Northwestern Institute on Complex Systems

Complexity Conference

March 28 – 29, 2007
Titles & Abstracts

Group I: Networks and Chains – Suppliers and Customers

David Simchi-Levi, Massachusetts Institute of Technology
"Managing Risk in Complex Supply Chains"

Recent industry trends, including outsourcing, offshoring and lean manufacturing that focus on reducing supply chain costs, significantly increase the level of risk in the supply chain. At the same time, a number of leading companies have been successfully transforming their supply chains into robust and resilient supply chains. In this presentation, we examine sources of risks in the supply chain, identify strategic and tactical strategies that help manage risk while creating value and improving supply chain performance, and report on case studies that illustrate the impact of these strategies.

Duncan Watts, Columbia University
"The Paradoxical Nature of Success in Cultural Markets: An Experimental Approach"

Cultural objects, like movies, books, and music, vary greatly in their success, suggesting that successful and unsuccessful objects are qualitatively different; yet, paradoxically, success in cultural markets appears highly unpredictable. In this talk I argue that social influence, in the form of information about the decisions of others, can resolve the paradox. To explore the counterintuitive effects of social influence, I will discuss the results of a series of four experiments (total n = 27,267), conducted via a website where subjects could listen to and download new pop songs. By controlling the information that subjects received about the behavior of others, we observed directly the effects of social influence, finding that it increased the inequality and the unpredictability of outcomes simultaneously; and that under some conditions the perceived success of a song became a self-fulfilling prophecy.

Group II: Cortical Neural Circuits – Structure and Function

Marcus Kaiser, PhD, School of Computing Science, Newcastle University, United Kingdom
"Brain Networks: How the Spatial and Modular Organization Enables Fast and Specialized Processing"

Many real-world networks, including the brain, show properties of small-world and scale-free networks [1]. Are there general principles that shape the network organization of neural systems? For the last decade, it was thought that saving resources should be the most important constraint for the brain. Similar to power-lines, establishing connections in the brain over a long distance consumes considerable resources both for establishing the connection as well as for propagating signals over the 'cable'. Therefore, long-distance connections should be avoided wherever possible. However, recent studies show that there are more long-distance connections than would be expected if saving resources was the only constraint [2]. These long-distance connections help to reduce path lengths in neural system and thus the number of intermediate processing steps. Indeed, a low number of intermediate processing steps, leading to a faster reaction time, higher synchronization, and better performance, was found to be more important than saving resources. The competition between different constraints also influences how robust neural networks can be. As for other biological networks, the brain is remarkably robust toward damage. But does this mean that the brain is optimized to be as robust as possible? I will outline that too much structural robustness harms the performance of the brain and indeed of all networks where nodes realize different functional roles.

References: [1] Sporns, Chialvo, Kaiser, Hilgetag (2004) *Trends in Cognitive Sciences* 8: 418-425
[2] Kaiser, Hilgetag (2006) *PLoS Computational Biology* 7:e95
More information can be found at: http://www.biological-networks.org/

Dietmar Plenz, NIH
"The organizing principles of neuronal avalanches: cell assemblies in the cortex?"

Neuronal avalanches are spatiotemporal patterns of synchronized activity that occur spontaneously in superficial layers of the mammalian cortex under various experimental conditions. These patterns reflect fast propagation of locally synchronized activity, display a rich spatiotemporal diversity, and recur over several hours. The statistic governing pattern sizes is invariant to the choice of spatial scale demonstrating that the functional linking of cortical sites into avalanches is described by a precise, fractal organization. These features suggest an underlying network of neuronal interactions that balances diverse representations with predictable recurrence, similar to what has been theorized for cell assembly formation. I propose that avalanches reflect the transient formation of cell assemblies in cortex and discuss various models that provide mechanistic insights into the underlying dynamics, suggesting that they arise in a critical regime.

Ivan Soltesz, UC Irvine
"Topological Determinants of Mammalian Neuronal Circuit Function and Dysfunction"

Within the last decade, large amounts of high-quality experimental data have become available on the precise connectivity and detailed functional properties of mammalian neuronal networks. These experimental data allow us to build highly realistic, structural and functional models of neuronal microcircuits, reflecting both healthy and diseased states. Building on insights provided by recent topological studies of biochemical and social networks, the electric grid, the internet, and the simpler nervous system of worms, we characterize the architectural properties of these anatomically and biophysically highly realistic virtual networks at unprecedented resolution. Subsequently, we test the functional relevance of network topologies using large-scale multicompartmental models. Such data-driven computational modeling approaches reveal the topological organizing principles of neuronal microcircuits, and demonstrate the importance of structural changes in neuronal networks in diseased states such as temporal lobe epilepsy.

Group III: Firms and Markets

Robert Axtell, Krasnow Institute for Advanced Study, George Mason University
"Firms Far From Equilibrium"

The existence and availability of comprehensive micro-data on firms is reshaping our basic understanding of the organization of economic activity. In lieu of conceiving of the economy as composed of many 'representative' firms, we now understand that firm sizes are so skew that no truly typical firm exists. Concerning firm growth, the data on the universe of all firms reveal that fluctuations are much more heavy-tailed than previously known, resembling qualitatively the character of financial returns. In this talk I will describe a multi-agent model of firm formation and growth capable of reproducing these facts about firms. I prove that the process of coalition formation in the model leads to dynamically-unstable (Nash) equilibria as agents constantly adjust how hard they work in response to their co-workers' efforts. Giving agents the ability to seek jobs with other firms as well as start-up new firms leads to perpetual change and adaptation at the agent level, metastable firms, yet stationary statistics at the aggregate level. I will argue that the self-organization of individuals into firms is a compelling example of the complex adaptive systems approach to economics.

J. Doyne Farmer, Santa Fe Institute
"Explaining Supply and Demand: Structure vs. Strategy"

In the last half century economics has focused increasingly on the strategic interactions of agents, embodied implicitly or explicitly in terms of game theory. There are some situations, however, where other factors may dominate, such as the emergent dynamics of the interactions of the players, or structural constraints on their interactions such as those imposed by institutions. Standard examples of social systems where this is true are traffic and crowd dynamics; in both cases the useful theories are much more like models of fluid flow than neoclassical economics.

I will discuss some new examples involving standard problems in economics. In particular, I will present a theory for market impact in financial markets, which is a close cousin of the excess demand function (i.e. demand - supply). The theory is based on understanding how individual fluctuations in supply and demand aggregate in time. The underlying idea that explains the shape of the market impact function for large numbers of transactions is a generalization of the central limit theorem. Testing the theory against data from the London and New York stock exchanges shows that the data fit the model extremely well. Strategic interactions as reflected in market efficiency cause important adjustments in the predictions of the model, but the dominant effect comes from understanding the structure and dynamics of the aggregation process. Time permitting, I will also give a very brief summary of a simple agent-based model suggesting that the fluctuations in supply and demand can only be understood by modeling the institutional constraints imposed by the continuous double auction.

Felix Reed-Tsochas, Oxford University
“The Dynamics of Decline and Collapse in a Complex Network of Firms”

The by now very substantial body of literature across disciplines on the dynamics of complex networks has to date restricted itself almost entirely to models of network growth. Growing networks such as the internet clearly play an important role in modern life, but the opposite process of network contraction should not be ignored since it is relevant to many social, economic, and ecological networks. In this talk I will focus on a specific empirical example, the network of firms in the New York Garment Industry over a period of almost 20 years. The New York Garment Industry declined from a vibrant economy with over 3000 production and design firms in the mid 1980s to about 200 firms in 2003. Over this period a dataset of 700,000 transactions allows us to track how the network of relationships between firms evolved as the firm population decreased by an order of magnitude. I will discuss our empirical findings, with a particular focus on the surprising topological robustness that this network exhibits while declining. This robustness depends on a combination of specific deletion and growth mechanisms that we have identified for the network’s nodes and links. These mechanisms are incorporated in a general model of network contraction, which is able to replicate our empirical results. The model also provides us with new insights about mechanisms that can promote robustness in declining networks.