

# FINAL PROGRAM

## THE 2010 INTERNATIONAL WORKSHOP ON COMPLEX NETWORKS

<http://www.complenet.org>

**Rio de Janeiro, Brazil**  
**October 13 - 15, 2010**

### STEERING COMMITTEE

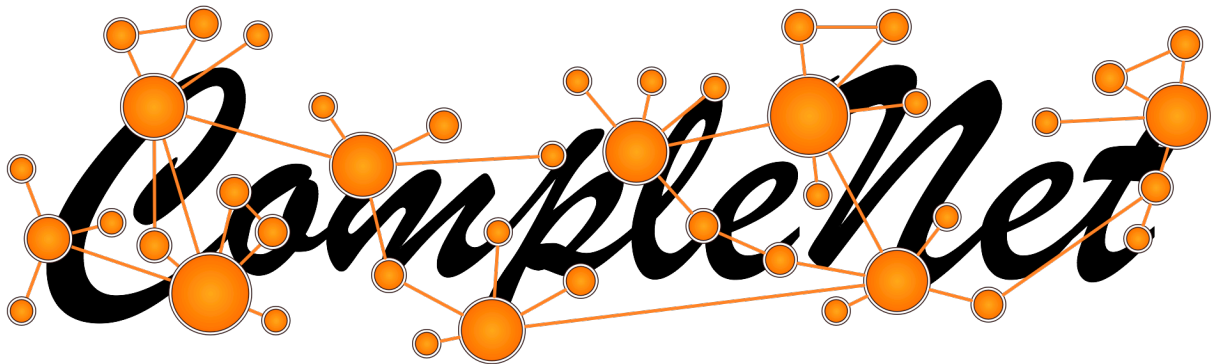
Giuseppe Mangioni  
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Giuseppe Mangioni

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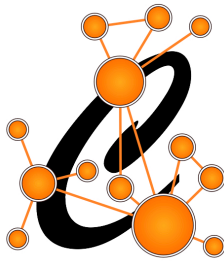


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## **COMPLENET 2010 INTRODUCTION**

The International Workshop on Complex Networks (CompleNet 2010) brings together researchers and practitioners working on areas related to complex networks. In the past two decades we have been witnessing an exponential increase on the number of publications in this field. From biological systems to computer science, from economic to social systems, complex networks are becoming pervasive in many fields of science. It is this interdisciplinary nature of complex networks that this workshop aims at addressing. CompleNet 2010 features 2 world-renowned keynote speakers: Dr. Madan Babu, PhD (Laboratory of Molecular Biology, Cambridge, UK) and Prof. Eugene Stanley, PhD (Department of Physics, Boston University, USA). This year's program includes five invited speakers: Marcio Argollo de Menezes, PhD (Universidade Federal Fluminense, Physics Institute, Niterói, Brazil), Cesar A. Hidalgo, PhD (Center for International Development, Harvard University, Cambridge, USA), Jure Leskovec, PhD (Computer Science Department, Stanford University, Stanford, USA), Maximilian Schich, PhD (Center for Complex Network Research, Northeastern University, Boston, USA) and Rita Zorzenon, PhD (Federal University of Pernambuco, Pernambuco, Brazil). The Technical Program offers 27 papers on three full days. The program starts at 9:00.

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Federal University of Rio de Janeiro

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University of Catania, Italy

**Luciano da F. Costa**

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**Sergei N. Taraskin** University of Cambridge, UK

**Andres Upegui** HEIG-VD, Switzerland

**Soon-Hyung Yook** Kyung Hee University, Seoul, Republic of Korea

**Rita M. Zorzenon dos Santos** Univ. Federal de Pernambuco, Brazil

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Federal University of Rio de Janeiro, Brazil

**Nelson Ebecken**

Federal University of Rio de Janeiro, Brazil

**Beatriz Lima**

Federal University of Rio de Janeiro, Brazil

### **Steering Committee**

**Giuseppe Mangioni**

University of Catania, Italy

**Ronaldo Menezes**

Florida Institute of Technology, Florida, USA

**Vincenzo Nicosia**

University of Catania, Italy

## **KEYNOTE SPEAKERS**

### **Dr. M Madan Babu, PhD**

Group Leader, MRC Lab. of Molecular Biology  
Hills Road, Cambridge CB2 0QH, UK  
Fellow of Darwin College, University of  
Cambridge, Cambridge CB3 9EU, UK



M MADAN BABU was awarded the Max Perutz Prize for outstanding PhD research in 2004. He subsequently received an NIH International Visiting Fellowship to work at the NCBI, USA where he identified fundamental principles of the organization of biological

networks. In 2006, he returned to the UK to become an independent Group Leader at the MRC Laboratory of Molecular Biology and was elected as a Schlumberger Research Fellow at Darwin College, Cambridge in 2007. His current research focuses on investigating how regulation is achieved at multiple levels of complexity in cellular systems and how this influences evolution of organisms and their genome. He is a recipient of the UK Biochemical Society's Early Career Award (2009) and the EMBO Young Investigator Award (2010).

### **Prof. Eugene Stanley, PhD**

University Professor; Professor of Physics;  
Professor of Chemistry; Professor of  
Biomedical Engineering; Professor of  
Physiology (School of Medicine)  
Director, Center for Polymer Studies  
Department of Physics, Boston University, 590  
Commonwealth Avenue, Boston, MA 02215  
USA



EUGENE STANLEY works is attempting to understand puzzles of interdisciplinary science. His main current focus is understanding the anomalous behavior of liquid water in bulk, nanoconfined, and biological environments. He has also worked on a range of other topics

in complex systems, such as quantifying correlations among the constituents of the Alzheimer brain, and quantifying fluctuations in noncoding and coding DNA sequences, interbeat intervals of the healthy and diseased heart. His publications have received 47,993 citations [40,891 to 986 articles and 7,102 to 23 books] and his Hirsch index is  $h = 101$ . Stanley has been elected to the US National Academy of Sciences (NAS) and the Brazilian Academy of Sciences, and as an Honorary Member of the Hungarian Physical Society.

## **WEDNESDAY KEYNOTE ADDRESS**

### **Understanding complexity at different scales in biological systems using network theory**

Dr. M Madan Babu, PhD

**WEDNESDAY OCTOBER 13, 2010, 9:30 – 10:30**

**ROOM  
MONIZ ARAGÃO**

**ABSTRACT**

TBD

## **THURSDAY KEYNOTE ADDRESS**

### **Catastrophic cascade of failures in interdependent networks**

Prof. Eugene Stanley, PhD

**THURSDAY OCTOBER 14, 2010, 9:10 – 10:10**

**ROOM  
MONIZ ARAGÃO**

**ABSTRACT**

TBD

## INVITED SPEAKERS



**CÉSAR A. HIDALGO** is an Assistant Professor at the Massachusetts Institute of Technology (MIT) Media Laboratory and a faculty associate at Harvard's University Center for International Development. Dr

Hidalgo's work focuses on improving the understanding of systems using and developing concepts of complexity, evolution and network science. His areas of application include (i) economic development, where he has pioneered the use of networks to quantify the productive structure of countries and its evolution, (ii) systems biology where he has published work on disease co-morbidity and genetic regulation, and (iii), social systems, where he has worked on human mobility and social network analysis using mobile phone data.



**MAXIMILIAN SCHICH** has obtained his Dr. phil. & Magister Artium in Art History in Humboldt-Universität, Berlin. In the Post-Doc he worked on bridging art research and science collaborating with researchers across disciplines at Barabási Lab and Max-Planck

Society. currently Visiting Associate Research Scientist examining Complex Networks in Art Research with Prof. Albert-László Barabási at the Center for Complex Networks Research (CCNR), Northeastern University, Boston. Dr. Schich has working with network data in art research, brokering within the tetrahedron of project-partners, users, programmers and customers, in particular with Projekt Dyabola.



**JURE LESKOVEC** is assistant professor of Computer Science at Stanford University where he is a member of the Info Lab and the AI Lab. In 2008/09 Jure was a postdoctoral researcher at Cornell University working with Jon Kleinberg and Dan

Huttenlocher. He completed his Ph.D. in Machine Learning Department, School of Computer Science at Carnegie Mellon University under the supervision of Christos Faloutsos in September 2008. Leskovec has authored the Stanford Network Analysis Package (SNAP), a general purpose network analysis and graph mining library, that easily scales to massive networks with hundreds of millions of nodes, and billions of edges. He owned the Graduate Research Fellowship and the ACM SIGKDD Dissertation Award in 2009.



**RITA ZORZENON** is studying the dynamics of the endemic process of Tuberculosis (TB) in Olinda - PE, Brazil. The TB incidence and mortality rates in this town are greater than the country average. From the study of the space-time correlation of the annual spatial distribution of cases

per census tract (CT - administrative district corresponding to 300 households) during the period 1996-2000, we have identified some CT as sources of infection as well as the CT network (or epidemiological network) in which the TB dissemination process takes place. While the first analysis indicates that the epidemiological network has small world characteristics, the weighted network exhibit scale-free properties.



**MARCIO ARGOLLO DE MENEZES** studies the

emergence of cooperation in physical and biological systems with statistical physics tools, mainly the scaling theory of phase transitions and fractal analyses of time series. His recent research interests

include dynamical and topological analyses of network systems, flux analyses of metabolic networks, formal proof theory, more specifically creating algorithms for finding distinct grammars that generate the same language, and time series analyses of physiological reflexes. His last collaborators include Alexei Vazquez, A.-L. Barabási, T. J. P. Penna, Cristian F. Moukarzel and A. R. Lima. He has also worked with Ronald Dickman on the study of critical phenomena in nonequilibrium systems.

# 2<sup>ND</sup> WORKSHOP ON COMPLEX NETWORKS COMPLENET 2010

## SCHEDULE AT A GLANCE

### WEDNESDAY OCTOBER 13, 2010

09:15 - 09:30	OPENING REMARKS
09:30 - 10:30	<b>KEYNOTE ADDRESS: M MADAN BABU</b>
10:30 - 11:00	COFFEE BREAK
11:00 - 12:50	NETWORK MODELING
13:00 - 14:30	LUNCH BREAK
14:30 - 15:20	<b>INVITED TALK: RITA ZORZENON</b>
15:20 - 16:15	APPLICATIONS
16:20 - 16:40	COFFEE BREAK
16:40 - 17:55	NETWORK DYNAMIC

### THURSDAY OCTOBER 14, 2010

09:10 - 10:10	<b>KEYNOTE ADDRESS: EUGENE STANLEY</b>
10:10 - 11:00	ANALYSIS OF REAL NETWORKS
11:00 - 11:15	COFFEE BREAK
11:15 - 12:10	COMMUNITY STRUCTURE
12:10 - 13:00	<b>INVITED TALK: CÉSAR A. HIDALGO</b>
13:00 - 14:30	LUNCH BREAK
14:30 - 15:20	<b>INVITED TALK: MARCIO ARGOLLO DE MENEZES</b>
15:20 - 16:15	NETWORK MODELING
16:15 - 16:35	COFFEE BREAK
16:35 - 17:50	APPLICATIONS
20:00 - 22:00	BANQUET: ZOZO RESTAURANT

### FRIDAY OCTOBER 15, 2010

09:10 - 10:00	<b>INVITED ADDRESS: MAXIMILIAN SCHICH</b>
10:00 - 10:50	NETWORKS DYNAMICS
10:50 - 11:10	COFFEE BREAK
11:10 - 12:30	COMMUNITY STRUCTURE
12:30 - 14:00	LUNCH BREAK
14:00 - 14:30	COMPLENET 2011 ORGANIZATION MEETING
14:30 - 15:20	<b>INVITED ADDRESS: JURE LESKOVEC</b>
15:20 - 16:10	APPLICATIONS
16:10 - 16:30	COFFEE BREAK
16:30 - 17:25	TECHNICAL PRESENTATIONS
17:25 - 17:35	CLOSING REMARKS

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## WEDNESDAY OCTOBER 13, 2010

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09:10 – 18:00 LOBBY

REGISTRATION

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09:15 – 09:30 ROOM: MONIZ ARAGÃO

OPENING REMARKS

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09:30 – 10:30 ROOM: MONIZ ARAGÃO

KEYNOTE ADDRESS

### Understanding Complexity at Different Scales in Biological Systems Using Network Theory

Dr. M Madan Babu, PhD

Group Leader, MRC Lab. of Molecular Biology  
Hills Road, Cambridge CB2 0QH, UK  
Fellow of Darwin College, University of  
Cambridge, Cambridge CB3 9EU, UK

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10:30 – 11:00 ROOM: VERMELHO

COFFEE BREAK

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11:00 – 12:50 ROOM: MONIZ ARAGÃO

NETWORK MODELING

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#### (11:00) Average Path Length of Deterministic and Stochastic Recursive Networks

Philippe Giabbanelli, *INRIA Sophia Antipolis Cedex, France*  
Dorian Mazauric, *Mascotte, INRIA, I3S, France*  
Jean-Claude Bermond, *Mascotte, INRIA, I3S, France*

The average shortest path distance  $L$  between all pairs of nodes in real-world networks tends to be small compared to the number of nodes. Providing a closed-form formula for  $L$  remains challenging in several network models, as shown by recent papers dedicated to this sole topic. For example, Zhang et al. proposed the deterministic model ZRG and studied an upper bound on  $L$ . In this paper, we use graph-theoretic techniques to establish a closed-form formula for  $L$  in ZRG. Our proof is of particular interests for other network models relying on similar recursive structures, as found in fractal models. We extend our approach to a stochastic version of ZRG in which layers of triangles are added with probability  $p$ . We find a first-order phase transition at the critical probability  $p_c = 0.5$ , from which the expected number of nodes becomes infinite whereas expected distances remain finite. We show that if triangles are added independently instead of being constrained in a layer, the first-order phase transition holds for the very same critical probability. Thus, we provide an insight showing that models can be equivalent, regardless of whether edges are added with grouping constraints. Our detailed computations also provide thorough practical cases for readers unfamiliar with graph-theoretic and probabilistic techniques.

#### (11:30) Traffic Congestion on Clustered Random Complex Networks

Thiago Henrique Cupertino, *Universidade de São Paulo, Brazil*

Liang Zhao, *Universidade de São Paulo, Brazil*

In this work we study the traffic-flow on clustered random complex networks. First, we derive a mathematical model to determine the congestion phase-transition point. This point is defined as the abrupt transition from a free-flow to a congested state. Second, we study the influences of different cluster sizes on the traffic-flow. Our results suggest that the traffic of centralized cluster network (a network which has a big central cluster surrounded by clusters with significantly smaller sizes) is less congesting than balanced cluster network (a network which has clusters of approximately the same size). These results have practical importance in urbanization planning. For example, according to the results of this study, the increasing of satellite cities surrounding a big city should be well controlled to avoid heavy traffic congestion.

#### (12:00) Fully Generalized Graph Cores

Alexandre P. Francisco, *Tech Univ of Lisbon, Portugal*  
Arlindo L. Oliveira, *Tech Univ of Lisbon, Portugal*

A core in a graph is usually taken as a set of highly connected vertices. Although general, this definition is intuitive and useful for studying the structure of many real networks. Nevertheless, depending on the problem, different formulations of graph core may be required, leading us to the known concept of generalized core. In this paper we study and further extend the notion of generalized core. Given a graph, we propose a definition of graph core based on a subset of its subgraphs and on a subgraph property function. Our approach generalizes several notions of graph core proposed independently in the literature, introducing a general and theoretical sound framework for the study of fully generalized graph cores. Moreover, we discuss emerging applications of graph cores, such as improved graph clustering methods and complex network motif detection.

#### (12:30) Deciding on the Type of a Graph From a BFS

Xiaomin Wang, *LIP6, Paris*  
Matthieu Latapy, *LIP6, Paris*  
Michèle Soria, *LIP6, Paris*

The node degree distribution of the Internet topology is considered as one of its main properties. However, it is only known through a measurement procedure which gives a biased estimate. This measurement may in first approximation be modeled by a BFS (Breadth-first Search) tree. We explore here our ability to infer the type (Poisson or power-law) of the degree distribution from such a limited knowledge. We design procedures which estimate the degree distribution of a graph from its BFS, and show experimentally (on models and real-world data) that this approach succeeds in making the difference between Poisson and power-law graphs.

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13:00 – 14:30

ROOM: VERMELHO

LUNCH BREAK

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**14:30 – 15:20**      **ROOM: MONIZ ARAGÃO**

**INVITED TALK**

## **On the Properties of Complex Networks Obtained from a Tuberculosis endemic Process in Brazil**

Rita Zorzenon, PhD

Federal University of Pernambuco  
Graduate Program in Physics,  
Pernambuco, Brazil

**15:20 – 16:15**      **ROOM: MONIZ ARAGÃO**

**APPLICATIONS**

### **(15:20) Using Digraphs and a Second-order Markovian Model for Rhythm Classification**

Debora Cristina Correa, *Universidade de Sao Paulo, Brazil*  
Luciano da Fontoura Costa, *Universidade de Sao Paulo, Brazil*

Jose Hiroki Saito, *Universidade Federal de São Carlos, Brazil*

The constant increase of online music data has required reliable and faster tools for retrieval and classification of music content. In this scenario, music genres provide interesting descriptors, since they have been used for years to organize music collections and can summarize common patterns in music pieces. In this paper we extend a previous work by considering digraphs and a second-order Markov chain to model rhythmic patterns. Second-order transition probability matrices are obtained, reflecting the temporal sequence of rhythmic notation events. Additional features are also incorporated, complementing the creation of an effective framework for automatic classification of music genres. Feature extraction is performed by principal component analysis and linear discriminant analysis techniques, whereas the Bayesian classifier is used for supervised classification. We compare the obtained results with those obtained by using a previous approach, where a first-order Markov chain had been used. Quantitative results obtained by the kappa coefficient corroborate the viability and superior performance of the proposed methodology. We also present a complex network of the studied music genres.

### **(15:50) Hybrid Complex Network Topologies are Preferred for Component-subscription in Large-scale Data-centres**

Ilango Leonardo Sriram, *University of Bristol, UK*  
Dave Cliff, *University of Bristol, UK*

We report on experiments exploring the interplay between the topology of the complex network of dependent components in a large-scale data-centre, and the robustness and scaling properties of that data-centre. In a previous paper we used the SPECI large-scale data-centre simulator to compare the robustness and scaling characteristics of data-centers whose dependent components are connected via Strogatz-Watz small-world (SW) networks, versus those organized as Barabasi-Albert scale-free (SF) networks, and found significant differences. In this paper, we present results from using the Klemm-Eguiliz (KE) construction method to generate complex

network topologies for data-centre component dependencies. The KE model has a control parameter  $[0,1]$   $R$  that determines whether the networks generated are SW ( $0 \ll R < 1$ ) or SF ( $R=1$ ) or a hybrid network topology part-way between SW and SF ( $0 < R < 1$ ). We find that the best scores for system-level performance metrics of the simulated data-centers are given by hybrid values of significantly different from pure-SW or pure-SF.

**16:20 – 16:40**

**ROOM: VERMELHO**

**COFFEE BREAK**

**16:40 – 17:55**

**ROOM: MONIZ ARAGÃO**

**NETWORK DYNAMICS**

### **(16:40) Epidemics in Anisotropic Networks of Roots**

Thomas Handford, *University of Cambridge, UK*  
Francisco Perez-Reche, *University of Cambridge, UK*  
Sergei Taraskin, *University of Cambridge, UK*  
Luciano da Costa, *University of Sao Paulo, Brazil*  
Mauro Miazaki, *University of Sao Paulo, Brazil*  
Franco Neri, *University of Sao Paulo, Brazil*  
Chris Gilligan, *University of Cambridge, UK*

The spread of epidemics is studied in an anisotropic network of three-dimensional bean roots placed on a square lattice. In particular, the effect of global anisotropy caused for example by an external resource field is analyzed. It is demonstrated that global anisotropy leads to reduced resilience to epidemic invasion as compared with a similar system of roots in the absence of external field. The origin of this effect is suggested to be correlations in transmission of infection between pairs of roots.

### **(17:05) New Transition Due to Repulsion in Axelrod Models of Social Influence**

Marcelo del Castillo-Mussot, *UNAM, Mexico*  
Alejandro Radillo-Díaz, *UNAM, Mexico*  
Luis A. Pérez, *UNAM, Mexico*

Since both attractive and repulsive effects among agents are important in social systems, we present simulations that include repulsion in Axelrod's homogenization mechanism. Repulsion is defined as the inverse of copying, that is, if agents share a number of features given by a threshold parameter, the common Axelrod attractive dynamics is implemented, but if they are too different, then a repelling dynamics is used. We vary the threshold parameter to obtain a new transition from a monocultural state to a fragmented one. We also present a partially repulsive model where only a fraction of repelling agents are considered to yield two different transitions: the initial one being as abrupt as the one found for the repulsive model, whereas the second one follows a less abrupt behavior and resembles that of the original Axelrod model. We calculate the associated entropy and the cumulated size distribution which shows as a function of cluster size a power-law behavior for values of cultural variability near the second transition.

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**(17:30) Opinion Discrimination Using Complex Network Features**

Diego Raphael Amancio, *University of São Paulo, Brazil*

Renato Fabbri, *University of São Paulo, Brazil*

Oswaldo Novais Oliveira Jr, *University of São Paulo, Brazil*

Maria das Graças Volpe Nunes, *University of São Paulo, Brazil*

Luciano da Fontoura Costa, *University of São Paulo, Brazil*

Topological and dynamic features of complex networks have proven in recent years to be suitable for capturing text characteristics, with various applications in natural language processing. In this article we show that texts with positive and negative opinions can be distinguished from each other when represented as complex networks. The distinction was possible with the use of several metrics, including degrees, clustering coefficient, shortest paths, global efficiency, closeness and accessibility. The multidimensional dataset was projected into a 2-dimensional space with the principal component analysis. The distinction was quantified using machine learning algorithms, which allowed a recall of 84.4% in the automatic discrimination for the negative opinions, even without attempts to optimize the pattern recognition process.

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**10:30 – 18:15**

**ROOM: CIRCULATION HALL**

**POSTER SESSION**

**Chaos Synchronization on a Spatially Embedded Network**

Marko Gosak and Marko Marhl,

**Assortative Mixing in the Amazon.com Book Network**

Ben Collingsworth, Ronaldo Menezes

**Understanding Online Social Network User Behavior With Formal Concepts Analysis**

Louise da Glória Avelar de Souza, Nilander R. Magalhães de Moraes, Humberto T. Marques Neto, Luis Enrique Gálvez Zárate

**Complex Systems Applied to the Design Process**

Luis Carli

**Dynamic Analysis in Financial Market Networks**

Thomas Kauê Dal'Maso Peron, Luciano da F. Costa and Francisco Aparecido Rodrigues

**An Iterative Approach to Generate Small-world Networks and its Application on System Biology**

Leandro de A. Lima, David C. Martins-Jr and Fabricio M. Lopes

**Resilience of Protein-protein Interaction Networks as Determined by their Large-scale Topological Features**

André L. Barbieri, Luciano da F. Costa and Francisco Aparecido Rodrigues

**Finding Potential Co-Workers in Scientific Collaboration Networks**

Cristian K. dos Santos, Alexandre G. Evsukoff, Maurício Onoda, Valeria M. Bastos, Marcello P. A. Fonseca, Nelson F. F. Ebecken

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**18:15 - 20:30**

**ROOM: MONIZ ARAGÃO**

**WELCOME RECEPTION**

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## THURSDAY OCTOBER 14, 2010

09:00 – 18:00 LOBBY

### REGISTRATION

09:00– 09:10 ROOM: MONIZ ARAGÃO

### OPENING REMARKS

09:10 – 10:10 ROOM: MONIZ ARAGÃO

### KEYNOTE ADDRESS

#### Catastrophic cascade of failures in interdependent networks

Prof. Eugene Stanley, PhD

University Professor; Professor of Physics;  
Professor of Chemistry; Professor of Biomedical  
Engineering; Professor of Physiology (School of  
Medicine)

Director, Center for Polymer Studies  
Department of Physics, Boston University, 590  
Commonwealth Avenue, Boston, MA 02215 USA

10:10 – 11:00 ROOM: MONIZ ARAGÃO

### ANALYSIS OF REAL NETWORKS

#### (10:10) PageRank for Characterizing Growth Possibility in Japanese Inter-firm Network

Takaaki Ohnishi, *The Canon Institute for Global Studies and University of Tokyo, Japan*

Hideki Takayasu, *Sony Computer Science Laboratories, Japan*

Misako Takayasu, *Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, Japan*

The purpose of this study is to measure the importance of firms from dynamics on transaction network. PageRank algorithm is applied to Japanese inter-firm network in 2005 based on a large-scale dataset provided by Tokyo Shoko Research. The network is consisted of 961,318 nodes representing firms and 3,783,711 directed links representing transactions of materials and services between firms. The direction of link is flow of money, that is, from customer firm to supplier firm. We extract the largest strongly connected component (426,602 nodes), where there is a directed path from each node to every other node, and calculate the ranks of these nodes based on PageRank without random jumps. The obtained PageRank value is exactly equal to the stationary density of the discrete-time simple random walk on the network, corresponding to the amount of money flow through the firm. The PageRank value is locally approximated by indegree. However, this mean-field approximation deviates from the correct PageRank value, because the network has a nontrivial global structure. In this network, the PageRank value and indegree have significant correlation with Spearman's rho of 0.55 (p-value is less than 0.01). We can find some firms with small (large) indegrees that are highly (lowly) ranked in the PageRank. We also analyze the relationship between firm's properties and these

ranks. Annual growth rate of sales is correlated with PageRank and indegree. Spearman's rho is 0.13 ( $p < 0.01$ ) and 0.10 ( $p < 0.01$ ), respectively. For the firms with indegree larger than 25, Spearman's rho between the growth rate and PageRank becomes 0.35 ( $p < 0.01$ ). By taking both PageRank and indegree into account, we could measure the importance of firms based on the network structure. Furthermore, the average PageRank values are calculated at the prefecture level. By comparing the average PageRank and indegree of each prefecture, we characterize the 47 prefectures in Japan.

#### (11:35) The Drosophila Development Networks

Monica Guimarães Campiteli, *Universidade de São Paulo, Brazil*

Roberto Marcondes César Jr, *Universidade de São Paulo, Brazil*

Luciano da Fontoura Costa, *Universidade de São Paulo, Brazil*

The proper functional development of a multicellular organism is dependent upon an intricate network of interacting genes that are expressed in accurate temporal and spatial patterns across the different tissues. The fruit-fly *Drosophila melanogaster* is a model animal whose larval development has been thoroughly studied and has provided the essential background for the current developmental biology investigations. In the past decade biology has witnessed a change of paradigm with the post-genomic era. Public databases are becoming imperative and a huge amount of several kinds of data represents an incalculable source of information for the knowledge construction. Our interest in this work is on image databases, more specifically, drosophila development images databases. Several laboratories are conducting efforts that result in genomewide image banks available in the Internet for the spatial patterns of gene expression along the larval development, obtained using techniques as fluorescent *in situ* hybridization. With simple image analysis techniques we can infer co-localization patterns of genes responsible for the larvae development and therefore infer the genes networks that are responsible for the functional phenotype of the adult form. The networks are of the order of thousands of genes and can be analyzed separately for each stage of development allowing comprehensive analysis by using complex networks techniques. Here we present the first results of such an approach, performed on the Krause lab image bank available at <http://fly-fish.cabr.utoronto.ca/>.

11:00 – 11:15 ROOM: VERMELHO

### COFFEE BREAK

11:15 – 12:10 ROOM: MONIZ ARAGÃO

### COMMUNITY STRUCTURE

#### (11:15) Community Structure in the Multi-Network of International Trade

Matteo Barigozzi, *London School of Economics and Political Science, UK*

Giorgio Fagiolo, *Sant'Anna School of Advanced Studies, Italy*

Giuseppe Mangioni, *University of Catania, Italy*

We study the community structure of the multi-network of commodity-specific and aggregate trade relations among world countries over the 1992-2003 period. We compare

structures across products and time by means of the normalized mutual information index (NMI). We also compare them with exogenous community structures induced by geographical distances and free trade agreements. We find that: (i) plastics and mineral fuels - and in general commodities belonging to the chemical sector - have the highest similarity with aggregate trade communities; (ii) both at aggregated and disaggregated levels physical variables such as geographical distance explain more the observed trade fluxes than free-trade agreements.

**(11:45) On Community Detection in Very Large Networks**

Alexandre P. Francisco, *Tech Univ of Lisbon, Portugal*  
Arlindo L. Oliveira, *Tech Univ of Lisbon, Portugal*

Community detection or graph clustering is an important problem in the analysis of computer networks, social networks, biological networks and many other natural and artificial networks. These networks are in general very large and, thus, finding hidden structures and functional modules is a very hard task. In this paper we propose new data structures and make available a new implementation of a well known agglomerative greedy algorithm to find community structure in large networks, the CNM algorithm. The experimental results show that the improved data structures speedup the method by a large factor, for large networks, making it competitive with other state of the art algorithms.

**12:10 – 13:00**                      **ROOM: MONIZ ARAGÃO**  
**INVITED TALK**

**Networks and The Structure of Economic Complexity**

Cesar A. Hidalgo, PhD

Adjunct Lecturer in Public Policy  
Center for International Development  
Harvard Kennedy School  
Harvard University, Cambridge, USA

**13:00 – 14:30**                      **ROOM: VERMELHO**  
**LUNCH BREAK**

**14:30 – 15:20**                      **ROOM: MONIZ ARAGÃO**  
**INVITED TALK**

**Analogies Between Road and Metabolic Networks**

Marcio Argollo de Menezes, PhD  
Universidade Federal Fluminense  
Physics Institute  
Niterói , Brazil

**15:20 – 16:15**                      **ROOM: VERMELHO**  
**NETWORK MODELING**

**(15:20) Connectivity Criteria for Ranking Network Nodes**

Jaime Cohen, *Univ. Federal do Paraná, Brazil*  
Elias Procópio Duarte Jr., *Univ. Federal do Paraná, Brazil*  
Jonatan Schroeder, *University of British Columbia, Canada*

The most studied connectivity property of network nodes is the degree which provides a local measure of connectivity. In this work we introduce the connectivity numbers of a node, a new quantitative criteria for assessing the connectivity of nodes based on the well known concept of edge-connectivity. The connectivity numbers consist of a hierarchy of measures that starts with a local measure that progressively becomes a global connectivity measure of the network. We show that the connectivity numbers can be computed in polynomial time. Experimental results are described showing how the proposed approach compares to other well known concepts involving connectivity and centrality of network nodes in real and synthetic networks. There are several applications for the connectivity numbers, including the analysis of topological properties of networks, resource placement and routing by alternative routes that pass through highly connected detours.

**(15:50) Modeling Word Adjacency Networks**

Paulino R. Villas Boas, *Universidade de São Paulo, Brazil*  
Diego R. Amancio, *Universidade de São Paulo, Brazil*  
Francisco A. Rodrigues, *Universidade de São Paulo, Brazil*  
Luciano da Fontoura Costa, *Universidade de São Paulo, Brazil*

Language is one of the most important achievements of human evolution, and, despite its complex organization, it presents some fundamental principles, as, for instance, the frequency of a word in texts is inversely proportional to its rank -- the so called Zipf's law. Representing the co-occurrence of adjacent words of a text as a complex network, it has been also shown that the resulting network has the scale-free and the small-world property. The former means that the distribution of words follows a power law with exponent -2.2, and the second property, that two distinct words have just a few words in between. In this work, a model of adjacent words for the reproduction the correspondent complex network measurements of several books was developed. The model creates a sequence of words by choosing them from a power law distribution. In order to generate a text with the same distribution of words, a smaller exponent in absolute value was used. This model not only generated the same distribution of words but also yielded similar complex network measurements found in the books.

**16:15 – 16:35**                      **ROOM: VERMELHO**  
**COFFEE BREAK**

**16:35 – 17:50**                      **ROOM: MONIZ ARAGÃO**  
**APPLICATIONS**

**(16:35) A Network-centric Epidemic Approach for Automated Image Label Annotation**

Mehdy Bohlool, *Florida Institute of Technology, USA*  
Ronaldo Menezes, *Florida Institute of Technology, USA*  
Eraldo Ribeiro, *Florida Institute of Technology, USA*

The process of searching through a large image database using either keywords or the actual image content is a very active research topic. The performance of image-based search engines as well as the quality and robustness of results provided are directly related to the quality of

metadata associated with the images in the database. Unfortunately, we are overwhelmed with images from sites like Flickr, Picasa, etc. which have little or no metadata. However, a dataset of images can be easily organized in a network in which similar images are nodes and are connected to one another via edges representing how similar they are. At the same time, recent advances in the now-called field of Network Sciences helped us understand and model interesting properties of networks such as social capital in social networks, and the dynamics of epidemics in human and computer networks. This paper investigates a mechanism to create a network of images using the scale-invariant feature transform (SIFT) approach from Computer Vision as similarity measure. Then we utilize the image network as a framework to economically annotate the images using approaches inspired from epidemiology. Nodes are selected based on a notion of importance and labeled manually. Our method follows with the propagation of these labels in the network utilizing the similarity measure as a probability of propagation. Our experiments show that the process of organizing images as a network helps us on labeling a large number images in the dataset in an economical way, i.e., with few manual annotations (manual assignment of labels to images).

**(17:00) The Effect of Host Morphology on Network Characteristics and Thermodynamical Properties of Ising model Defined on the Network of Human Pyramidal Neurons**

Renato Silva, *Universidade de São Paulo, Brazil*  
Matheus Viana, *Universidade de São Paulo, Brazil*  
Sergei Taraskin, *University of Cambridge, UK*  
Luciano Costa, *Universidade de São Paulo, Brazil*

The question about effect of the host (node) morphology on the complex network characteristics and properties of dynamical processes defined on such networks is addressed. The complex networks are formed by hosts represented by realistic neural cells of complex morphology. The neural cells of different types are randomly placed on a 3-dimensional cubic domain. The connections between nodes established according to overlaps between different nearest-neighbor hosts significantly depend on the host morphology and thus are also random. The influence of the host morphology on the following network characteristics has been studied: network density, clustering coefficient, giant component size, global efficiency, degree entropy, and assortative mixing. The zero-field Ising model has been used as a prototype model to study the effect of the host morphology on dynamical processes defined on the networks of host which can be in two states. The mean magnetization, internal energy and spin-cluster size as function of temperature have been numerically studied for several networks composed of hosts of different morphology.

**(17:25) Assessing Respondent-Driven Sampling in the Estimation of STDs Prevalence in Populations Structured in Complex Networks**

Elizabeth Albuquerque, *Fundação Oswaldo Cruz, Brazil*  
Cláudia Codeço, *Fundação Oswaldo Cruz, Brazil*  
Francisco Bastos, *Fundação Oswaldo Cruz, Brazil*

Several factors may hamper the characterization of a population. When the sampling frame of a population cannot be defined - either because it requires expensive/time-consuming procedures or targets a stigmatized or illegal behavior that may compromise the identification of potential interviewees -, traditional sampling methods could not be applied. The latter populations are called hidden

populations, and include men who have sex with men (MSM), sexual workers and drug users. Here, we focused on Respondent-Driven Sampling (RDS), a snowball sampling method, with subsequent weighting, originally proposed by Heckathorn. The aim of this work was to assess the behavior of prevalence estimators using RDS data in scenarios of populations organized in complex structures, i.e. different combinations of social networks structures and disease spreading patterns. We used simulation models parameterized after empirical data from a RDS study conducted in Brazil on MSM. Three aspects were considered: the time elapsed before obtaining the desired sample size; the accuracy of the estimates without taking in consideration the weighting strategies; and the weighting strategy itself. Overall, RDS performed well, showing it is a valid strategy to assess hidden populations, but the need to analyze the underlying network structures and patterns of disease spread should not be minimized. Additional simulations will be carried out profiting from a large empirical study on 3,500 drug users.

20:00

TBD

BANQUET

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## FRIDAY OCTOBER 15, 2010

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**09:00– 09:10**                      **ROOM: MONIZ ARAGÃO**  
**OPENING REMARKS**

**09:10 – 10:00**                      **ROOM: MONIZ ARAGÃO**  
**KEYNOTE ADDRESS**

### **Complex Networks in Art History and Archeology**

Maximilian Schich, PhD

DFG Visiting Research Scientist  
Center for Complex Network Research  
Northeastern University, Boston, USA

**10:00 – 10:50**                      **ROOM: MONIZ ARAGÃO**  
**NETWORK DYNAMICS**

#### **(10:00) Controlled Synchronization Time as a Node-node Distance Measure for Complex Networks**

Jean Huertas Lopez, *Universidade de São Paulo, Brazil*  
Liang Zhao, *Universidade de São Paulo, Brazil*

Networks are powerful representations for many complex systems, where nodes represent elements of the system and edges represent connections between them. Synchronization via pinning control has been studied in complex networks. This paper explores the use of the synchronization time via pinning control as asymmetric distance measure on complex networks. In this case, the distance between two nodes in the network is the time that one of them takes to reach a synchronization state with the other one, which is pinned. A new technique for community detection of complex networks has been developed based on the proposed asymmetric distance measure. The method has been tested with various networks and promising results have been obtained.

#### **(10:25) Information Dissemination based on Weak Ties in Wireless Communication Networks**

Matthias R. Brust, *University of Central Florida, USA*  
Amanda Leonel, *Technological Institute of Aeronautics, Brazil*

Mustafa Akbas, *University of Central Florida, USA*  
Carlos Henrique Costa Ribeiro, *Technological Institute of Aeronautics, Brazil*

An increasing number of wireless communication devices such as notebooks, hand-held devices or tiny sensors has an enormous impact on our daily lives. Devices that are within transmission range are able to spontaneously form wireless communication networks and unpredictably join and leave network partitions. A dynamic wireless network that potentially consists of thousands of devices create new challenges on how to handle the emerging complex communication topologies in order to reliably and efficiently disseminate information throughout the entire network. One possible approach is understanding the structure and

function of our own social network, which is capable to spread rumors and news efficiently in spite of its constantly increasing size, to find answers on how to model a wireless communication network to deal with the complexity. Our social network is a highly complex structure that is tied by different types of interdependency, such as histories, interests, trades, neighborhood, and communications. These ties or links are neither randomly nor uniformly distributed and the characteristics of the links vary considerably. Most interestingly for the problem considered in this paper, our social network is built on a certain diversity of links. Granovetter reports on the difference between friends and acquaintances, pointing out that acquaintances are more useful for certain tasks such as finding a job and disseminating news or rumors. Links between acquaintances are called weak ties. He concludes, that strong ties are better for action, weak ties for new information". Transferring these findings on modeling an efficient wireless communication network, strongly connected devices-i.e. clusters-should concentrate on processing information whereby weak ties should be dedicated mostly on information dissemination in order to reach efficiency. Models for community-like structures that exhibit weak ties have been proposed in the literature. However, most of these models focus on network evolution, therefore the model needs convergence time to establish the final topology. However, wireless communication networks like ad hoc and sensor networks are modeled as geometric random network where the links between nodes depend on the radio transmission range and evolutionary approaches are not suitable since the network constantly change and maintains the characteristics of a geometric random networks. Furthermore, the initial network topology corresponds to the definition of a unit disk graph and introduction of additional spatial links is not feasible. In this paper we present an algorithm that works locally and fully distributed and does not require convergence time for exhibiting a community-like structure and weak ties a geometric random network. To overcome the restriction of not being able to add links to the network topology, we focused on the clustering coefficient. The clustering coefficient expresses the probability that two neighbors of a node are neighbors themselves. The definition of the clustering coefficient might induce that more links in each nodes neighborhood result in a higher clustering coefficient. Our approach, however, is based on the observation that even the removal of dedicated links can increase the global clustering coefficient. As results we show that increasing of the local clustering coefficients by removing dedicated links promotes the emergence of weak ties in a network.

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**10:50 – 11:10**                      **ROOM: VERMELHO**  
**COFFEE BREAK**

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**11:10 – 12:30**                      **ROOM: MONIZ ARAGÃO**  
**COMMUNITY STRUCTURE**

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#### **(11:10) Uncovering Overlapping Community Structure**

Qinna Wang, *Université de Lyon, France*  
Eric Fleury, *Université de Lyon, France*

Overlapping community structure has attracted much interest in recent years since Palla et al. proposed the k-clique percolation algorithm for community detection and pointed out that the overlapping community structure is more reasonable to capture the topology of networks.

Despite many efforts to detect overlapping communities, the overlapping community problem is still a great challenge in complex networks. Here we introduce an approach to identify overlapping community structure based on an efficient partition algorithm. In our method, communities are formed by merging peripheral clusters with cores. Therefore, communities are allowed to overlap. We show experimental studies on synthetic networks and real networks to demonstrate that our method has excellent performances in community detection.

**(11:40) Communities Unfolding in Multislice Networks**

Vincenza Carchiolo, *University of Catania, Italy*  
 Alessandro Longheu, *University of Catania, Italy*  
 Michele Malgeri, *University of Catania, Italy*  
 Giuseppe Mangioni, *University of Catania, Italy*

Communities structure detection in complex networks is a research field that gained a considerable attention in the last few years. Such interest is due to the possibility to discover hidden behaviors by simply studying the network partitioning into communities. In literature there exist several methods to address the problem of community uncovering. However, few of them consider the more general case of communities in time-dependent and/or multiplex networks. On the other hand, networks whose topology evolves over time are quite common. In this case, studying the community structure simply considering the network obtained by "summing" all the network variations across time can be too simplistic, thus not permitting to explore the temporal evolution of communities. To address this problem, recently Mucha et al. presented a general framework to study the community structure of arbitrary multislice networks, i.e. a set of individual networks linked together by the use of inter-slices links. Multislice networks are general enough to be used to model time-varying, multiplex and multiscale networks. To assess the quality of a given partition into communities, Mucha et al. presented an extension of the modularity function ( $Q_{NG}$ ), to be applied to the more general case of multislice networks ( $Q_{multislice}$ ). A natural way to explore communities structure in multislice networks is by direct optimization of the  $Q_{multislice}$  function. Unfortunately, it has been shown that exact optimization of the  $Q_{NG}$  modularity function is an NP-complete problem, and a similar problem is also present in  $Q_{multislice}$  function. To deal with the problem of discovering community structure in very large networks, several approximation methods have been developed. Among them, that devised by Blondel et al. is one of the fastest algorithm, although sufficiently accurate. In this work we present an algorithm to uncover communities in large multislice networks.

**(12:05) Fast Community Detection For Dynamic Complex Networks**

Sanjukta Bhowmick, *University of Nebraska, USA*  
 Shweta Bansal, *The Pennsylvania State University, USA*

Community detection is an important branch of network analysis and has been studied in the context of many biological, social and technological networks. Most community detection algorithms have been confined to static networks, where nodes and edges remain unchanged. However, the interaction of real-world complex networks are more fluid, the connections between nodes can change and a dynamic representation better reflects the reality. There are not many community detection methods focused towards dynamic networks. Though consequent temporal configurations of a dynamic network vary by only a small amount, most community detection methods treat each

configuration as a separate network.

The information regarding communities from the previous configuration is not used and the communities have to be recomputed as a whole, requiring redundant computations. In this paper, we develop a fast community detection algorithm for dynamic networks. Our algorithm is based on storing information about communities generated in the previous configuration, thereby enabling us to bypass computations associated with the unchanged portion of the graph. Our preliminary results show that our dynamic community detection method can improve over the static algorithm by as much as 20%.

**12:30 – 14:00 ROOM: VERMELHO**  
**LUNCH BREAK**

**14:00 – 14:30 ROOM: MONIZ ARAGÃO**  
**COMPLENET 2011 ORGANIZATION MEETING**

**14:30 – 15:20 ROOM: MONIZ ARAGÃO**  
**INVITED TALK**

**Networks, Communities and Kronecker Products**

Jure Leskovec, PhD  
 Computer Science Department  
 Stanford University  
 Stanford, CA 94305-9040 USA

**15:20 – 16:10 ROOM: MONIZ ARAGÃO**  
**APPLICATIONS**

**(15:20) Using Networks to Understand the Dynamics of Software Development**

Christopher Roach, *Apple Inc., USA*  
 Ronaldo Menezes, *Florida Institute of Technology, USA*

Software engineering, being a relatively new field (the term having only first formally appeared in a 1968 NATO publication), has been struggling to find ways of gauging the success/failure of development projects. The ability to determine which developers are most crucial to the success of a project, which areas in the project contain the most risk, etc. has remained elusive thus far. Metrics such as SLOC (Source Lines of Code) have been used in the past, and continue to be used, to determine the efficacy of individual developers on a project but have many well documented deficiencies. In this work, we propose a new way to look at software development using complex network theory, we examine one large open source software development project---the Python programming language---using networks to explain and understand the dynamics of the software development process.

Past works have focused on the open source community as a whole and the relationships between the members within, this work differs in that it looks at a single project and studies the relationships between the developers and the code they create. We begin our analysis with a description of the basic network characteristics of the project. We follow with the main contribution of this work which is to examine the quality of the code correlated with the network measures of the developers such as degree centrality, betweenness centrality, etc. Lastly we look at community formation and how membership to certain communities influences the quality of the code committed by a developer to the project.

### **(15:45) Speech Polarity Detection using Complex Networks Measures: First Explorations**

Renato Fabbri, *Universidade de São Paulo, Brazil*

Diego Amancio, *Universidade de São Paulo, Brazil*

Luciano da F. Costa, *Universidade de São Paulo, Brazil*

Oswaldo N. O. Oliveira Jr., *Universidade de São Paulo, Brazil*

This research is aimed at developing speech characterization methods based on complex network concepts. Sequential acoustic information extracted from speech signals, including fundamental frequency, amplitude, harmonics, articulation (e.g. phonemes per second and silences), jitter and shimmer, has been mapped onto complex networks. The metrics obtained from these networks will be used to identify emotions, which could be advantageous in comparison to traditional statistics methods that are normally based on simple measures such as mean, standard deviation, median, quartiles and range. The latter measures do not take into account the sequence in which the measurements are presented, which is critical for human perception and production of nuances, including emotive clues. As a first approach, we are concentrating on fundamental frequency evolution of spoken instances for polarity recognition, as a way to explore the specific contribution of pitch in expression and perception of emotion. An accuracy of up to 72% is currently reached by our results in recognizing polarity (negative/positive emotion) using the graph label propagation semi-supervised learning technique, and with single speaker utterances classified into positive and negative instances by a single human judge. It is hoped to determine which fractions of the utterances can be correctly recognized using only complex networks measures and which require additional measures. The possibility to use machine-learning methods with a large number of complex network metrics is promising for obtaining high accuracy in classification of distinct types of emotion.

**16:10 – 16:30**

**ROOM: VERMELHO**

**COFFEE BREAK**

**16:30 – 17:25**

**ROOM: MONIZ ARAGÃO**

**NETWORK MODELING**

### **(16:30) Structure-dynamics Interplay in Directed Complex Networks with Border Effects**

Lucas Antiquiera, *Universidade de São Paulo, Brazil*

Luciano da Fontoura Costa, *Universidade de São Paulo, Brazil*

Sergei Taraskin, *University of Cambridge, UK*

Despite the large number of structural and dynamical properties investigated on complex networks, understanding their interrelationships is also of substantial importance to advance our knowledge on the organizing principles underlying such structures. We use a novel approach to study structure-dynamics correlations where the nodes of directed complex networks were partitioned into border and non-border by using the so-called diversity measurement. The network topology is characterized by node degrees being the most direct indicator of node connectivity, while the dynamics is related to the steady-state random walker node occupation probability (called here node activity). Correlations between degree and activity were then analyzed inside and outside the border, separately. The obtained results showed that the intricate correlations found in the macaque cortex and in a WWW subgraph are in fact composed of two separate correlations of in-degree against the activity occurring inside and outside the border. These findings pave the way to investigations of possibly similar behavior in other directed complex networks.

### **(17:00) Generating Power Law Distribution of Spatial Events with Multi-agents**

Vasco Furtado, *Universidade de Fortaleza, Brazil*

Douglas Oliveira, *Universidade de Fortaleza, Brazil*

The automated generation of events that follows a Power Law (PL) distribution has been extensively researched in order to mimic real world phenomena. Typically, the methods pursuing this goal consist of a unique generating function able to reproduce the inner features of PL distributions. On the contrary, most events that follow a PL distribution are produced through the interaction of different and distributed agents, which are often independent, autonomous, and have a partial perception of the world that surrounds them. In this paper, we investigate the circumstances in which multiagents, in particular their communication mechanisms, produce spatial events that follow a PL. We are going to focus on models in which the agents behavior is based on the ant colony optimization algorithm. We show that restricted models of agent communication based exclusively on pheromone exchange require an extension to represent direct communication in order to generate PL data distributions.

**END OF COMPLENET 2010 EVENT!**

**THANK YOU FOR YOUR PARTICIPATION**

**AND**

**HOPE TO SEE YOU NEXT YEAR!**

## CONFERENCE VENUE

# FÓRUM DE CIÊNCIA E CULTURA UFRJ

CompleNet 2010 will be held at the Forum of Science and Culture in Rio de Janeiro, Brazil. The Forum is one of the most significant buildings of the Federal University of Rio de Janeiro, formerly known as University of Brazil. The main purpose of the Forum is to integrate research education and outreach activities, in a general effort to share knowledge, and create a network to aid the exchange of ideas between academia and society in the areas from science, the arts, and politics.

Since its inception, in the early 70s, the Forum is based at the University Palace in Praia Vermelha Campus. The building portrays the beauty of neoclassical architecture lies between the beach on one side and the mountains on the other. It is located only 5 minutes from Copacabana beach, where there is a great offer of hotels of all categories and also walking distance to one of best shopping centers of Rio de Janeiro. The Forum is also located only 15 minutes walk to the Sugar Loaf, one of the most famous tourist locations in Rio.



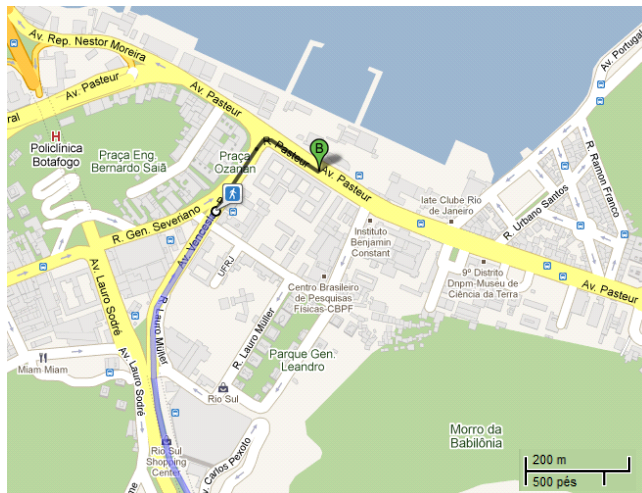
The workshop will be held at the Moniz de Aragão room, located on the second floor. The Moniz de Aragão room has 87 square meters and holds up to 120 people. It has been used in the past for book releases, receptions with cocktails, small exhibitions, and musical performances. The name honors the first president of the Federal University of Rio de Janeiro and Minister of Education and Culture, Moniz de Aragão. When the Palace went to the University, the hall was redesigned to house the University Council



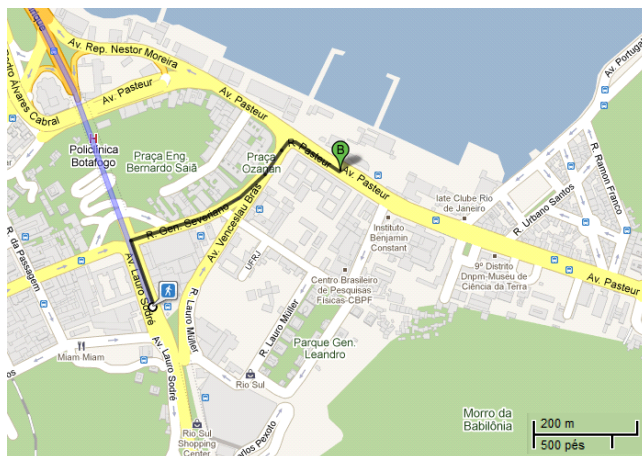
## HOW TO GET THERE

The Forum is located at Pasteur Avenue, 250 - 2° floor, Urca. Tel: 2295-1595.

Coming from Copacabana or Ipanema by bus, go down at the Venceslau Brás street, just after the Rio Sul Shopping, and continue by walking turning at right on Pasteur Avenue. Coming by the 512 line, go down at Pasteur Ave., just after the Forum main entrance.



Coming from Flamengo or Downtown by bus, go down at the Lauro Sodré Avenue, near the Rio Sul Shopping and continue by walking on Venceslau Bras street, turning at right on Pasteur Avenue.



Coming from Botafogo or by the subway (Metro Rio), take the bus line 511A (Integração - Urca) and get off at Pasteur Avenue just after the Forum main entrance.

