** From Lauria to Stesicoro**.**

Informations: https://museodiocesanocatania.com/

da Hotel Nettuno, Viale Ruggero di Lauria, 121, 95...
a Piazza del Duomo, 95100 Catania CT

19:01 (giovedì) - 19:27
(26 min)

534

19:03 da Lauria
10 min

Aggiungi al calendario

19:01 **Hotel Nettuno**
Viale Ruggero di Lauria, 121, 95127 Catania CT

A piedi
Circa 2 min, 210 m

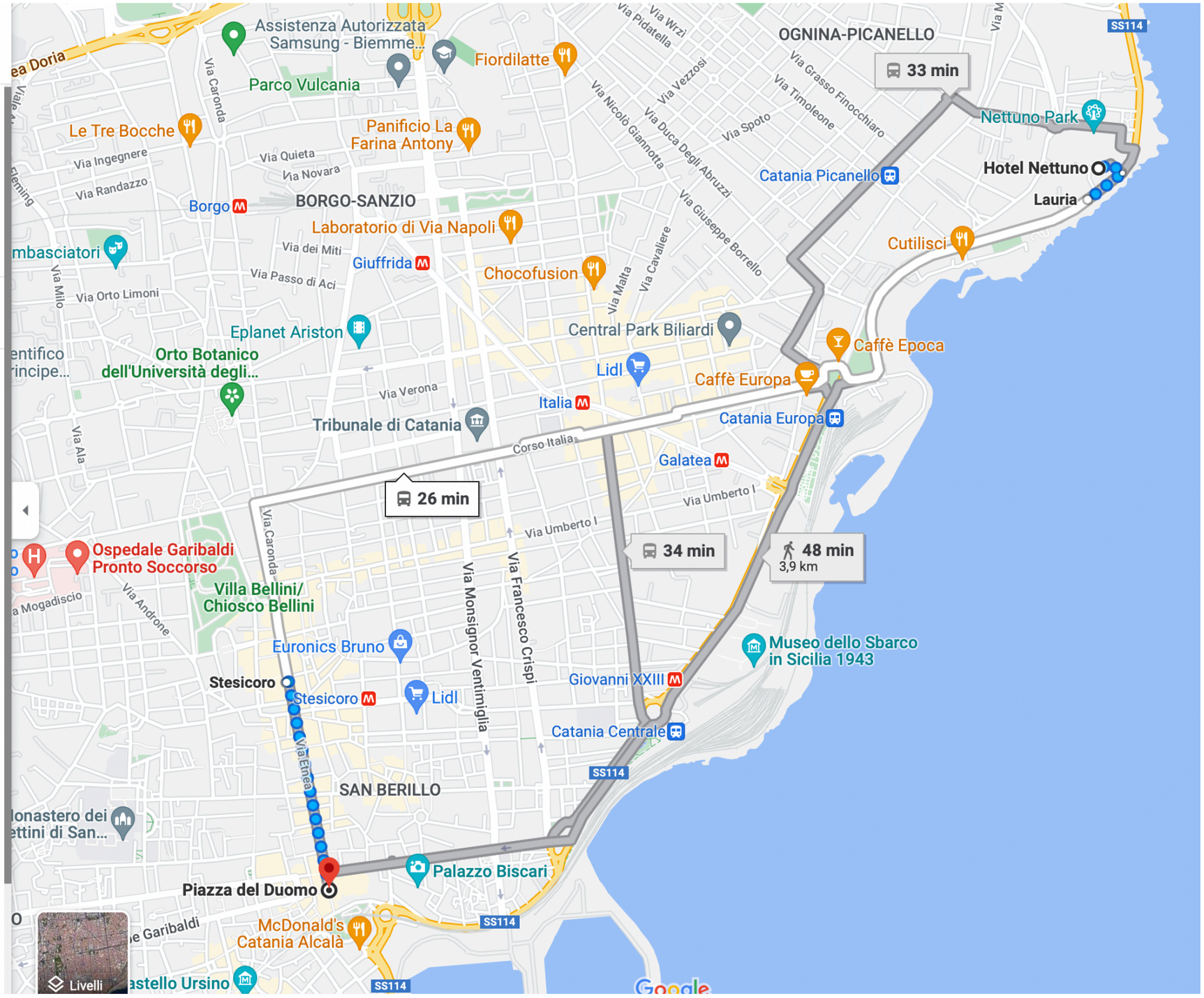
19:03 **Lauria**

534 Terminal Borsellino Ovest
16 min (12 fermate)

19:19 **Stesicoro**

A piedi
Circa 8 min, 650 m

19:27 **Piazza del Duomo**
95100 Catania CT



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GRAPHIC DESIGN:

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