From Theory to Applications of Complex Networked Systems

III International Conference

Net-Works 2010

Zaragoza, June 8-10, 2010

Edited by:

Regino Criado

Luis M. Floría

Jesús Gómez-Gardeñes

Yamir Moreno

Miguel Romance

Conference held in cooperation with

Printed in Spain in June, 2010

Preface

Welcome to Net-Works 2010!

This International Conference on Modelling and Computation on Complex Networks and related topics covers a wide range of backgrounds, including physics, chemistry, biology, engineering and mathematics, focusing on the interdisciplinary research in complex networks. In fact, Net-Works 2010 is a meeting devoted to update the knowledge in Complex Networks from its basic aspects to different applications and related topics in applied mathematics, nonlinear dynamics and statistical physics.

The sessions of this conference will cover topological properties, algorithms and computation tools, models of interactions between complex systems, synchronization and control of complex non-linear systems and related topics.

The **Net-Works 2010** conference also represents an outstanding framework for the interchange of ideas on theoretical and computational tools between scientists and engineers who work on the field of complex networks. This is the real strength of this conference series, supporting the scientific interaction to spur on the rapidly growing field of complex networks. This is the primary scope of the International Conference NET-WORKS, which this year 2010 takes place in Zaragoza, Spain.

This year, we are particularly happy to give young researches the opportunity to present their results. Besides, the conference will pay special attention to the latest applications of complex networks rather than the theoretical aspects. However, we have been careful to preserve the intrinsic rigor of the mathematics in each contribution.

Finally, we would like to express our gratitude to the all the members of University of Zaragoza, University Rey Juan Carlos, BIFI and IUMA who have taken part in the organization of this event, for the extraordinary effort made during the organization; without their help this conference would not have been possible. All those involved in the organization of such an outstanding event are aware of the difficulties to overcome, the moments of excitement and also the moments of discouragement. However, at the end all these efforts have undoubtedly been worth. We sincerely hope that you all enjoy these days in Zaragoza to the utmost.

Welcome to **Net-Works 2010**!

Best regards,

Luis Mario Floría and Regino Criado
Chairmen of **Net-Works 2010**

Acknowledgements

Many thanks to:

- The members of Scientific Committee for their help and their important support. Specially to :
  - A-L. Barabàsi, Notre Dame University, IN (USA)
  - S. Boccaletti, Istituto dei Sistemi Complessi, Florence (Italy)
  - L. Da Fontoura Costa, University of Sao Paulo (Brasil)
  - J. Kurths, Potsdam University, (Potsdam, Germany)
  - V. Latora, Università di Catania, (Italy)
  - J. Marro, University of Granada, (Spain)
  - Y. Moreno, University of Zaragoza (Spain)
  - E. Schöell, Technische Universität Berlin (Germany)

  We must note here that is a great honour for us that the above leaders on Complex Networks have accepted to participate Scientific Committee of **NET-WORKS 2010**.
- The invited speakers for their acceptance to give keynote lectures on the scope of the conference.
- The anonymous referees, as well as various special session organizers and assistants, who have contributed to the success of this conference, earning the gratitude of all participants.
- The Organising Committee for all the efforts.

We also take this opportunity to thank all members of University of Zaragoza and University Rey Juan Carlos with whom we have shared many efforts and interactions to organize the multiple aspects related with the organization of this conference.

Specially to:

- The Vice-Chancellor of Rey Juan Carlos University José Manuel Azcona, for his help and important support.
- The academic and the board team of the Institute for Biocomputation and Physics of Complex Networks (BIFI) of the University of Zaragoza. Actually, this conference wouldn't have been the same without their help and support.
- Prof. Yamir Moreno, for great efforts for the success of the organization of NET-WORKS 2010 and the help in the construction of the web page.

This Conference has been supported and financed by the BIFI (University of Zaragoza) and the University Rey Juan Carlos, and sponsored by IUMA (Instituto Universitario de Matemáticas de Aragón).

Contents

Time Schedule

09:00–09:40 **Registration**

09:40–10:00 **Opening Ceremony**

10:00–11:00 **A. Arenas**, Universitat Rovira i Virgili, Tarragona (Spain)
Optimal map of the modular structure of complex networks

11:00–11:30 **Coffee break**

11:30–11:50 **J.M. Buldú**, Universidad Rey Juan Carlos, Madrid (Spain)
Analysis of brain functional impairments

11:50–12:10 **J. Borge-Holthoefer**, Universitat Rovira i Virgili, Tarragona (Spain)
Navigation and Cognition in Semantic Networks

12:10–12:30 **I. Sendiña-Nadal**, Universidad Rey Juan Carlos, Madrid (Spain)
Dynamical overlap of protein interaction networks: A method to predict protein functions

12:30–12:45 **Short break**

12:45–13:05 **L. Prignano**, Universitat de Barcelona, Barcelona (Spain)
Dynamical patterns in networks of non-identical Kuramoto oscillators

13:05–13:25 **J.A. Almendral**, Universidad Rey Juan Carlos, Madrid (Spain)
The dynamics of overlapping structures in modular networks

13:25–13:45 **P. Erola**, Universitat Rovira i Virgili, Tarragona (Spain)
Structural navigability on complex networks

Lunch Break (13:45–15:30)

15:30–16:30 **S.N. Dorogovtsev**, Universidade de Aveiro (Portugal)
Percolation on correlated networks

16:30–17:40 **Posters & Coffee Session**

17:40–18:00 **R.M. Benito**, Universidad Politécnica de Madrid (Spain)
Optical Communication Networks

18:00–18:20 **A. Sánchez**, Universidad Rey Juan Carlos, Madrid (Spain)
An Algorithm to Compute Interest Points in Images based on Geometrical Complex Networks

18:20–18:40 **A. Hackett**, University of Limerick (Ireland)
Percolation in a class of clustered random networks

09:00–10:00 **F. Pedroche**, Universidad Politécnica de Valencia, Valencia (Spain)
Modelling social networks sites with PageRank and social competences

10:00–10:20 **V. Nicosia**, Università di Catania (Italy)
Competitive co-evolution of species in complex networks

10:20–10:40 **D. Aguilar**, Universidad de Sevilla (Spain)
Determining evolutionary dynamics in complex networks using genetic algorithms

10:40–11:00 **C. Gracia-Lázaro**, Universidad de Zaragoza
Axelrod-Schelling: A vectorial model for segregation and difusion of culture

11:40–11:30 **Coffe break**

11:30–11:50 **L. Lacasa**, Instituto de Física Interdisciplinar y Sistemas Complejos, Palma de Mallorca (Spain)
The Horizontal Visibility graphs discriminate randomness from chaos

11:50–12:10 **G. Vidal**, Universidad de Navarra
Hash-Function based on chaos

12:10–12:30 **M. Zanin**, INNAXIS Foundation & Research Institute, Madrid (Spain)
Uncertainty in Complex Networks

12:30–12:45 **Short break**

12:45–13:05 **A. Díaz-Guilera**, Universitat de Barcelona, Barcelona (Spain)
Synchronization of networks of mobile oscillators

13:05–13:25 **Z.K. Zhang**, University of Freiburg (Switzeland)
Hybrid Recommendation Algorithm Based on Two Roles of Social Tags

13:25–13:45 **J.L.García-Domingo**, Universitat de Vic (Spain)
Pair approximation for spatial forest dynamics with height structure

Lunch Break (13:45–15:30)

15:30–16:30 **M. Kaiser**, Newcastle University & Seoul National University (UK and South Corea)
Understanding the connectome: Topological, spatial and dynamic features of brain network

16:30–17:00 **Coffee Break**

17:00–17:20 **F. De Vico Fallani**, University of Rome "Sapienza" (Italy)
The graph theoretical approach in brain functional networks

17:20–17:40 **P. Gleiser**, Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina)
An adaptive complex network model for brain functional networks

17:40–18:00 **C. Granell**, Universitat Rovira i Virgili, Tarragona (Spain)
Data clustering using community detection algorithms

18:00–18:20 **M.L. Mouronte**, Telefónica I+D & Universidad Carlos III, Madrid (Spain)
A model for the dynamic behaviour in large organisations

18:20–21:00 **Social Event & Buffet Dinner**

09:00–10:00 **M. Nekovee**, British Telecom Research & University College London (UK)
Coupled wireless communication and transportation networks

10:00–10:20 **S. Gómez**, Universitat Rovira i Virgili, Tarragona (Spain)
Epidemic-aware dynamics in complex networks

10:20–10:40 **S. Melnik**, University of Limerick (Ireland)
The Unreasonable Effectiveness of Tree-Based Theory for Networks with Clustering

10:40–11:00 **J. Serrà**, Universitat Pompeu Fabra, Barcelona (Spain)
Cover song networks: analysis and accuracy increase

11:40–11:30 **Coffe break**

11:30–13:00 **L. Chua**, University of California, Berkeley (USA)
Memristor Minds: Remembrance of things past

13:00–13:15 **Closure Ceremony**

Abstracts of the Talks

Optimal map of the modular structure of complex networks

Alex Arenas
Departament d'Enginyeria Informàtica i Matematiques, Universitat Rovira i Virgili, Tarragona (Spain)

Many real complex networks display well-defined modular structure. This work provides novel tools to scrutinize the modular structure of complex networks, based on the Singular Value Decomposition (SVD) of the matrix that completely characterizes the network's topological mesoscale, the contribution matrix. Truncation of SVD (TSVD) provides an optimal 2D projection.

Analysis of brain functional impairments

J.M. Buldú, R. Bajo, F. Maestu, N. Castellanos, I. Leyva, I. SendiñaNadal, J.A. Almendral, S. Boccaletti, and F. del Pozo

One of the promising challenges of the application of graph theoretical analysis is the identification of the signatures of different brain diseases. In the current work, we investigate the functional connectivity of the brain (cortical) activity in patients suffering from Mild Cognitive Impairment (MCI). We performed magnetoencephalograms (MEG) to a group of 19 MCIs patients and 19 control subjects during a memory task. By means of the synchronization likelihood (SL) we quantify the correlation between the 148 channels of a MEG record and we obtain a probability matrix of the connections between cortical areas. Next, we apply complex networks analysis in order to understand the structure of the functional networks of both groups (MCI and control). From the macroscopic point of view, we observe a significant increase of the strength of the intra/inter lobe connections, together with a long range biased increase of the outreach in the MCI networks. This fact indicates that, during a memory task, MCI patients require a higher cost (related to a higher synchronized activity) in order to obtain similar cognitive performance. In addition, MCI networks show topological properties closer to random networks. A statistical analysis of the topological network parameters shows that they can be used as a metric to distinguish between MCI and healthy individuals.

Keywords: brain, functional networks, mild cognitive impairment

Navigation and Cognition in Semantic Networks

J. Borge-Holthoefer and A. Arenas

Semantic memory is the cognitive system devoted to storage and retrieval of conceptual knowledge. Empirical data indicate that semantic memory is organized in a network structure. Everyday experience shows that word search and retrieval processes emerge providing fluent and coherent speech, i.e. are efficient and robust. Nonetheless, links between pairs of words in semantic memory encode a rich variety of relationships, and not merely semantic closeness. To extract this semantic closeness, we schematize a process based on uncorrelated random walks from node to node, which converge to a feature vectors network. This mechanism forces the emergence of semantic similarity. Interestingly, the robustness of the original structure is much lower than that of the product of the dynamics upon it. We define this problem in the framework of percolation theory and relate it to actual semantic memory impairment in aging and disease.

Keywords: information retrieval; complex networks; percolation; semantic impairment

Dynamical overlap of protein interaction networks: A method to predict protein functions

I. Sendiña-Nadal, Y. Ofran, J.A. Almendral, D. Li, I. Leyva, J.M. Buldú, S. Havlin, S. Boccaletti

The latest advances in the field of genoma sequencing technologies have tremendously increase the number of known proteins. The challenge is now how to characterize those proteins and elucidate their function within the different biological processes. One recent approach to assign a function to one protein is by means of the network of its interactions with other proteins [Sharan07]. Novel high-throughput techniques for protein-protein interaction measurements have let to obtain those networks of protein interaction from different organisms [Aebersold03, Field05]. Using this network representation, proteins as nodes and detected physical interactions among them as links, it is possible to apply the tools from complex networks theory to predict and annotate a function to a given protein.

While most of the works on functional annotation of proteins via their network of interactions are exclusively based in topological measurements from the properties of the PIN, we propose the application of an algorithm based on the synchronization behavior emerging from a modular network organization. The method relies on how phase oscillators organize in a network structure of dynamical interactions, and on a recently proposed technique for the identifaction of synchronization interfaces and overlapping communities [Li08] in ensembles of networking dynamical systems. The combination of the synchronization behavior of the PIN structure and an initial modular classification of proteins drawn from a manual assignment available from a ten years old database from the Munich information Center for Protein Sequences (MIPS) allows for protein function predictions that is in genuine agreement with more recent and better refined manual assignments obtained from Gene Ontology database.

Keywords: complex systems, protein interaction networks, community, overlapping

Dynamical patterns in networks of non-identical Kuramoto oscillators

A. Díaz-Guilera and L. Prignano

We analyze populations of Kuramoto almost identical oscillators with a fixed coupling strength and a given frequency distribution. We find out some interesting connections between the dynamical behavior and both local and global topological properties, looking respectively at the transition point from the synchronized to the incoherent state and just above it.

The dynamics of overlapping structures in modular networks

J.A. Almendral, I. Leyva, D. Li, I. Sendiña–Nadal, J.M. Buldú, S. Havlin and S. Boccaletti

Modularity is a fundamental feature of real networks, being intimately bounded to their functionality, i.e. to their capability of performing parallel tasks in a coordinated way. Although the modular structure of real graphs has been intensively studied, very little is known on the interactions between functional modules of a graph. Here we present a general method based on synchronization of networking oscillators, that is able to detect overlapping structures in multi-modular environments. We furthermore report the full analytical and theoretical description on the relationship between the overlapping dynamics and the underlying network topology. The method is illustrated by means of a series of applications.

Keywords: complex networks, community, overlapping

Structural navigability on complex networks

P. Erola, S. Gómez, A. Arenas

The famous Milgram's small-world experiment revealed that there is something special in the structure of natural and man-made complex systems [2]: without a global view of the network, a message can be routed effciently between any pair of nodes. Our initial hypothesis is that the community structure, that proves meaningful insights on the structure and function of complex networks, is an important actor in these routing properties. To exploit the modular structure in networks we need to analyze the contribution of each node to the modules. Unfortunately, this analysis involves a huge amount of data. To reduce this problem we propose to build a map using the linear projection theory [1] as a basis of a guided routing. First we project the matrix of contributions of each node of a given network to its modules in a plane using the Truncated Singular Value Decomposition. This two- dimensional plane reveals the structure of modules and their boundaries and we will use it as the map for navigating through the network. Considering that each node only has knowledge about their neighbors, we define a simple greedy routing algorithm to guide the communication among them. We apply our framework to the Internet Autonomous Systems (ASs) network achieving, in high percentage, close to optimal paths.

Keywords: Game theory, evolution, social systems.

[1] Optimal map of the modular structure of complex networks, A. Arenas, J. Borge-Holthoefer, S. Gomez and G. Zamora-Lopez, New Journal of Physics (2010)

[2] Navigation in a small world, J. M. Kleinberg, Nature 406, 845 (2000)

Percolation on correlated networks

S.N. Dorogovtsev
Universidade de Aveiro (Portugal)

I will present the problem of percolation on an equilibrium random network with degree-degree correlations between nearest-neighboring vertices focusing on critical singularities at a percolation threshold. I will show how to obtain criteria for degree-degree correlations to be irrelevant for critical singularities. Also present examples of networks in which assortative and disassortative mixing leads to unusual percolation properties and new critical exponents.

Optical communication networks

R.M. Benito J.P.. Cárdenas, J.C. Losada, A. Santiago and M.L. Mouronte

Today, Synchronous Digital Hierarchy (SDH) and its North American equivalent SONET, are the standard technology for information transmission in broadband optical networks. Both systems are multiplexing protocols closely related for transferring multiple digital bit streams over the same optical fiber. Unlike systems with unplanned growth, such as those of natural origin or the Internet network, these telecommunication networks are strictly planned as rings, meshes, stars or tree-branches structures designed to connect different equipments. In spite of that, we have found that the SDH network operated by Telefónica in Spain shares remarkable topological properties with other real complex networks as a product of its evolution since 1992. In particular, we have found powerlaw scaling in the degree distribution ($N \cdot P(k) = k^{-\gamma}$) and small-world networks properties.

The complexity found in the Spanish SDH system obeys to a mixture of planning and unpredictable events that can be incorporated into a model. In this work we propose two network models with the aim to reproduce the complexity observed in the telecommunication network from two points of view. The first model (ad hoc model [1]) considers real planning directives and take into account geographical and technological variables with the aim to predict the network growth. The other one, the Compatibility Attachment Model (CAM) [2], is a simplistic model based on a rule called compatibility that measure the affinity among SDH equipments. Both models can reproduce the topology of SDH systems.

The fact that the ad hoc model reproduces the empirically observed properties of the real SDH networks evidences the possibility to generate an algorithm that captures the events associated to the network evolution and predicts the future topology of the system. However, all these events can be incorporated into the compatibility rule in a simplistic approach behind the CAM algorithm.

[1] J.P. Cárdenas, M.L. Mouronte, R.M. Benito and J.C. Losada: Compatibility as Underlying Mechanism Behind the Evolution of Networks, Physica A, 389 (8), 2010.

[2] A. Santiago, J.P. Cárdenas, M.L. Mouronte, V. Feliu and R.M. Benito: Modeling the topology of a SDH networks, Int. J. Modern Physics C, 19, 12. 2008.

An Algorithm to Compute Interest Points in Images based on Geometrical Complex Networks

R. Criado, M. Romance and A. Sánchez

Feature detection is an essential component of many Computer Vision areas [2]. Some of the most basic features that someone can detect in an image are some specific locations of points like corners. Interest points are a set of pixels in an image which are characterized by a mathematically well-founded definition [3]. These keypoints present some interesting properties [4]: in particular, they have a clearly defined position in the image space, they are rich in terms of information content, and are also stable on local and global changes in the image domain. These point variations are mainly due to image perspective transformations (i.e. scale changes, image rotations or translations) or on illumination changes. Interest points are commonly used as local features in many image applications like content-based image retrieval or object recognition. In particular, the corresponding feature points in overlapping images can be matched among them using stereo vision techniques for 3D image reconstruction. Moreover, these feature points can also be good indicators of object boundaries and occlusion events in image sequences.

The purpose of this work is to introduce a novel approach of computing the interest points of an image by using complex network analysis. We associate a weighted geometrical and fast-computable complex network to each image that gives some valuable information about the location of the interest points and we can rank the regions of an image according to its interest in the whole image. The use of complex networks with a spatial structure are usual in several real-world applications [1], but this work present a new use in the realms of Computer Vision. Since the classical mathematical definition of the interest points are mainly of local nature, we use local measures of the associated network and we discuss the use of other tools and properties of the weighted geometrical network.

Keywords: Interest points, computer vision, geometrical complex networks

[1] Boccaletti S., Latora V., Moreno Y., Chavez M. and Hwang D. U. "Complex Networks: Structure and dynamics", *Physics Reports* **424**, pp. 175–308, 2006.

[2] D.A. Forsyth and J. Ponce, Computer Vision: A Modern Approach, Prentice-Hall, 2003.

[3] D. Lowe, "Distinctive Image features from Scale-Invariant Keypoints", *International Journal of Computer Vision* **60(2)**, pp. 91–110, 2004.

[4] K. Mikolajczyk and C. Schmid, "Scale and affine invariant interest point detectors", *International Journal of Computer Vision* **60(1)**, pp. 63–86, 2004.

Percolation in a class of clustered random networks

A. Hackett, J.P. Gleeson and S. Melnik

n [1] a model was introduced for the creation of a class of random networks with nonzero clustering. Within this model the degree distribution and clustering spectrum of a network are prescribed, and as such can be fitted to given real-world data. Here we present analytical results for site and bond percolation in these networks. Theoretical predictions for the location of the percolation threshold and the size of the giant connected component are shown to match well with numerical simulations on both real and synthetic networks. We also demonstrate why our approach may be seen as complimentary to Newman's recently proposed model of random graphs with clustering [2].

[1] Gleeson, J. P., Bond percolation on a class of clustered random networks. Phys. Rev. E 80, 036107, (2009).

[2] Newman, M. E. J., Random Graphs with Clustering. Phys. Rev. Lett. 103, 058701, (2009).

Modelling Social Network Sites with PageRank and Social Competences

Francisco Pedroche
Universitat Politècnica de Valencia, Spain

In this lecture we review some characteristics of the Social Network Sites (SNSs) and some new concepts are presented. A new method to classify the users of an SNS into Competitivity groups is shown. The method is based on the PageRank algorithm. Competitivity groups are sets of nodes that compete among each other to gain PageRank via the personalization vector. Specific features of the SNSs (such as number of friends or activity of the users) can be considered as Social Competences . By means of these Social Competences a node can modify its ranking inside a Competitivity group. Some numerical examples are shown.

Keywords: Google matrix, PageRank, SNS, link analysis

Competitive co-evolution of species in complex networks

V. Nicosia, V. Latora and F. Bagnoli

We consider an evolutionary model in which individuals of various species move over a complex network, and are subject to reproduction and selection at the nodes of the network. We propose a simple mean field approximation of the process and we study how the underlying graph structure does impact on the evolution of species. In particular, we observe that the network topology heavily affects the stability of fixed points of the dynamical process, so that it is possible to predict the final overall distribution of species by knowing the diffusion rate of individuals, , the strength of the selection process and the ensamble to which the underlying network belongs. The proposed evolutionary model can be useful to study the influence of the network structure on opinion formation, languages selection, biotypes evolution and many other dynamical systems which are based on diffusion and competitive interaction among individuals.

Determining evolutionary dynamics in complex networks using genetic algorithms

D. Aguilar, A. Córdoba and M.C. Lemos

Gene regulatory networks are one of the most important goals in the novel discipline of system biology. These regulatory networks, through the interaction of multiple genes, control and guide the proteic interactions and, in fact, the cellular behaviour. Understanding this regulation is, therefore, essential in the investigation in organogenesis, during the embryonic stages of the organisms, and in the research of genetic diseases. The whole set of simple genetic interactions inside the network converges in complex behaviours, so it is imperative to analyse the problem in the field of network theory and the evolutionary dynamic of complex systems.

All this has led us to investigate the evolutionary dynamics in generic networks, this way, the results can be used in experimental researches in the field of system biology. This research aims to decode the evolutionary rules governing the transformation dynamics in a network. To do this, a genetic algorithm has been implemented, in which, starting from initial and ending network stages, it is possible to determine the transformation dynamics between these stages by using simple acting rules. The network description is the following: a) The network nodes states in the initial and ending stages can be active or inactive; b) The network links can act as activators or repressors; c) An evolutionary set of rules is established in order to transform the initial stage into the ending one; d) Due to the low connectivity in gene regulatory networks, each node will hold a maximum of three inputs with no restriction on outputs. The "chromosomes" of the genetic algorithm includes two parts, one related to the nodes links and another related to the evolutionary rules.

The implemented evolutionary rules are based in certain genetic interactions behaviour. This set of rules includes the following: 1) Rule of Most: If the target node inputs consist on activators and represors, the node final state is determined by the action of most. 2) Absolute repressor rule: In this case, just one repressor is enough to inhibit the target and deactivate the node. 3) Logic gate AND with activators: The target node will be active only if the input consists on, at least, two activator links. 4) Logic gate AND with repressors: The target node will be inactive only if the input consists on, at least, two repressor links. These rules and their combinations are compound by logic conditions and set the bases to the network motifs formation, which are the building blocks of the network dynamics.

The implemented algorithm results discovered satisfactorily appropriate dynamics in complex networks evolution between different stages for several cases.

Axelrod-Schelling: A vectorial model for segregation and difusion of culture

Y. Moreno, L.M. Floría, C. Gracia-Lázaro

We have modified Axelrod's model for cultural dissemination by introducing a density of empty sites and a probability that agents can move into them, according to their neighborhood dissimilarity and an intolerance parameter. This mobility enhances the cultural convergence; However, when density of empty sites is high enough to enable the formation of cultural clusters, a new multicultural fragmented phase appears for low values of initial cultural diversity. While for medium values of diversity the global cultural state reappears, for even higher values new erosion-adhesion phenomena arise in cultural domains. Further works along this line include the influence of the degree of tolerance of the dominant culture as well as the emergence of ethnic segregation.

Keywords: complex systems, sociophysics, segregation

Horizontal Visibility graphs discriminate randomness from chaos

L. Lacasa, R. Toral

Nonlinear time series analysis is an active field of research that studies the structure of complex signals, in order to derive information of the process that generated those series, for understanding, modeling and forecasting purposes. In the last years, some methods mapping time series to network representations have been proposed, in order to investigate on the properties of the series through graph theoretical tools recently developed in the core of the celebrated complex network theory. Among some other methods the so called visibility algorithm has received much attention, since it has been shown that series correlations are captured by the algorithm and translated in the associated graph, opening the possibility of building fruitful connections between time series analysis, nonlinear dynamics, and graph theory. Here we show that the horizontal visibility algorithm is able to distinguish between correlated stochastic, uncorrelated and chaotic processes just by calculating a single parameter λ in the associated graphs. We show that in every case the series map into an exponential degree distribution $P(k) \sim \exp(\lambda k)$, where the value of λ fully characterizes the process. The frontier between chaotic and correlated stochastic processes can be calculated exactly, and some other analytical developments confirm the results provided by extensive numerical simulations and real data.

Keywords: time series, complex networks, chaos

Hash-Function based on chaos

G. Vidal and H. Mancini

Many algorithms have been implemented in order to check errors or to avoid possible attacks during digital communications. Codes such as MD5, SHA-1, SHA-2, are a few examples used actually. Although all of them provide good security, permanent development to powerful computers transform these methods in obsoletes. We present a cipher method based on a chaotic dynamical system that can be used as a digital signature, time mark or error checking method. We show that, if the plaintext is larger enough, Shannon's optimum for secrecy could be achieved. A Whitening signal method and the properties of the dynamic system are the keys used to get this objective.

Keywords: Cryptography, Chaos, Hash Function

Uncertainty in Complex Networks

M. Zanin

Complex networks have been a valuable tool to analyze complex systems, and to understand their structure and inner dynamics. They are usually considered as deterministic; the existence of a link is an initial information, or is defined by the evolution of some dynamics: but this information is always known at the time of analyze the graph. In this work, we introduce a new approach to define complex networks which includes uncertainty inside the adjacency matrix.

Synchronization of networks of mobile oscillators

A. Díaz-Guilera, N. Fujiwara, J. Kurths

Synchronization is one of the paradigmatic examples of emergence of collective behaviors in populations of oscillating units, depending not only on the type of individual dynamics but on the pattern of interactions. In nature there are many examples of synchronization where the connections between the units are not fixed in time. Here we present a model of synchronization of oscillators that move on a 2-d plane interacting only with other oscillators that are within a finite range. This makes that the network of interactions changes in time. We show that there exists an optimal regime where both fast synchronization and high efficiency are achieved. We propose an analytical framework based on the set of linearized equations with time dependent interactions that can be applied to any type of agent motion and oscillator dynamics. This approach enables to estimate the asymptotic behaviors of the system.

Keywords: synchronization, complex networks

Hybrid Recommendation Algorithm Based on Two Roles of Social Tags

Zi-Ke Zhang and Chuang Liu

The past few years have witnessed the great success of a new family of paradigms, social tagging networks, which allows users to freely associate social tags to items and efficiently manage them. Thus it provides us a promising way to effectively find useful and interesting information. In this paper, we considers two typical roles of social tags: (i) an accessorial tool helping users organize items; (ii) a bridge that connects users and items. We then propose a hybrid algorithm to integrate the two different roles to obtain better recommendation performance. Experimental results on a real-world data set, *Del.icio.us*, shows that it can significantly enhance both the algorithmic accuracy and diversity.

Keywords: Personalized recommendation, social tagging networks

Pair approximation for spatial forest dynamics with height structure

J.L. Garcia-Domingo, J. Saldaña

WWe present an analytical model based on the pair approximation for spatial forest dynamics defined on a regular lattice. The model assumes three possible states for a lattice site: empty (gap site), occupied by an immature tree, and occupied by a mature tree, and considers three nonlinearities in the dynamics associated to the processes of light interference, gap expansion, and recruitment. We obtain an expression of the basic reproduction number R_0 which, in contrast to the one obtained under the mean-field approach, uses information about the spatial arrangement of individuals close to extinction. Moreover, we analyze the corresponding survival-extinction transition of the forest and the spatial correlations among gaps, immature and mature trees close to this critical point. Predictions of the pair approximation model are compared with those of a cellular automaton.

Keywords: pair approximation, spatial forest dynamics, light interference, cellular automaton.

Understanding the Connectome: Topological, spatial, and dynamic features of brain network

Marcus Kaiser
Institute of Neuroscience, Newcastle University (UK) and Department of Brain and Cognitive Sciences, Seoul National University

The human brain consists of connections between neurons at the local level and of connections between brain regions at the global level. The study of the entire network, the connectome, has become a recent focus in neuroscience research. Using routines from physics and the social sciences, neuronal networks were found to show properties of scale-free networks, making them robust towards random damage, and of small-world systems leading to better information integration. I will describe the main features of the topological and spatial organisation of neural systems and how they differ from artificial systems information processing systems such as computers. Recent clinical studies in the last three years have shown that the network features of the healthy brain differ from that of schizophrenia, epilepsy, and Alzheimer's disease patients. These features even differ depending on cognitive features such as IQ. I will show how network features and simulations of brain activity can be used to assess and model changes in patients. For example, simulating the spreading dynamics of epileptic seizures can inform of underlying reasons for epilepsy. We are also testing different strategies for slowing down spreading in complex networks. I will finally outline how these feature extractions and models can be applied to clinical problems in neural and other biological networks.

The graph theoretical approach in brain functional networks

D. De Vico Fallani, L. Astolfi, F. Cincotti, D. Mattia, G. Vecchiato, J. Toppi, C. Di Lanzo, S. Salinari, F. Babiloni

Although it can be thought that mathematics could not be the proper tool for a full comprehension of the brain functions, often this is not the case. In the last ten years, many different brain-imaging devices have conveyed a lot of information about the brain functioning in different experimental conditions. In every case, biomedical engineers, physicists, mathematicians, and physicians are called to elaborate the signals related to the brain activity in order to extract meaningful and robust information to correlate with the external behavior of people. In such attempt, different signal processing tools used in telecommunications and other field of engineering or even social sciences have been adapted and re-used in the neuroscience field [1,2,3].
In the present contribution, we show how functional connectivity networks, estimated from high-resolution EEG signals, could be analyzed by means of a graph theoretical approach. In particular, we briefly discuss the theoretical aspects of this methodology and we present some practical examples in the case of motor and cognitive tasks in healthy subjects and clinical patients. The general outcome indicates that the performance of cognitive and motor tasks as well as the presence of neural diseases affects significantly the topological structure of the communication within the brain. In particular, the observed structural changes depend critically on the dynamic binding of different cortical areas, which can modulate their interaction according to the specific task [4].
The evaluation of different network properties, like degree, efficiency, clusters, motifs as well as the presence of multiple pathways, gives the power to quantify the communication within the brain, and to classify different cerebral "states" or "traits".

This study was performed with the support of the COST EU project NEUROMATH (BM 0601).

Keywords: Brain functional networks, Graph theory, EEG

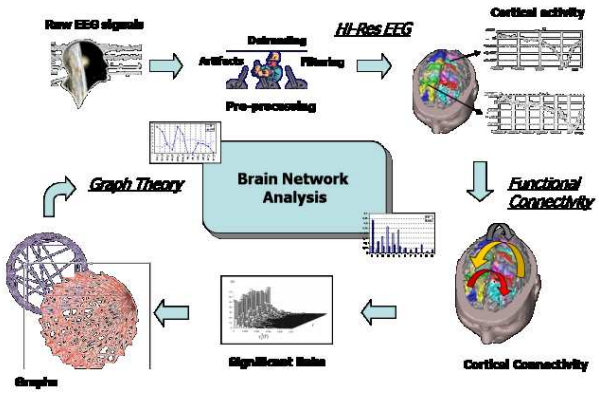

Figure 1. Brain functional network from EEG signals

[1] A. Gevins, P. Brickett, B. Reutter, J. Desmond, *Brain Topography* **4**, 125 (1991).

[2] L.A. Baccalà, K. Sameshima, *Biological Cybernetics* **84**, 463 (2001).

[3] C.J. Stam and J.C. Reijneveld, *Nonlinear Biomed. Phys.* **1**, 3 (2007).

[4] F. De Vico Fallani and F. Babiloni, *Morgan and Claypool, Paperback* **ISBN 1608454495**, (2010).

An adaptive complex network model for brain functional networks

P. Gleiser

I will present a growing network model, with dynamical nodes and adaptive links, that allows for the emergence of complex networks with characteristics similar to those observed in functional brain networks. In these networks the vertices represent different anatomical regions and the links their functional connectivity. First, I will show how these networks can be built using data obtained with functional magnetic resonance imaging. Then, I will analyze the main characteristics, such as degree distribution, the presence of modules and hierarchical structure. Finally, I will describe in detail the model and discuss the relation between the synchronization properties and the underlying emerging network structure.

Data clustering using community detection algorithms

C. Granell, S. Gómez and A. Arenas

One of the most important problems in science is that of inferring knowledge from data. The most challenging issue is the unsupervised classification of patterns (observations, measurements, or feature vectors) into groups (clusters) according to their similarity. The quantification of similarity is usually performed in terms of distances or correlations between pairs. The resulting similarity matrix is a weighted complete graph. In this work we investigate the adaptation and performance of modularity-based algorithms to analyze the structure of the similarity matrix. Modularity is a quality function that allows comparing different partitions of a given graph, rewarding those partitions that are more internally cohesive than externally. In our problem cohesiveness is the representation of the similarity between members of the same group. The modularity criterion, however, has a drawback, the impossibility to find clusters below a certain size, known as the resolution limit, which depends on the topology of the graph. This is overcome by applying multi-resolution analysis. Using the multi-resolution approach for modularity-based algorithms we automatically classify typical benchmarks of unsupervised clustering with considerable success. These results open the door to the applicability of community detection algorithms in complex networks to the classification of real data sets.

Keywords: Community structure, clustering, similarity matrix.

A model for the dynamic behaviour in large organisations

M.L. Mouronte, L.G. Moyano, J.P. Cárdenas, J. Salcedo and R.M. Benito

Complex networks of a technological nature are of paramount importance in modern life, having as direct impact on our daily lives. The major role of technological networks have lead to rising questions on how their complexity affects their most vital properties, such as their reliability, stability or security [1, 2, 3]. In many cases, the large amount of components and their intricate interrelationship can lead to global behaviour which was not planned nor expected.

One of the most interesting questions regarding this networks asks how complex network structure affects the dynamics that may take place within [1]. Important steps forward have been made, for example, in epidemiologic spreading in social networks [4], in metabolic pathways networks [5], as well as in several other cases. One example of such networks are the highly interconnected systems that provide support to operations and business in large organisations, such as companies or corporations[6,7]. Known as Operational Support Systems (OSS) and Business Support Systems (BSS), these networked systems sustent most activities in large organisations. OSS and BSS networks support processes, which in this context can be interpreted as an information flow which is processed by systems, and that is transferred from system to system through interfaces, in a sequential way. On the other hand, a particular system is usually part of many different processes, so there are interactions between processes.

We present a simple model of fixed-path dynamical processes in a network. Our model encodes two-party negotiation through zero-sum games between interacting nodes. Our simulations show interesting results, in particular, we have explored part of the parameter space and described how the efficiency E of the network, (i.e., the normalised average number of steps for a process to finish), depends on the load a the processes represent on any node. Moreover, we have shown that the ratio NR/N presents a pseudo-bifurcation when considered as a function of the density . Curiously enough, this result mimics the behaviour of a simple nonlinear dynamical system, where bifurcations in the atractor diagram can be found as the result of a change in the stability of solutions with different periods. On the other hand, this result could be of interest for very practical reasons, since represents a very clear example of an emergent, unexpected behavior. Moreover, our model has the simplicity and flexibility to depict many other interesting situations as well which are presently under study, e.g., unbalanced payoff matrices, non-zero-sum node interactions, heterogeneous process lenghts, individual load and load thresholds, more general (e.g., evolutionary) next-state rules and strategies, among others. Finally, another important work in progress is the comparison of the present results with other network topologies, in particular to scale-free networks, for the determination of the effect of topology on the dynamical properties of fixed-path network processes.

[1] S. Boccaletti et al, Physics Reports, 424 (2006) 175.

[2] B.A. Carreras et al, in Proc. of Hawaii Int. Conf. on Sys. Sci., Hawaii (2000); M.L. Sachtjen et al, Phys. Rev. E 61 (2000)4877

[3] J.P. Cárdenas et al, Compatibility as underlying mechanism behind the evolution of networks, Physica A, Elsevier (2010)

[4] R. Pastor-Satorras and A. Vespignani, Phys. Rev. E 63 (2001) 066117

[5] J. Stelling et al, Nature 420 (2002) 190; A.E. Motter, Phys. Rev. Lett. 93 (2004) 098701

[6] M.L. Mouronte, et al,"Modification propagation in complex networks", "Complex Sciences", Part 1, Serie "Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering", Vol. 4, Springer, (2009)

[7] M.L. Mouronte, et al, Global Behaviour of Fixed-Pathways Dynamics in Technological Networks, IEEE-Xplore, Digital Object Identifier: 10.1109/COMPENG.2010.32 (2010), Page(s): 97 - 99

Coupled Wireless Communication and Transportation Networks

Maziar Nekovee
British Telecom Research and University College London, UK

Vehicular communications networks (VCNs) are created by vehicles equipped with short and medium range wireless communication technology. They include vehicular ad-hoc networks, vehicle-to-vehicle and vehicle-to-infrastructure communications. There is a growing interest in these networks from governments, industry and the research community. Automobile manufacturers are currently prototyping vehicles equipped with Wi-Fi and governments have recently allocated radio spectrum for vehicular communications. In this talk I will discuss the unique features and challenges that characterise these highly dynamic networks, and explore their role in future intelligent transport systems, where cooperative driving between cars enabled by wireless communication results in improved safety, smoothing of traffic flow and reduced Co2 emission. I will review our research on modelling and simulations of dynamics of coupled wireless communication and transportation networks, including wireless computer worm dynamics, reliable information dissemination, time synchronisation and traffic congestion reduction.

Epidemic-aware dynamics in complex networks

A. Arenas, J. Borge-Holthoefer, S. Gómez, S. Meloni and Y. Moreno

The problem of modeling how diseases spread among individuals has been intensively studied for many years. The development of mathematical models to guide our understanding of the disease dynamics has allowed addressing important issues such as immunization and vaccination policies. The discovery of the important role played by the complex connectivity structure between individuals has lead to an increasing interest in the analysis of epidemic spreading in complex networks.

In all the standard models of epidemic spreading, it is implicitly supposed that individuals do not change their behavior, even when an epidemic outbreak has appeared in the network. This is not realistic, since people try to avoid exposition to the disease if possible.

Within the framework of reaction-diffusion models of epidemic spreading, we introduce two main alternatives to account for epidemic-aware behaviors: cancellation of trips, and change of destinations. We show how these epidemic-aware dynamics modify the characteristics of epidemic outbreaks in complex networks.

Keywords: Epidemic spreading, complex networks, reaction-diffusion, epidemic threshold

The Unreasonable Effectiveness of Tree-Based Theory for Networks with Clustering

S. Melnik, A. Hackett1, M.A. Porter, P.J. Mucha and J.P. Gleeson

Analytical results for complex networks are rather rare, especially if one wants to study a dynamical system on a network topology that attempts to incorporate even minimal features of real-world networks. Furthermore, most analyses assume that the network under study has a locally tree-like structure, so that it can only possess very few small cycles (or loops), whereas most real networks have significant clustering (and, in particular, possess numerous small cycles). Most existing theoretical results for (unweighted) networks are derived for an ensemble of networks using (i) only their degree distribution p_k, which gives the probability that a random node has degree k (i.e., it has exactly k neighbors) or using (ii) their degree distribution and their degree-degree correlations, which are defined by the joint degree distribution $P(k, k')$ describing the probability that a random edge joins nodes of degree k and k'. We refer to case (i) as "p_k- theory" (the associated random graph ensemble is known as the "configuration model") and to case (ii) as "$P(k, k')$-theory". The clustering in sample networks is low in both situations; it typically decreases as $N-1$ as the number of nodes $N \to \infty$, so these so-called "tree-based theories" cannot in general guarantee meaningful predictions for real-world networks with significant clustering. We show that analytical results derived using tree-based $P(k, k')$-theory can be applied with high accuracy to certain networks despite their high levels of clustering. Specifically, the analytical results for bond percolation, k-core sizes, susceptible-infected-susceptible (SIS) epidemic model, and some other processes accurately match numerical results for a given (clustered) network provided that the mean intervertex distance in the network is sufficiently small i.e., that it is close to its value in a randomly rewired version of the network which has the same degree-degree correlation $P(k, k')$. Recalling that a clustered network with a low mean intervertex distance is said to have the small-world property, we find that tree-based analytical results are accurate for networks that are "sufficiently small" small worlds.

In order to assess the strength of a relation between the theory error E and some characteristic of the network, we calculate the coefficient of determination R^2 using a linear regression.

SM, AH, and JPG acknowledge funding provided by Science Foundation Ireland under programmes 06/IN.1/I366 and MACSI 06/MI/005. MAP acknowledges a research award (#220020177) from the James S. McDonnell Foundation. PJM was funded by the NSF (DMS-0645369). We thank Adam DAngelo and Facebook for providing the Facebook data used in this study. We also thank Alex Arenas, Mark Newman, CAIDA, and Cx-Nets collaboratory for making publicly available other data sets used in this study. We additionally thank Alessandro Vespignani for useful comments.

Cover song networks: analysis and accuracy increase

J. Serrà, M. Zanin and P. Herrera

he application of community detection in complex networks is explored within the framework of cover song identification, i.e. the automatic detection of different audio renditions of the same underlying musical piece. In the last years this particular task has been widely studied within the music information retrieval field as a query problem, where one song was submitted and a list of possible matches was created by the system. In this contribution we propose a new point of view: songs are embedded in a complex weighted network, whose links represent similarity (common musical content between songs). We analyze this network and find a strong modular structure, with well-defined communities and a clustering coefficient higher than expected. We then perform clustering and community detection to identify groups of songs that are versions the same musical piece. Importantly, the information gained through this process is used to increase the overall accuracy of the system. Results show that accuracy increments of 5 percent points can be easily achieved. A further out-of-sample test provides evidence that this increase can be potentially higher.

Keywords: Complex networks, community detection, music information retrieval, cover song identification.

Memristor Minds : Remembrance of Things Past

Leon O. Chua
BUniversity of California, Berkeley, USA

What is a memristor? Why is it called the 4th circuit element? Why did it take 37 years to make a memristor? Why did the hp memristor generate so much excitements ? How does the memristor retain its memory even after the power is switched off? What is the difference between a non-volatile memristor and a locally-active memristor? How smart are memristors? These are some FAQ to be addressed in this introductory talk.

Abstracts of the Posters

Modeling the Porous Media of Soils as Heterogeneous Complex Network

A. Santiago, J.P. Cárdenas, F. Borondo and R.M. Benito

After soil texture, the geometry of pore space as well as pore size is probably one of the most important factors to understanding the transport of water, gas and solute in soils [1]. However, a quantitative and explicit characterization, by means of a physical interpretation, is difficult because of the complexity of the pore space [2]. In this work we present a new approach to the modelization of porous media by means of Network Theory. We propose a dynamical complex network model as a new way to quantify the structure of porous soils and relate them with soil texture.

In our proposed model we interpret porous soils as heterogeneous networks where pores are represented by nodes with distinct properties (size and spatial location) and the links represent fluid flows between them. The networks of pores are generated by the Heterogeneous Preferential Attachment (HPA) model [3]. In the model, properties of pores, such as position and size, are described by fixed states in a metric space. An affinity function is introduced to bias the attachment probabilities of links according to these properties and soil texture [4].

We perform an analytical study of the degree distributions in the model and develop a numerical analysis of the model for a combination of parameters corresponding to eleven empirical soil samples with different physical properties and five different textures. The simulation results exhibit a good agreement with the analytical predictions.

[1] Ball, B.C., Watson, C.A. and Baddeley, J.A.: Soil physical fertility, soil structure and rooting conditions after ploughing organically managed grass/clover swards, Soil Use Manage, 23, 20– 27, 2007.

[2] Leij, F.J., Ghezzehei, T.A. and Or, D.: Analytical models for soil pore-size distribution after tillage, Soil Sci. Soc. Am. J. 66, 1104–1114, 2002

[3] Santiago, A. and Benito, R. M.: An extended formalism for preferential attachment in heterogeneous complex networks, Europhys. Lett. 82, 58004, 2008.

[4] Santiago, A., Cárdenas, J.P., Losada, J.C., Benito, R.M., Tarquis, A.M. & Borondo, F.: Multiscaling of porous soils as heterogeneous complex networks, Nonlin. Processes Geophys., 15. 2008.

Comparing geodesic and spectral properties of a graph with those of its line graph

R. Criado, J. Flores, J. García del Amo and M. Romance

Efficiency and (Bonacich) centrality are well known parameters associated to a given network, G. Also well known since the thirties is the line graph, G^*, associated to the (directed or undirected) graph G, and particularly meaningful in the urbanism design context. A natural question arises: what is the relation between those parameters on G and the corresponding ones on G^*? More precisely, is it possible to give analytical estimations of the efficiency and centrality of G in terms of those on G^* and conversely? We provide a positive answer by using the bipartite graph $B(G)$ and the parameters above on it.

Keywords: Line graph, efficiency, centrality.

Feigenbaum Graphs

B. Luque

The visibility graph, a mapping between time series and complex networks, allows us to apply methods of complex network theory for characterizing time series. In this work we make use of this tool to fully characterize the route to chaos in unimodal maps in terms of the network properties of the associated visibility graphs.

Keywords: time series, complex networks, chaos.

Kibble-Zurek mechanism in a pattern forming secondary bifurcation

M.A. Miranda, J. Burguete, W. González-Viñas and H. Mancini

We present new experimental results on the quenching dynamics of an extended thermo-convective system (an array of 80 convective cells) through a secondary bifurcation. The topology of new coherent structures, when a weakly subcritical bifurcation is crossed upwards at different rates from a basic stationary multicellular pattern, allows us to characterize a freezing dynamics related to the Kibble-Zurek mechanism. This mechanism defines a correlation length at the freezing: the frozen correlation length $\xi \sim \mu^{\alpha}$, where the quench timescale is given by the control parameter rate of change μ at the bifurcation threshold. The critical modes at this secondary bifurcation are the oscillatory modes, which develop reminiscent structures (domains, fronts and topological defects) of this freezing dynamics. Spatio-temporal correlation processes will allow us to determine the behavior of such mechanism.

Keywords: Complex Networks, non-equilibrium phase transitions, critical phenomena, symmetry breaking bifurcations, quenching dynamics, experimental cosmology, cosmic domains.

Cost propagation in business networks

M.L. Mouronte, M. L. Vargas and F. J. Garcia Algarra

In recent years, it has become very clear to large business organizations that their systems and networks are evolving increasingly complex. The amount of different components in a system and the various ways these elements may interconnect each other result in quite intricate network topologies. To keep up with rapidly changing conditions, business systems and their associated networks are growing increasingly intricate as never before. By doing this, network management and operation costs not only rise, but are difficult even to measure. This fact must be regarded as a major constraint to system optimization initiatives, as well as a setback to derived economic benefits. In this work [**?**, **?**] we introduce a simple model in order to estimate the relative cost associated to modification propagation in complex architectures. Our model can be used to anticipate costs caused by network evolution, as well as for planning and evaluating future architecture development while providing benefit optimization.

To estimate how costs depend on the complexity that a substrate architecture or network exhibits, we generated set artificial scale-free networks [**?**] (close to 200 randomly generated networks). These networks have a fixed number of nodes and links ($N = 110$; $N_l = 270$), but variable topological parameters, such as the (scale-free) degree distribution exponent γ, and average shortest length L (i.e., the average minimum number of links needed to travel between two nodes). Our results were calculated with K_{ij} coefficients taken from a Rayleigh distribution of $\sigma = 0.04$ to describe each node pair. Then, for each artificially generated test network, we calculated the associated cost and directly observed the relationship between cost and structure. Our preliminary results show that there is a strong influence from the topology of the network on our cost model. In Fig. 2 we show the modification propagation cost as a function of these two complexity parameters, namely, the degree distribution exponent (right) and the average shortest length L (left). As we can see from the figure, our results show that, in average, costs decrease as the average shortest length increases and increases with a higher heterogeneity of the networks. In order to have a general estimative of the relative change, we performed linear fits in our results.

In both cases, the absolute change in costs (associated with the chosen range of L and γ) is of about 20%, being the slopes $m_\gamma = 0.012$ and $m_L = 0.0123$. Clearly, a linear estimate is more suits for the length dependence than for the dependence, where more analysis is needed to determine its influence. Such analysis is currently being addressed.

[1] Benito Zafrilla, R. M., Cárdenas Villalobos, J. P., Mouronte López, M. L.: Redes Complejas: El nuevo paradigma. Sociedad de la Información, Tecnología e Información Bulletin (Fundación Telefónica), Madrid (2007)

[2] J.P. Cárdenas,M.L. Mouronte, R.M. Benito, J.C. Losada, Physica A (2010)

[3] Catanzaro, M., Boguña, M., and Pastor-Satorras, R.: Generation of uncorrelated random scale-free networks, Phys. Rev. E. 71, 027103 (2005)

[4] Pastor-Satorras, R., Vespignani, A.: Epidemic dynamics in finite size scale-free networks, Phys. Rev. E. 65, 035108 (2002)

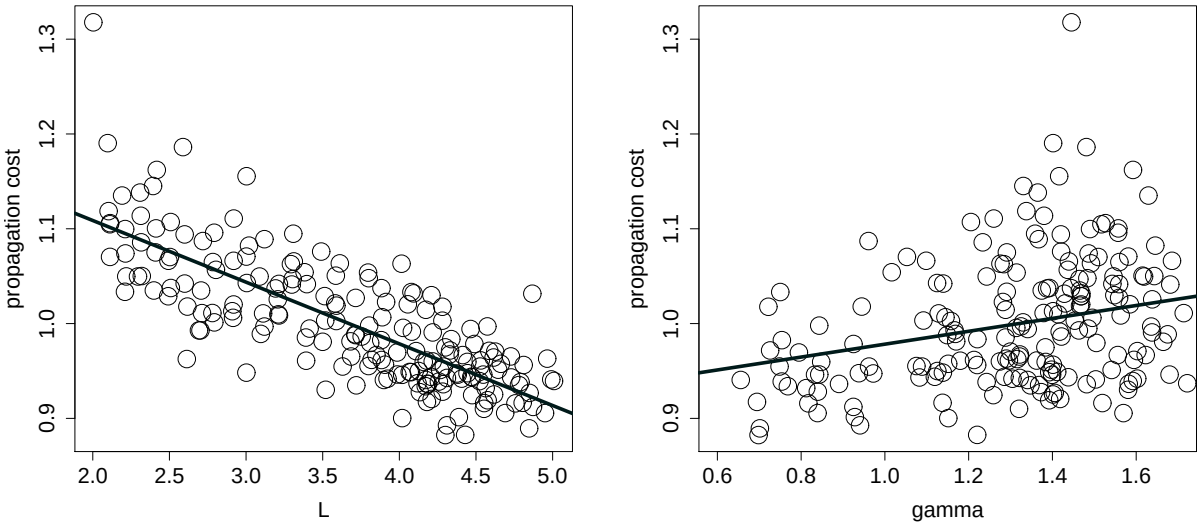

Figure 2: Left: Propagation cost C as a function of the average shortest length of the network L. Right: Propagation cost C as a function of the degree distribution exponent γ. In solid line, a linear fitting. Both quantities present an overall relative cost change of approximately 20%, with negative slope in the case of the average shortest length L, and with positive slope regarding the γ dependence, in the ranges shown in the figures.

The role of social networks and their importance in artisanal fishing communities in the central area of the Province of Santa Cruz. Argentina Topics . Social networks and dynamics

U.G. Navarro

This work has the overall objective to study the evolution of the network of fishermen from the inclusion of open technologies in the context of sustainable development and technology, from the analysis of mediation and collaborative processes of artisanal fishermen in the Province of Santa Cruz; exploring the multiple attributes of network analysis to observe the various activities and agencies of its participants, and characterizing the fishing nets along the cycle, giving an account of the changes from the comparison of two periods.

The working hypothesis is the use of communication technologies in an innovative way affects the dynamics of relationships and the overall production process of the fishing net and its environment.

At present, there is a high demand for handmade products destined for tourism activity throughout the Patagonian region. This scenario presents a formidable artisanal possibility of growth and expansion of the hand of a very familiar activity in a market still unknown.

So far there are few associations that have become standard equipment for the packaging of fish and although they have taken action that has allowed them to frame their products in minimum quality standards, does not have a protocol processing but each one produces according to prescription and without ensuring the durability of the product over time.

In general, the production of products takes place in a small scale in the homes of every fisherman. Consequently, the resulting volumes are insufficient to access large markets, thus restricting visibility to businesses or local fairs.

These features, coupled with the lack of unifying criteria, impossible to obtain significant amounts of products of specified quality and sustainable in the long term. That is why the access of fishermen to markets increased demand and complexity is clearly restricted.

This work fits within the scope of Social Network Analysis as a broad approach that allows to observe the social structures that arise from the various forms of relationship, but also as a specific set of methods and techniques.

This study was carried out comparing an armed network product social relationships with 16 fishermen used to working without the mediation of communication technology, and constitute more of a social network here in the network connections are social knowledge have fishermen together. We used the software Pajek (Pajek, 2000) and its variability over time by adding ICT to communicate, in order to compare the behavior of the network.

It has been tested and shown to be the net fishermen of identical nature, after the inclusion of training and communication technologies is completely different behavior. This evidence suggests that the structure of the physical network differs significantly from the initial network, which is the first experimental example of the phenomenon of diffusion can substantially modify the relationships and the status quo of a network.

In this sense, the first conclusion to draw is as follows. After the training to the fishermen interviewed and connected the center of the province, and taking into account the links between them, we reached the figure of 184, now connected through the use of communication technologies.

This work also shows the potential of using Pajek (Pajek, 2000) in the analysis of time-varying networks.

Thus, the main contribution of this work has been to offer advanced technology and Elgg (Elgg, 2008) and Pajek (Pajek, 2000) through the investigation of the ARS, which allowed us to construct a social network of fishermen, allowing envision them better conditions for sustainable development.

Keywords: Analysis of social networks, free software.

Assessing Spanish mobility through Complex Networks

M. Zanin, S. Ladousse and R. Herranz

In this contribution we present a model of the Spanish transport infrastructure based on Complex Networks analysis. A Scheduled Network object [Chaos **19**, 023111 (2009)] is used to calculate the cost, in terms of time duration of the trip, for passengers going from any point of the Spanish geography to the airport of Madrid Barajas. Users are distributed between different transportation modes (normal and high speed train, car or commercial airplane) according to a *logit* economical model of utilities, which includes duration of the trip, prices and delays in modal changes. As a result, some relevant metrics are derived for a deeper understanding of the transportation system in Spain, like for instance, citizens' mobility and environmental impact of mobility.