Student Conference in Complexity Science

Book of Abstracts
Social Systems

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Social Systems

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10:00 - 11:00   Language and Social Dynamics

Why not to learn from each other - A new approach to investigate the evolution of social learning

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Organisms strive to reduce uncertainty in their environment by gaining as much information about it as possible. Theory predicts that learning from others (social learning) is an adaptive strategy that avoids the high costs of private (asocial) learning. Animal studies, however, show that relying on asocial learning is far more common than theory predicts. Here, we present an agent-based model that simulates a producer-scrounger game where individuals have to compete over resources, i.e. rewards have to be shared by individuals that perform the same action. Although competition is an omnipresent property in nature it is missing in other learning strategy models. We show that the fitness of pure social learners decreases with its frequency and even falls below the fitness of pure asocial learners. We also show that the pay-off distribution affects the fitness of social learners. Thus, asocial learners benefit from normally distributed pay-offs, while social learners benefit from exponential pay-offs. We suggest incorporating competition and testing the effect of pay-off distributions in future learning strategy models to increase their biological relevance.

Measuring success in communication

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Conceptual spaces are a representation framework in which concepts are defined in terms of a set of attributes and an associated distance metric. Concepts are thus represented as convex regions within a conceptual space, which itself is made up of several feature dimensions. In this paper we describe a possible tactile conceptual space for an artificial fingertip. We then show how this space can be used in a language game, in which a population of autonomous agents co-evolves a set of shared tactile concepts. In particular, we have analysed a variety of textures and chosen two features to represent them. Given these features, we run simulations where agents use this conceptual space with a language model to communicate about the textures. Using a learning process to update their concepts based on the assertions of others, these agents can coordinate the way they describe the textures they observe.

Vocabulary growth curves: from random to real books

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The study of language from a quantitative perspective has its roots in the late 19th century and has since never ceased, being embraced in recent years by the complexity community. In this work we cast doubt in the compatibility of two of its most basic laws: Zipf's law and Heap's law. The former, undoubtedly the most well-known and studied fact in the field, states that the number of different words with a given frequency follows a power-law distribution with an exponent γ close to 2; the latter, also known as Herdan's law, states that the number of different words $V(l)$ in the first l words of a corpus also follows a power law, $V(l) \propto l^\alpha$ with $\alpha < 1$. Using very simple mathematics, we will show that both laws cannot hold simultaneously for random texts, at least in a strict sense. By constraining the distribution of frequencies to be a pure power-law, we will derive the expected growth of the vocabulary $V(l)$, showing that the resulting function is not a power-law. Our results consistently hold not only for simulated random texts, but also for the case of real texts. In both cases, the observed curves $V(l)$ show a clear bending or concavity in log-log space, which our solution accurately captures, and which is at odds with the classic power-law formulation of Heap's law.

11:20 - 12:20   Society and Technology

IN SEARCH OF A MODEL OF HUMAN DYNAMICS ANALYSIS APPLIED TO SOCIAL SCIENCES

Dalton Martins, Universidade Federal de Goiás, Brazil (dmartins@gmail.com)

The study of Social Systems, particularly what we call human dynamics, is essentially a multidisciplinary field and requires the establishment of research approaches that take account of their complexity. The objective of this research is to present a field of analysis that consider 3 dimensions for analytical research and development of new knowledge about social systems focusing on human dynamics. These dimensions are referred to in this proposal as a philosophical mathematical and technological dimensions. The philosophical dimension seeks to connect explanatory models of human behavior, focusing specifically on the biopolitics of Michel Foucault and further developed and updated by Toni Negri and Michael Hardt, and the historical materialism of Karl Marx updated by current discussions of David Harvey. The mathematical dimension seeks to articulate principles of statistics, especially multivariate analysis, in addition to social networks analysis and complex systems as a way to operationalize the abstract concepts used by the philosophical dimension. The technological dimension proposes ways to use technology, such as programming language, spreadsheet and graphic design tools as a way of creating images, representations and ways of showing what the mathematical dimension allows operationalize.

We used these 3 dimensions in the production of researches in the area of public policy, particularly in the areas of social welfare and health. There is substantial evidence that the articulation of these dimensions has allowed us to create new concepts and mathematical operators, such as transversallity index hierarchical coefficient, among others . We believe that only by expanding the dimensions of analysis you can perform innovative research and new concepts and ways to operationalize these concepts that produce new ways of understanding the social systems.

ANATOMY OF SCIENTIFC EVOLUTION

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The quest for historically impactful science and technology provides invaluable insight into the innovation dynamics of human society, yet many studies are limited to qualitative and small-scale approaches. Here, we investigate scientific evolution through systematic analysis of a massive corpus of digitized English texts between 1800 and 2008. Our analysis reveals remarkable predictability for long-prevailing scientific concepts based on the levels of their prior usage. Interestingly, once a threshold of early adoption rates is passed even slightly, scientific concepts can exhibit sudden leaps in their eventual lifetimes. We developed a mechanistic model to account for such results, indicating that slowly-but-commonly adopted science and technology surprisingly tend to have higher innate strength than fast-and-commonly adopted ones. The model prediction for disciplines other than science was also well verified. Our approach sheds light on unbiased and quantitative analysis of scientific evolution in society, and may provide a useful basis for policy-making.

UNDERSTANDING INFRASTRUCTURE, SHARED RESOURCES AT ALL BIOLOGICAL LEVELS

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As human societies and economies have grown in scale, scope and complexity they have come to be ever more reliant on infrastructures. If defined simply as "shared means to many ends" (sensu Brett Frischmann) then the notion of "infrastructure" can include many of the things we traditionally regard as infrastructure, such as transport systems, utilities and communications networks. In addition we can easily conceive of more abstract infrastructures, such as the internet, legal systems and common-pool resources. Existing approaches in economics and the social sciences have not systematically the topic of infrastructure, especially in its broader sense. However, simulation models and other dynamic systems approaches can help to illuminate the important and subtle role that infrastructures play in the development and stability of complex adaptive socio-technological systems.

14:00 - 15:00   ABM: Human-natural Systems

ABM IN DIGITAL HUMANITIES: THE CASE STUDY OF THE MOVIUS LINE

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The Movius Line controversy is one of the most persistent research themes in Early Palaeolithic Archaeology. A number of hypotheses have been put forward to explain the pattern of the spatial distribution of Mode 1 and Mode 2 industries. It has been suggested (Lycett & Von Cramon-Taubadel 2008; Lycett & Norton 2010) that in areas further away from the origins of the first 'Out of Africa' dispersal the population density was lower than in the zones closer to Eastern Africa. As a result, smaller and less well connected human groups could not sustain the sophisticated technological knowledge necessary to produce Mode 2 implements and reverted to simpler knapping strategies i.e. Mode 1.

An Agent-based model was developed to test the above hypothesis. It consists of an paleoenvironmental reconstruction of the Old World coupled with a dynamic simulation of the sea level fluctuations in which large areas of dry land would occasionally (on a geological time scale) become submerged and reappear due to climatic changes, acting as an 'environmental pump' driving human movement. The goal of this study is to compare population density in the Acheulean and Oldowan regions throughout the simulation to evaluate if the proposed demographic disparity between the two regions is plausible. If, under a wide sweep of parameters informed on contemporary hunter-gatherer but also mammalian data, the model will show no differences between the Mode 1 and Mode 2 areas in terms of population density then the aforementioned hypothesis can be rejected.

References: Lycett, S. J., and C. J. Norton. 2010. "A Demographic Model for Palaeolithic Technological Evolution : The Case of East Asia and the Movius Line." Quaternary International 211 (1-2) (January): 55–65; Lycett, S. J, and N. Von Cramon-Taubadel. 2008. "Acheulean Variability and Hominin Dispersals : a Model-bound Approach." Journal of Archaeological Science 35: 553–562.

INSIGHTS TO PAST MIGRATION BEHAVIOUR IN THE MALDIVES

Laurens Speelman, University of Southampton, UK (lhs1e11@soton.ac.uk)

Impacts of climate change for low-lying islands will almost certainly include accelerated coastal erosion and increased flooding from the sea. Resettlement has often been mentioned as a potential adaptation option to sea-level rise on these islands. Previous studies focused on calculating the potential number of environmental refugees by directly projecting physical impacts on coastal societies. However, there are many social, economic and environmental factors involved in migration decision-making and to date there has been limited effort to investigate migration behaviour in low-lying islands. Based on demographic, socio-economic, and environmental datasets this paper explores historic migration behaviour in the Republic of Maldives. Careful analysis of this new dataset shows that addition to classic migration determinants such as level of education, age, employment and health; factors such as vulnerability to storm surges and impacts of the 2004 Boxing Day tsunami are also important in predicting migration behaviour in the Maldives.

THE USE OF PARTICIPATORY APPROACHES AND AGENT-BASED MODELLING TO EXPLORE THE COMPLEXITY OF FOOD SECURITY WITHIN RURAL MALAWI.

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Food security remains a deep seated issue throughout Sub-Saharan Africa. Within Malawi, the vast majority of the rural population are engaged in subsistence farming. Continued reliance upon rain-fed agriculture renders smallholders vulnerable to climatic shocks, whilst high population densities, small plot size and poor soil quality further compound food insecurity. In order to elicit greater understanding of the complex behavioural decisions and coping strategies undertaken by subsistence farmers, simulation techniques have been proposed as a potential tool. Agent-based modelling (ABM) is one possible technique, which comprises a computerised simulation of agents located within an environment. ABM can be categorised as abstract, experimental, historical or empirical depending on the type of rules they abide

by. The aim here was to determine whether results from participatory exercises could be utilised in the construction of an empirical ABM. A participatory rural appraisal (PRA) exercise was designed to elicit greater understanding of smallholder responses to drought; as well as the perceived impact of government interventions in the form of input subsidies. Results from participatory field work were successfully incorporated into an agent-based model of Malawian smallholders. However, scarce availability of data was identified as a key factor undermining model integrity. Initial implementation of the model found inferences could be made concerning the impact of policy upon household decision making and food security. Overall the project provides fertile ground for future work. It is hoped that by integrating PRA exercises and ABM it will be possible to create a collaborative framework which promotes interaction between scientists, policy makers and stakeholders, alike.

15:00 - 16:00 ABM: Epistemology and Methods

"BUT ALL MY FRIENDS DO IT!" - EVIDENCE FOR A THRESHOLD MODEL OF SOCIAL CONTAGION

Daniel Sprague, University of Warwick, UK (D.A.Sprague@warwick.ac.uk)

In human society, some trends and behaviours die out quickly, while others explode in popularity: some bands gain fans and become huge hits, while others stay obscure. Much of collective social behaviour shows these highly variable, unpredictable outcomes. There have been attempts to model this and similar phenomena, using ideas such as preferential attachment, but they are generally agent-based or Monte-Carlo models, which are therefore difficult to fit to data, or they are empirical generalisations of data without a firm underlying model. Instead, we use a simple model for social influence based on ‚complex contagion‘, in which individuals canvas a small number of friends; if more than some threshold number of these friends are taking part in the behaviour or trend then the individual is much more likely to also take part. We combine these ideas with the SIR model of an epidemic to obtain a simple, low-dimensional model of the spread of a trend, which we then fit to internet search data to show that ‚complex contagion‘ is a better model for social trends than a simpler, linear model of contagion.

DECIDING TO DISCLOSE: PREGNANCY AND ALCOHOL MISUSE

Jonathan Gray, University of Southampton, UK (j.gray@soton.ac.uk)

In this paper we examine the feasibility of Bayesian games played by populations of decision theoretic agents as an approach to Agent Based Modelling (ABM). The use of explicit and theoretically grounded models of decision making is intended to address concerns about the perceived ad hoc character of ABM. Taking alcohol consumption during pregnancy as an exemplar, we apply a combination of agent based modelling and decision theory to explore a scenario where a population of pregnant women choose how far to disclose their drinking patterns to their midwives.

This is explored through an agent based model of a set of stylised scenarios, where populations corresponding to pregnant women and midwives play a series of games. In each game, the woman chooses to claim a level of alcohol consumption, and their midwife chooses whether to refer them to a specialist. Both players employ a simple decision rule using information from previous rounds to choose their actions. Midwives attempt to refer only women who need treatment, and women endeavour to avoid being stigmatised for their drinking behaviour while still receiving appropriate treatment.

There are two key questions addressed in this work: firstly how far a relatively abstract decision theoretic agent based model is able to capture the dynamics at play in a complicated, and opaque real world situation; secondly, to investigate how information sharing within the two populations affects overall behaviour. The simulation model is able to produce a number of qualitative trends described in the literature, in particular an increased tendency to disclose as women have more encounters, and greater underreporting of consumption by heavy drinkers. The results also demonstrate that how the decision making is operationalised in such models, is an important decision in itself.

Gaussian process emulators for Bayesian uncertainty and sensitivity analysis and calibration of agent based models

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The analysis of Agent Based Models (ABMs) is often complicated. Large parameter spaces; non-linearities and feedback; stochasticity; long run-times; and uncertainty in input variables are just some of the obstacles faced by those attempting to makes sense of their models. Gaussian Process Emulators offer a way avoid some of these difficulties by creating a flexible statistical model of the simulation based on a relatively small sample of training runs. Simulator outputs can then by inexpensively estimated by the emulator. A Bayesian framework allows uncertainty around input parameters to be reflected in the distribution in the model output. A sensitivity analysis can also be conducted by examining reduction in output variance achieved by observing a parameter or collection of parameters.

This work examines the utility of Gaussian Process Emulators as a tool for the analysing and calibrating agent-based social models, using a simple example. The advantages and the limitations of such an approach are assessed, and the paper concludes with a discussion of how ABMs might be used in combination with Gaussian Process Emulators to make policy choices in situations of uncertainty within a decision-analysis framework.