PREFACE: "NEW TRENDS, MODELS AND APPLICATIONS IN COMPLEX AND MULTIPLEX NETWORKS"

The real world surrounding us is full of complex systems from various types and categories. Internet, the World Wide Web, biological and biochemical networks (brain, metabolic, protein and genomic networks), transport networks (underground, train, airline networks, road networks), communication networks (computer servers, Internet, online social networks), and many others (social community networks, electric power grids and water supply networks,...) are a few examples of the many existing kinds and types of networks [1, 2, 3, 4, 6, 8, 9, 10, 11]. In the recent past years, the study of structure and dynamics of complex networks has been the subject of intense interest. Recent advances in the study of complex networked systems has put the spotlight on the existence of more than one type of links whose interplay can affect the structure and function of those systems [5, 7]. In these networks, relevant information may not be captured if the single layers are analyzed separately, since these different components and units interact with others through different channels of connectivity and dependencies. The global characteristics and behavior of these systems depend on multiple dimensions of integration, relationship or cleavage of its units.

Several extensions of complex networks to multistructure or multirelational networks have been developed in recent years (hypergraphs, interdependent networks, interacting networks, multidimensional networks, coupled networks, network of networks, ...) (see [5] or [7] for a more detailed description).

Multilayer and multiplex networks constitute the natural mathematical environment to describe systems whose units are interconnected through different categories and kinds of connections: each channel (category, activity, relationship) is represented by a layer, and the same node or entity may have different kinds of interactions with the rest of the nodes or entities. These concepts generalize the "traditional" network theory, developing a solid foundation and providing the consequent new associated tools to study multilayer and multicomponent systems in a comprehensive fashion [5, 7].

This special issue is characterized for covering several aspects related to the different models of interactions between complex systems and some other related topics emphasizing the latest applications of complex and multiplex networks.

It is finally remarkable that the development of complex and multiplex networks theory is intrinsically related to the study of real-world systems instead of being motivated by a merely theoretical problem. In fact, the burst of complex and multiplex networks theory has been certainly promoted by the optimized rating of computing facilities, and by the availability of large datasets about the interaction patterns of real complex systems.

Some examples related to this two highlighted features that speak clearly to the thematic focus of this special issue are related to the study and analysis of mobile phone data to provide information about the regional and ethnics interactions in Ivory Coast, two papers devoted to research some aspects of collective transport

networks in which structural analysis of the quantitative data on the travel patterns of the passenger and transferability are presented, a study of community detection and link prediction in multiplex networks, a paper on the resilience of mutualistic networks where a simple and bounded model derived from the logistic approach to simulate mutualistic dynamics is presented, and some other papers where several models, tools and applications to intentional risk analysis, stock markets, analysis of social power, brain functional networks and the international trade market are presented and discussed. Also, an interesting paper where the authors present a systematic investigation of the magnetic anisotropy effects observed in the deterministic spin dynamics of a magnetic particle in the presence of a time-dependent magnetic field is included.

So, it is clear that the applied nature of complex and multiplex networks theory is at the core of the works presented in this special issue.

Therefore, this special issue is mainly devoted to present some new results about the structure and dynamics of complex and multiplex networks and its goal is to give a selection of contributed papers that covers a wide range of relevant and modern aspects in the analysis of complex and multiplex networks, giving a state of the art picture of this field. The aim of this special issue of Networks and Heterogeneous Media is to provide a flavour of recent trends in this fast growing research area. It contains twelve original papers about various aspects of the structure and dynamics of complex networks: some of them present new theoretical results whereas others deal with numerical algorithms and applications of the theory.

The contributed papers presented in this special issue were selected among the most relevant works presented at the International Conference Net-Works 2013. This conference, which took place in El Escorial (Spain) on December 11th-13th, 2013, was held in cooperation with the Society for Industrial and Applied Mathematics (SIAM) and the American Institute for Mathematical Sciences (AIMS). The conference has gathered more that 80 researchers in this area from different countries and it has also attracted young researchers from neighbouring areas.

We are extremely grateful to the Networks and Heterogeneous Media, and specially warm thanks to the Editor in Chief Benedetto Piccoli for giving us this editorial opportunity, to Prof. Corrado Lattanzio for the excellent management of this special issue, to the Director of the American Institute of Mathematical Sciences Shouchuan Hu and the Publishers for having hosted this theme section. Finally we would like to express our most sincere thanks and great appreciation to all the members of Scientific Committee for their help and their important support, specially to S.Boccaletti, J.García-Ojalvo, H.J. Jensen, J.Kurths, V.Latora, H.Mancini, E.Schoell, and J.J. Torres. It was a great honour for us to count on the above leaders on Complex Networks as members of Scientific Committee of Net-Works 2013. We also want to thank all those colleagues who have helped us in the realization of this special issue, the contributors of the different manuscripts, and all our colleagues who assisted us in the reviewing process of the papers. We are honoured to bring you this collection of papers generated from the contributions and discussions held at Net-Works 2013. We hope that this special issue will contribute to the development of new activities in the field.

REFERENCES

[1] R. Albert and A. L. Barabási, Statistical mechanics of complex networks, *Rev. Mod. Phys.*, **74** (2002), 47–97.

[2] A. L. Barabási and R. Albert, Emergence of scaling in random networks, *Science*, **286** (1999), 509–512.

[3] Y. Bar-Yam, *Dynamics of Complex Systems*, 1st Edition, Addison-Wesley, Boston, 1997.

[4] A. Barrat, M. Barthélemy and A. Vespignani, *Dynamical Processes on Complex Networks*, 1st Edition, Cambridge University Press, New York, 2008.

[5] S. Boccaletti, G. Bianconi, R. Criado, C. I. del Genio, J. Gómez-Gardeñes, M. Romance, I. Sendiña-Nadal, Z. Wang and M. Zanin, The structure and dynamics of multilayer networks, *Physics Reports*, **544** (2014), 1–122.

[6] S. Boccaletti, V. Latora, Y. Moreno, M. Chavez and D.-U. Hwang, Complex networks: Structure and dynamics, *Physics Reports*, **424** (2006), 175–308.

[7] M. De Domenico, A. Solè-Ribalta, E. Cozzo, M. Kivelä, Y. Moreno, M. A. Porter, S. Gómez and A. Arenas, Mathematical formulation of multi-layer networks, *Phys. Rev. X*, **3** (2013), 399–404.

[8] M. E. J. Newman, The structure and function of complex networks, *SIAM Review*, **45** (2003), 167–256.

[9] M. E. J. Newman, A. L. Barabási and D. J. Watts, *The Structure and Dynamics of Networks*, Princeton University Press, Princeton, NJ., 2006.

[10] S. H. Strogatz, Exploring complex networks, *Nature*, **410** (2001), 268–276.

[11] D. J. Watts and S. H. Strogatz, Collective dynamics of small-world networks, *Nature*, **393** (1998), 440–442.

Guest editors:

Rosa M. Benito
Regino Criado
Juan C. Losada
Miguel Romance