Special Session 54: Dynamics in Complex Networks

Juan A. Almendral, Rey Juan Carlos University, Spain
Miguel Romance, Rey Juan Carlos University, Spain

Complex Networks constitutes a theoretical framework that allows modeling the complexity of the systems that can be found in fields as diverse as biology, ecology, sociology or neuroscience. Although Complex Networks became a research line only 10 years ago, the number of disciplines in which their tools are useful is continuously increasing, being at the present moment one of the more active research fields. Its fundamental premise is that the understanding of a real system made of an ensemble of components should consider not only the nature of these units but also the distribution and features of the interactions.

Following the chronology of the Complex Networks development, the studies were initially focused on the topological and structural characteristics of networks, considered like graphs, regardless of the nature of its units. Later, the interest shifted to dynamics in networks, where each node represents now a dynamical unit interacting with the rest of the network according to certain complex distribution of links. This process results in the emergence of certain properties (synchronization, activation, diffusion, propagation) that cannot be deduced from the unit features.

In the last years, the research in this field is focused on the role that network modularity has in the emergence of a specific function. In other words, the study of how the organization in communities that bridge between the local dynamics and the global statistic affects the collective behavior of a system; issue in which not only the community functioning and structure is being debated, but also its detection at different scales. The functioning of many biological (neuronal, metabolic, genetic...), social and technological networks is precisely based on the coordination of parallel processes carried out by different communities. For example, vision depends on the emergence of a collective behavior in two different brain areas, thus perception implies the simultaneous coordination of both processes. How this process coordination takes place and which are its inner (topological and dynamical) mechanisms are still opened questions, although it is already well known that the information processing in the brain combines the distribution (to different points from the network) and segregation (in communities) of this information.

The integration/segregation phenomena from the complex networks viewpoint

Juan Almendral
Rey Juan Carlos University, Spain
juan.almendral@urjc.es
Vanesa Avalos Gaytan, Satu Elisa Schaeffer, Stefano Boccaletti

We study the integration/segregation problem from the viewpoint of complex networks, but considering that the network topology is not static but there is an adaptive mechanism acting on the links. Our goal is to identify under which conditions network synchronization occurs and what structural properties are present in the network topology when this happens. In particular, we experimentally compute the main descriptive structural properties of the network when it has been modified with the proposed mechanism, and it is elucidated the relationship between these results and the observed synchronization at both the local and global scale. Our main finding is that modularity, a global feature, can naturally emerge in a network when evolving links are considered, that is, by means of dynamical properties at the local scale.

⟶ ∞ ⋄ ∞ ⟵

Dynamics in a social network surrounding an online political protest

Rosa Benito
Universidad Politecnica de Madrid, Spain
rosamaria.benito@upm.es
A. Morales, J.C. Losada

Over the past years, new technologies and specially online social networks have penetrated into world's population at an accelerated pace. In this talk we analyze collected data from the web application Twitter, in order to describe the structure and dynamics of the emergent social networks, based on complexity science. We focused on a Venezuelan protest that took place exclusively by Twitter during December, 2010. We found community structure with highly connected hubs and three different kinds of user behavior that determine the information flow dynamics. We noticed that even though online social networks appear to be a pure social environment, traditional media still holds loads of influence inside the network.

⟶ ∞ ⋄ ∞ ⟵

Emerging meso-and macroscales from synchronization of adaptive networks

Stefano Boccaletti
Center for Biomedical Technology - UPM, Spain
stefano.boccaletti@gmail.com

Most systems analyzed in the past years using complex networks are characterized by the presence of two important topological features: modular structures and scale-free degree distributions. Yet, an open problem is understanding how these characteristics can spontaneously emerge from the dynamics of the elements composing the system, i.e., without an external intervention. In this talk, we consider a set of interacting phase oscillators, in which the coupling between pairs of them varies according to their synchronization level; also, nodes have limited resources, thus restricting their connectivity. We show that such a competitive mechanism leads to the emergence of a rich modular structure underlying cluster synchronization, and to a scale-free distribution for the connection strengths of the units.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Analyzing offline events through the mirror of online social networks

F. Javier Borondo
Universidad Politecnica de Madrid, Spain
fj.borondo@upm.es
A .J. Morales, J.C. Losada, R.M. Benito

Online social networks, are ideal platforms to exchange and propagate information. Due to the rapidly growing number of users, online social networks have become an increasingly important topic in scientific research. Recent studies have focused on determining the structure and dynamics behind these networks and characterizing user behavior. Following this trend we have studied how important events occurring offline are reflected on these online social networks. To this end, we have built the networks corresponding to the interactions taking place among users.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Defibrillation mechanisms on a one-dimensional ring of cardiac tissue

Jean Bragard
university of navarra, Spain
jbragard@unav.es
A. Simic

Defibrillation is a medical treatment used to terminate ventricular fibrillation or pulseless ventricular tachycardia. An electrical device via a pair of electrodes delivers controlled amount of electrical energy to the heart in order to reestablish the normal heart rhythm. First generation of defibrillators applied monophasic shock, in which electrodes did not change polarity during the application of the shock. Later it was found that changing the polarity of the electrodes during the shock leads to better result with less energy applied. Optimal monophasic and biphasic shock release approximately 200 J and 150 J, respectively. It is desirable to use as less energetic shock as possible in order to reduce the damage done to the tissue by the strong electric current. However, to this day, there is no full understanding why biphasic shocks are better than monophasic shocks. To assess this question, we have used a bidomain model for cardiac tissue with modified Beeler-Reuter model for transmembrane currents. Modifications account for anode break phenomena and electroporation effect known to happen during defibrillation. We have studied three different types of protocols for shock application (i.e. monophasic; symmetric biphasic; and asymmetric biphasic shock) in a one dimensional ring of cardiac tissue. The size of the ring was chosen to exhibit a discordant-alternans dynamics. Results of the numerical simulations reveal that monophasic shocks defibrillate with higher rate of success than the two biphasic shock protocols at lower energies. On the contrary for higher shock energies, the biphasic shock are significantly more effecient than monophasic shocks. This latter result confirms the medical common wisdom about defibrillators. Moreover, in this study, we were able to identify and classify the different defibrillation mechanisms that happen in this system. One identifies four different types: direct block, delayed block, annihilation and direct activation. Which defibrillation mechanism prevails depends on the energy level, the current dynamic state of the system and the shock protocol. This study has permitted to uncover and confirm the experimental fact stating that biphasic shocks are more efficient (at high energy) than monophasic shock to defibrillate cardiac tissue.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Some structural properties of multilevel networks

Regino Criado
Universidad Rey Juan Carlos, Spain
regino.criado@urjc.es
Miguel Romance

The concept of multilevel network has been introduced in order to embody some topological properties of heterogeneous -type complex systems which are not completely captured by the classical models. In this talk we will present some metric and structural properties of multilevel networks, a new paradigm for networks with a mesoscaled structure.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Analysis of human behaviors from telephone interactions; serendipity measures

Juan Carloss Losada
Universidad Politecnica de Madrid, Spain
juancarlos.losada@upm.es
F. Borondo, W. Creixell, T. Arredondo

Serendipity is defined as fortunate discoveries made by chance. In this work we explore the idea that topological and dynamical measures of a person's telephone interaction networks could be an indicator about how likely that person is to experience fortunate discoveries. In order to study this phenomenon, a data-set rich in users contextual data was used. We analyse the data obtained in the Reality Mining project at MIT. The data included call logs and nearby Bluetooth devices corresponding to 350000 hours of human behaviour recorded during a nine month period. In that data-set, social network evolution in time can also be observed throughout this period of time.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Influence maximization for advertising in multi-agent markets

Mahsa Maghami
University of Central Florida, USA
mmaghami@cs.ucf.edu

The question of how to influence people in a large social system is a perennial problem in marketing, politics, and publishing. It differs from more personal inter-agent interactions that occur in negotiation and argumentation since network structure and group membership often pay a more significant role than the content of what is being said, making the messenger more important than the message. In this paper, we propose a new method for propagating information through a social system and demonstrate how it can be used to develop a product advertisement strategy in a simulated market. We consider the desire of agents toward purchasing an item as a random variable and solve the influence maximization problem in steady state using an optimization method to assign the advertisement of available products to appropriate messenger agents. Our market simulation accounts for the 1) effects of group membershipon agent attitudes 2) has a network structure that is similar to realistic human systems 3) models inter-product preference correlations that can be learned from market data. The results show that our method is significantly better than network analysis methods based on centrality measures.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Robustness in the urban transportation network of Madrid

Mary Luz Mouronte
Universidad Carlos III de Madrid, Spain
mmouront@it.uc3m.es

Madrid has an urban bus network with 204 lines and 4,455 stops and, a subway network with 16 lines and 272 stops. It has also 21 districts with quite different population densities and an unequally distribution of stops. It is possible to improve these networks identifying their critical points where some planning tasks should be done. This research analyzes the robustness of the urban bus and metro networks in the districts of Madrid. Both networks are abstracted in a graph G= (N; L) where N are the nodes corresponding to the stops and L are the links between them. So, we calculate the distribution of the number of pairs of nodes separated by the shortest distance in the original network and in the same network with the most relevant removed nodes; we also estimate the sensitivity in as Slm = — /N - /N— where is the average path length in the original network, and N' correspond to the values of average path length and size of networks with m removed nodes. We identify the more sensitive districts and those in which the distance distribution changes drastically. The results can help to improve the public transportation network in Madrid.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Controlling structural properties of complex networks: centrality measures

Miguel Romance
Rey Juan Carlos University, Spain
miguel.romance@urjc.es
Vincenzo Nicosia, Vito Latora, Giovanni Russo and Regino Criado

The control of properties of complex networks it is a challenge in the study of complex network analysis. In this talk we will present some results related to controlling spectral centrality measures of weighted and unweigthed networks by giving an analytical solution to the inverse centrality problem in several cases. We will also show how to to modify the centrality scores of the nodes by acting on the structure of a given network. We prove that there exist particular subsets of nodes, called controlling sets, which can assign any prescribed set of centrality values to all the nodes of a graph, by cooperatively tuning the weights of their out-going links. We show that many large networks from the real world have surprisingly small controlling sets, containing even less than 5-10

$\longrightarrow \infty \diamond \infty \longleftarrow$

Dynamic community structures analysis

My Thai
University of Florida, USA
mythai@cise.ufl.edu
T. N. Dinh

Most complex networks exhibit a special property: community structures. Identifying community structures can help deeply understand the structures and functions of a network as well as design a robust system with minimum costs. Unfortunately, understanding this structure is very challenging, especially in dynamic complex networks where nodes and links are evolving rapidly. Can we quickly and efciently identify the network community structure? Can we adaptively update the network structure based on previously known information instead of recomputing from scratch as recomputing from scratch may result in prohibitive computational costs and introduce incorrect evolution phenomena? In this talk, we introduce a general approach to efficiently detect and trace the evolution of communities in an evolving network. Our solution can identify the communities of each network snapshot based on the communities of previous snapshots, thus dynamically updating these communities. We provide a compact network representation that effectively combines the current network structural information with the change of network in next steps. Many existing community detection algorithms can be embedded into our framework to efficiently detect modules and modules' evolution in dynamic complex networks.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Network reconstruction from vectors of features

Massimiliano Zanin
Centre for Biomedical Technology, UPM, Spain
massimiliano.zanin@ctb.upm.es

In the last decade, Complex Networks have proven their potential for the analysis of real world systems. Especially in those cases where information about the relationships between the elements composing the system are not explicitly available, methods for network reconstruction have enabled a better understanding of the underlying structure and dynamics. Yet, most of these techniques only focus on the presence of a *similar* (or correlated) evolution in the dynamics of the composing elements. In this talk, we will explore a new approach for network reconstruction, which allows analyzing sets of *features*, in the search of abnormal relationships between them. Therefore, the focus shifts from *similarities* to *differences*, the natural center of interest in the analysis of data associated to medical and biological systems. The usefulness of this methodology, positioned in the middle of complex systems analysis and data mining, will be proven through several case studies, ranging from the detection of diseases in genetic and metabolic data, up to the identification of the function of unknown genes of plants.

$\longrightarrow \infty \diamond \infty \longleftarrow$