from LAB to SOCIETY - Opportunities in Complexity

PhD 'Research in Progress' III

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Organisers

David M.S. Rodrigues (Lisbon University Institute, School of Technologies and Architecture, PhD research student), dmsrs@iscte.pt
Larisa Mihoreanu (Kings College, London, Postdoctoral fellow)
Iain Kusel (Design Group, Open University, PhD research student)
Andrea Apolloni (ENS-Lyon, Postdoctoral fellow)
David Chavalarias (CREA, CNRS Researcher, Paris)
Mafalda Sampayo (Lisbon University Institute, School of Technologies and Architecture, PhD research student)
Yixian Song (Darmstadt University of Technology, Institute of Condensed Matter Physics, PhD research student)

Programme (Room Sem3)

Session 1

09:00 - Welcome Address
09:15 - M. Barons, F. Griffiths, N. Parsons, M. Thorogood - **A mathematical approach to medical complexity**
09:45 - A. Patil, A. Dongre - **Complexity of Built Environment in Public Realm**
10:15 - N. Caseiro, P. Trigo - **Emergency Management Concepts: A network approach**
10:45 - Coffee Break

Session 2

11:15 - M. Kovacs, A. Schaefer, K. Kratky - **The Effects of Yoga Breathing Techniques on Heart Rate Variability**
11:45 - J. Matos - **Organizational Crisis Preparedness and Response: from a Complex Network Model to a Complex Networked World**
12:30 - Lunch Break

Session 3

14:00 - B. Hassani-Mahmooi - **Conflict is Complex**
14:30 - F. Atun - **Transportation System Before, During and After a Natural Disaster in a Complex City Environment**
15:00 - A. Jarynowski, K.Kulakowski - **Should we cooperate of defect? Polarization of strategies in social games**
15:30 - J. Bacelar - Evolution of Retirement: Intergen**erational Cooperation and Strong Reciprocity**
16:00 - Coffee Break

Session 4

16:30 - P. Migdal, M. Denkiewicz, J. Rsczaszek-Leonardi, D. Plewczynski - **Three and more heads deciding: models of information-sharing and aggregation for two-choice discriminative tasks**
17:00 - Invited Talk - David Hales - **The social transformation and your role in it**
18:00 - Closing remarks

The social transformation and your role in it

By DAVID HALES (INVITED TALK) - OPEN UNIVERSITY, UNITED KINGDOM

Modern social systems have always been in a state of transformation. Today is no different. Indeed, recent events indicate that major social and economic transitions are in progress globally. What can complexity science offer in the way of increased understanding and practical application during turbulent times? What is the role of complexity scientists in these transitions?

I will discuss these questions with reference to some of my own work and interests involving the interplay of centralised (top) versus decentralised (bottom-up) control in social and technological systems.

I'll include reference to a) recent interlinked events such as the Wikileaks project, the financial crisis and the Arab Spring uprisings; b) technologies such as peer-to-peer systems, cloud computing and social software; c) social theory and models.

Message to Young Complex Systems Researchers

By PROFESSOR JEFFREY JOHNSON, PRESIDENT OF THE COMPLEX SYSTEMS SOCIETY

It is a great pleasure to introduce this ECCS'11 Satellite Meeting From Lab to Society organised by a new generation of researchers working towards masters and doctoral degrees. It is very impressive that over twenty researchers will present their work and I am sure it will be a great day.

The Complex Systems Society has a policy of encouraging researchers in the early stages of their careers. More than it ever was, science today is a team enterprise and it is essential to learn how to work with others, both organising research and doing it.

Our Society was started in 2005 and since then has been dominated by those with grey hair or none. We have done our best but we really need the energy and creativity of the next generation. This year there will be elections to the Council of the Society and I strongly hope that as many as possible of you will put your names forward and vote for each other. A strong representation of younger researchers can only be good for everyone.

This workshop is a wonderful example of what young researchers can achieve. It has now become an established forum at ECCS where you can present your work to a sympathetic audience who will generously help you by commenting on your ideas, suggesting new things that may be helpful, and helping you gain experience and confidence in your presentations. And you have an impressive range of things to talk about – medicine, the built environment, emergency management and preparing for crises, yoga and heart rates, transportation, cooperation and defection in social games, intergenerational cooperation and reciprocity in retirement, models of information sharing, networks, mathematics and much else.

Paradoxically, this wide range of systems is what binds us together. As complex systems scientists we are interested in the methods of science that enable the study of systems of systems of systems that may include many traditional domains. In the complex future that lies ahead, as complex systems scientists you will be well placed to find creative new solutions to new and unprecedented problems. Many of you will remain collaborators, colleagues and friends for the rest of your lives. I wish you all the best for the exciting times that lie ahead.

Transportation system before, during and after a natural disaster in a complex city environment

By F. ATUN - POLITECNICO DI MILANO – DIAP – SPATIAL PLANNING AND URBAN DEVELOPMENT, MILANO, ITALY

When the effects of a natural hazard combine with a complex city system which is consisted of numerous and diverse variables affected by each other, it turns into a disaster which creates serious human causalities, physical damages, economic and moral losses. The disaster risk depends on both the severity of hazard and pre-existing vulnerabilities in the area. Without making any changes on the ratio to hazard, risk could raise due to an increase in the physical, social, economic and organizational systems' vulnerabilities. Which means that when a city is hit by a disaster, having damages on the transportation system could serve to exacerbate the pre-existing conditions of vulnerability by being connected and interdependent to other sub-systems, such as economy, built environment, water, gas, sewage, electricity, communication and fuel supply.

"How ideas of complexity can be applied to transportation system to increase the resilience of the entire city system" is the starting question of this research. The hypothesis of this study is that with an understanding of the complex nature of transportation system and interdependent character to its own components and to other sub-systems in time (disaster phases: pre-disaster/emergency/post-disaster) and spatial scales (such as local and regional), a stronger and more sustainable transportation system could be achieved. The latter could significantly contribute to resilient of a city. By aiming to prove the hypothesis, this study focused on quite many case studies to understand the effects of natural disasters on transportation system.

In the complex environment of a city, there are some reasons which make transportation system so attractive to study. First of all, transportation system is large, complex and strongly interdependent system which covers the entire city. All the lifeline systems depend on the transportation system at different levels. On the other hand, components of the transportation system, such as roads and railroads, are strongly depended on the other systems. Secondly, transportation system often requires longer repair times than other lifeline systems, and this situation leads to long term economic impacts depending on loss of competitiveness, decreasing number of jobs and changes on the spatial pattern. Finally, the importance and the function of the transportation system are changing depending on the disaster phase and scale, although in every phase transportation system enables vehicular movement, flow of people and goods.

What is the main reason behind the damage after a disaster? Is it complexity?
In the disaster risk management literature failures as a result of a complex environment are described by many theorists from different point of views. All those theories constitute a framework to investigate the reasons behind

cities breakdown after a disaster (see White, 1936; Beck, 1992; Schneider, 1995; Balamir, 2001). However, even complex physical, economic and social networks are the factors amplifying the effects of a disaster, they also provide the opportunities to decrease the risk and increase the resilience of each system and the city. The overall aim of this study is to reveal these opportunities by focusing on the reasons of the transportation system's failures which are conditional on the complex nature of the city, and to provide solutions by introducing a methodology.

Problem Statement: The problems that need to be achieved during this study are threefold. First of all, the literature study states that the solutions are provided for single problems in the transportation system, such as strengthening a bridge, without considering its relation within the entire transportation network. Secondly, dealing with transportation system without considering its interdependent nature with other sub-systems and environments is another problematic issue which is considered during this study. Moreover, it can be said that the most problematic issue is not having interaction between the research community and society. The latter could lead to problems while trying to implement the achieving results of the study.

Chang and Nojima (2001) state that while much attention has been paid to understanding and predicting the performance of individual bridge structures under seismic loading, only recently have researchers begun to evaluate the performance of the transportation system as a whole. There are studies focusing on bridge's damage modelling (Rojahn et al. 1997; Werner et al. 1997), the costs associated with travel times (Werner et al. 1997), network traffic flows (Werner et al. 1997; Nojima, 1997; Wakabayaski and Kameda, 1992), transport cost, cost of operation the projects (Ponti, 2006), regional production losses (Shinozuka et al. 1998). However, there is a need to study more natural hazards to the transportation system by considering the relation of an individual transportation network with the entire transportation system. To be clear, it can be said that not considering the complex nature of the system while providing solutions and policies leads to new problems while trying to solve the existing point-shaped ones.

Aims: Within the overall aim of turning the complexity into an advantage instead of being a weakness for the transportation system to increase the resilience of a city, the research identifies the following specific aims. The first aim is to determine the needs of transportation system during diverse disaster phases (pre-, emergency and past-) and depending on the diverse disaster types (flood, earthquake, landslide etc.). The literature review starts with some case studies to understand nature and structure of transportation system with particular emphasis on vulnerabilities in diverse disaster phases and types. The second aim is to investigate failures on other systems due to the failures on transportation system and vice-versa by defining the internal and external components that interact and influence each other. Last but not least, the aim in this study has been to introduce complexity theory by using some insights of it for providing a way forward to deal with uncertain behaviour of the system due to interconnectedness of the existing components.

Significance of the study for selected audiences: In particular this study provides a way forward to handle the complex problems in the transportation system between the components existing in a city on the one hand and decision makers on the other hand. Thus, for engineers and urban planners the question is "what should be the methodology to solve the problems in the transportation system due to being hit by a disaster before its occurrence". For decision makers, or governmental authorities, the questions of "how to use the expert knowledge and implement it without being affected from the complex nature of governance", "how to provide funds for implementation of the policies" and "from where do a governmental authority start spending the provided funds" can be answered more easily by using the complexity theory which helps to identify the hidden connections in the system between single vulnerable parts which affect the whole system.

To conclude, this study proves that cities are dynamic complex systems, and providing solutions to their problems as they are static in their nature does not help to ensure their safety and security when a natural disaster is in the question. Moreover the results of the study comes up with a positive answer to the research question and introduces a way to prove the hypothesis. As a final statement, one more time it would be said that with an understanding of the complex nature of transportation system, a strong and sustainable transportation system could contribute to resilient of a city.

Evolution of retirement: intergenerational co-operation and strong reciprocity

By S. BACELAR - ISCTE-IUL, LISBON UNIVERSITY INSTITUTE, LISBON, PORTUGAL

Retirement is a special case of intergenerational cooperation, where young workers agree to pay the pension of retired people in return for the promise that the next generation of workers pays for their pension. Retirement pensions (PAYG) are a stream of payments that redistribute income between 'total strangers', from the younger generation to the older, with the approval of the electorate. Mainstream Economics, based on the assumption of a selfish human motivation, has some difficulty to explain the reason why people vote for that redistribution. The reason why people support welfare state and intergenerational cooperation is because it conforms to the behavioral schema of strong reciprocity, that differs from self-interested forms of cooperation. Experimental evidence proves that strong reciprocity is a better explanation for the motivations to support welfare state than homo economicus or altruism. Strong reciprocators adopt strategies of conditional cooperation and conditional punishment. They evaluate the fairness of retirement related behavior of other players, from the same generation or from the older generation and adjust their propensity to support redistributive policies. Low or non-contributors are punished, even if that implies a cost to retaliators. We want to build an over-

lapping generations agent-based model to show the aggregate behavior of individuals that generalizes the lifecycle model. Using a game-theoretic framework, preferences for reciprocity can be modeled based on the assumption that utility of player i depends both on own payoff and on the payoffs of other players. Reciprocal behavior consists of the reward of kind actions and the punishment of unkind ones. Retirement is usually regarded as a formal norm that is imposed top–down by the State to the individuals. Our bottom-up approach will try to grow the retirement norm, from a set of attributes and behaviors of interacting agents.

A mathematical approach to medical complexity

By M. BARONS, F. GRIFFITHS, N. PARSONS, AND M. THOROGOOD - COMPLEXITY SCIENCE DOCTORAL TRAINING CENTRE, UNIVERSITY OF WARWICK

Healthcare is a complex interaction of individual characteristics, treatment characteristics and organisational characteristics. Tailoring treatments to patients has potential to improve patients' quality of life and reduce resource consumption. In the UK, lower back pain has an annual period prevalence of 37% and costs the economy an estimated £1632 million (∼€2000 million), not including the cost of treatment. A clinical trial of a new, complex intervention for low back pain, which included a cognitive behavioural element, was shown to be clinically effective on average and cost effective. [Lamb et al, 2010] The power of mathematics is used to drive efficient and provably robust machine learning, which has the capacity to predict outcomes in the case of complex interactions, such as in healthcare. Using individual characteristics relevant to the intervention, latent class analysis produces models which cluster patients into subgroups. The choice of model is guided by statistical validation and comparison with qualitative descriptions of medically meaningful subgroups. Group membership has a significant association with clinical outcome suggesting potential for tailoring treatments to patients. Another approach, which captures nonlinear interactions between input variables, is to use an artificial neural network. A multi-layer perceptron with a single layer of hidden units is trained, tested and optimized, and used to categorize the patients' attendance, compliance and recovery. This is compared to the approach of a classification tree, more familiar to clinicians, and showed that the same input variables gave the best models.

Emergency Management Concepts: A network approach

By N. CASEIRO AND P. TRIGO - ISCTE/FCUL; IPCB – INSTITUTO POLITÉCNICO DE CASTELO BRANCO, PORTUGAL

The socio-technical systems that make part of our lives are subject to disturbances through disasters that can have serious consequences (at the limit, completely destabilizing the basis system). To deal with this situation modern societies have developed structures, tools and mechanisms that aim to reduce the probability of occurrence of these negative situations.

Good decision making is critical and information is needed when analyzing the environment for risks, when defining emergency plans, when training agents and society to deal with the foreseen accidents. All elements and people involved in the emergency cycle need to have a common mental structure to deal with information issues.

Our research goal is to identify and build a semantic base underlying the mental model from experts by using a collaborative web tool. Mental models, underlie how people structure concepts; how they relate them; which are the similarities and differences of these structures; what concepts they recall first and which concepts they associate with them.

The approach we propose merges both the power of collaborative web-based techniques and the use of social sciences methods to obtain the data, through questionnaire, that will allow to build a network of concepts.

We expect that, by aggregating all the answers, will allow us to deepen the analysis of the resulting network, to understand connections and main group concepts in this domain. Some of the research questions we want to address are:

- concepts with more commonalities/dissimilarities among participating subjects and from subjects with specific profiles;
- type and intensity of the relations defined;
- network coherence, by searching missing key nodes or relations.

Finally, an ontology will be developed based on the information gathered and applied in a real context to test the suitability of the application.

Should we cooperate of defect? Polarization of strategies in social games.

By A. JARYNOWSKI AND K.KULAKOWSKI - SMOLUCHOWSKI INSTITUTE OF PHYSICS, JAGIELLONIAN UNIVERSITY, CRACOW, POLAND

A simple model of the Prisoner Dilemma, which can imitate a mechanism of rapid norm change, is proposed. The setting is described by players acquiring reputation and evolving altruism, which in turn determine their choice of strategy. The probability of cooperation depends linearly, both on the player's altruism and the co-player's reputation. Collective behavior is introduced by altruistic optimism (punishment) and reputation reciprocity (fail). Agents can establish the best strategy in repeated games. The final, stationary probability of cooperation can vary sharply with the initial conditions and jumps to zero or one for some critical values. Specification of the rules as initial

conditions have impact on final states as well as on dynamics of the system. If only the reputation could vary[*] one would observe coexisting strategies but with altruism change all players choose only one strategy [Fig.]. In both approaches, payoffs are not relevant and only mutual interaction between players are significant. We also observe, that the transition state close to the boarder between the two regimes can be described as Gaussian cumulative distribution function.

The Effects of Yoga Breathing Techniques on Heart Rate Variability

By M. KOVACS, A. SCHAEFER, AND K. KRATKY - UNIVERSITY OF VIENNA, FACULTY OF PHYSICS, PHYSICS OF PHYSIOLOGICAL PROCESSES, VIENNA AUSTRIA

The human organism is a highly complex system of intertwined variables, their mutual dependence being not fully understood yet. To determine the impact of controlled breathing on some of these variables, our group has done research on the effects of specific yoga breathing techniques (Pranayama). For this purpose we recorded the electrocardiogram (ECG), blood volume pulse, thoracic and abdominal breathing amplitude, skin conductance and oxygen saturation during periods of rest, as well as during the performance of breathing exercises. Some of the 24 probands were yoga teachers with different levels of experience, others were students.

One focus of our analysis up until now is the heart rate variability (HRV) derived from ECG data, the most notable results being a significant decrease in heart rate after the application of breathing techniques, a stronger decrease of heart rate variance for higher adeptness levels of yoga and several differences regarding sex. Further analysis will include the thorough assessment of breathing activity: breathing rate variability (BRV) will be examined as well as possible correlations between HRV and BRV. Additional results concerning the evaluation of breathing data and skin conductance levels will be discussed at the conference.

We feel confident that this kind of interdisciplinary and intercultural research is crucial when it comes to exploring new ways of enhancing as well as preserving well-being and health.

Conflict is Complex

By B. HASSANI-MAHMOOI - MEDICAL UNIVERSITY OF VIENNA, VIENNA, AUSTRIA

In economic analyses, conflict, as an alternative to productive behaviour, had been neglected until almost forty years ago when researchers started to develop special frameworks to include unproductive activities and artificial transfers in their economic models. These frameworks are usually studied as the theory of production and conflict (P&C) where each agent allocates its resources between production and fighting and have been applied to study diverse issues ranging from matters in defence economics to topics about crime, piracy and terrorism. In this research, firstly I would review the current equation-based P&C models and then highlight their limitations in dealing with real world complexities. Later, a modular agent-based model is introduced with boundedly-rational agents who can allocate a fraction of their effort to predatory behaviour. The agents are capable of learning and optimizing their decisions using a genetic framework to select the best combination of allocation strategies. A Cobb-Douglas production function and a standard contest-success function are embedded in each agent with heterogonous attributes. The basic model is tested and the agentsí emergent behaviour has been shown to be adaptive. Then, I have enriched the model with different subjects of conflict, separate product and resource appropriation procedures, private and common resources and capacity for collaboration among agents to study the relations between resource scarcity and security. The model is run under different population, resource degradation and social network structure scenarios with different sets of initial conditions; both individual and Monte Carlo outputs are reported. The results show a high level of complexity in agentsí allocation behaviour with outputs ranging from no statistically significant allocation changes to widespread conflict in the environment supporting previous empirical findings that the main link between climate change and conflict is through changes in the distribution of resources rather than their overall availability.

Preparedness and Response: from a Complex Network Model to a Complex Networked World

By J. MATOS - ISCTE-IUL LISBON UNIVERSITY INSTITUTE, LISBON, PORTUGAL

The present research work in progress is focused on the impact of organizational design and business networking on organizational crisis preparedness and response. For this purpose an integrated approach making use of agent-based computer simulation, complex network theory and dynamic modelling is adopted and developed based on a complex adaptive system (CAS) paradigm perspective. A pervasive research theme lies in the tension between organizational efficiency-gain initiatives, frequently implemented at the expense of vulnerabilities that remain dormant until a crisis appears, and organizational resiliency, implying the allocation of resources often seen as diverted from their possible contribution to the firm's short-term competitive position improvement.

Conceived as a preliminary study at the intersection of a subsequent three-phase research process, the current initial research stage involves an agent-based model with interacting grid spaces of competing organizations, customers, and suppliers. Translating management theory concepts, like Porter's five competitive forces, to CAS

properties and mechanisms, the model is used to assess firms' ability to avoid and handle crises under different market turbulence conditions. The following research phases focus specifically on a multilayer organization performance perspective, on a supply chain and alliances network resiliency perspective, and on organizational dynamic crisis response from a business fitness landscape perspective.

Aiming to help closing the gap between management theory development and real-world business decision-making needs, the significant contribution that the present research may provide to a more sustainable business environment is addressed, specifically in the impacts resulting from organizations' improved capability to: (1) more adequately value the drivers of organizational resiliency and particularly the impact of crisis preparedness and response measures; (2) make a more insightful assessment of their available options considering the corresponding ordered-complex-chaotic transition context and competition-cooperation co-evolutionary dynamics; and (3) gain a better understanding of the short term benefits expected versus long term potential consequences faced.

Three and more heads deciding: models of information-sharing and aggregation for two-choice discriminative tasks

By P. MIGDAL, M. DENKIEWICZ, J. RŠCZASZEK-LEONARDI, AND D. PLEWCZYNSKI - DEPARTMENT OF PSYCHOLOGY, UNIVERSITY OF WARSAW, WARSAW, POLAND

Everyone who ever took part in a group decision making or problem solving, probably asked oneself whether it actually made any sense - wouldn't it be better if simply the most competent person made the choice? Put differently, the question is whether a group can outperform its most capable member. We investigate mathematical models for estimating performance of a group solving a two-choice task. In these models each trial is characterised by a single, continuous parameter, determining the difficulty of the trial. For a given participant or group we can then fit a psychometric function that describes his/hers/its performance. The models describe a relationship between group and individual functions. We also consider if data is collected all-at-once or as a dynamical process, when only small subgroups can communicate at a time. Our research follows Bahrami et al. (2010, Science), who provided deep introduction and model foundation for describing experimental data gathered from dyads (a pairs) of people solving difficult perceptual task. It turns out that in most models a groups outperform the most skilled member, as long as the performance difference is small. Furthermore, the hierarchical decision-making process decreases the performance only little, for the most realistic models. For every model we investigated the group performance is a product of a scaling factor depending of the group size (e.g. constant, square root, linear) and an average (arithmetic mean, quadratic mean or maximum) member performance. The paper is an invitation for an experiment, as it proposes how to distinguish different models of information-sharing and decision making in terms of simple and easily measurable quantities. By investigate the properties of the models one can determine, which group size and/or composition is most promising, prior to designing an experiment.

Complexity of Built Environment in Public Realm

By A. PATIL AND A. DONGRE - DEPARTMENT OF ARCHITECTURE AND PLANNING, VNIT, NAGPUR

Approximately 50,000 years of man's existence has undergone drastic transformation and is continuing in an exponential manner. Urbanisation of the commumnity is one of the most spectacular changes of our times. The rapid pace of urbanization is posing one of the greatest challenges of designing and managing our fast growing cities. The modernist approach of Architects and urban planners of the early 20th century came under criticism through the work of Jane Jacobs. The transformation in elements and disciplines of the city is much faster than the advancement in the process of urban design. The major effect of this is on public realm in urban areas which remains every ones responsibility and hence, no one's responsibility. This has resulted in declining quality of public realm primarily due to the disturbed equilibrium of use, user and used. The public realm is the best representation of urban chaos in Indian context. The quest is to know how to design, manage, build and control public realm as it increases in size and connectivity. The concepts from complexity science have potential of addressing this issue. Can complexity science aid urban designers in generation of coherence at smallest and most important scale of public realm in urban areas? These concepts can be systematically explored for analyzing complexity of built environment in public realm and identifying their potentials to harness the same. Varied concepts from complexity science and urban design explored simultaneously have substantial potential to equip urban designers with processes, which will ensure efficient predictability in public realm. Although the research will draw a lot of inputs from the peripheral fields the interest strictly remains in the field of urban design (built environment) and intends to develop model for addressing physical design issues related to the public realm. This complexity science based new approach is presently dominated by mathematical instruments and computational techniques which act as barrier for architects and urban designers. The need is to overcome this barrier. Any progress in this regard will enable us to develop appropriate public realm which is essentially used by urban population and enhance their experience. Adopting such developed models in practice in due course of time would be instrumental in improving the quality of urban life at large.