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ADVANCE COMMUNICATION

Northwestern Institute on Complex Systems

Complexity Conference: "Agents and Networks"

Featuring:
Lada Adamic[1], Katy Börner[2], Carter Butts[3], Joshua M. Epstein[4], Nigel Gilbert[5], Michael Macy[6] , James Moody[7], Garry Robins[8], Paul Torrens[9]

[1]University of Michigan; [2]Indiana University; [3]University of California, Irvine; [4]The Brookings Institution; [5]University of Surrey; [6]Cornell University; [7]Duke University; [8]The University of Melbourne; [9]Arizona State University

Abstract. The Northwestern Institute on Complex Systems (NICO) welcomes you to its Complexity Conference. The goal of this conference is to present the most exciting complex systems research taking place in the social, behavioral, biological, and physical arenas to the Northwestern and wider academic communities. Conference themes this year are agents and networks.

Sponsors. Kellogg School of Management and Westlaw.

Location. McCormick Tribune Auditorium - James L. Allen Center.

Geographic Variability and Network Structure

The geography of human settlement patterns is highly variable, with heterogeneity visible across a wide range of scales. Here, I explore some of the likely implications of this variability for interpersonal network structure, using extrapolative simulations of geographically embedded social networks. These findings suggest the presence of distinctive effects of population density vaiation on local structural properties, in addition to larger-scale structures such as tie flows. Potential implications for phenomena such as diffusion and regional identification are discussed.

Carter T. Butts is currently Associate Professor in the Department of Sociology and Institute for Mathematical Behavioral Sciences at the University of California, Irvine. Dr. Butts obtained his Ph.D. from the Department of Social and Decision Sciences at Carnegie Mellon University, where he was a member of the Center for the Computational Analysis of Social and Organizational Systems and the Institute for Complex Engineered Systems. He also holds an M.S. from Carnegie Mellon University, and a B.S. from Duke University. Dr. Butts's research involves the application of mathematical and computational techniques to theoretical and methodological problems within the areas of social network analysis, mathematical sociology, quantitative methodology, and human judgment and decision making. Currently, his work focuses on: the structure of spatially embedded large-scale interpersonal networks; models for informant accuracy, network inference, and graph comparison; representation and modeling of intertemporal relational data; and models for human behavior in strategic settings. Dr. Butts also studies social phenomena related to emergency situations, and is involved in research which seeks to combine social science and information technology to improve group and organizational responses to disasters and other adverse events.

Activity, Closure and Brokerage in Social Network Models*

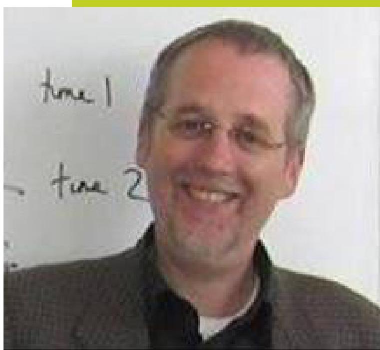
In this presentation, we describe new specifications for social network statistical models to assist the joint modeling of network *activity, closure* and *brokerage*.

Actors in a social network have different levels of *network activity*, as expressed through the degree distribution. But activity can take different structural forms. An ongoing theme in social network theory is the contrast between *network closure* – the tendency for closed cyclic and clique-like substructures to form within social networks – and *network brokerage* – the propensity for some ties to bridge between these more closed network regions. Burt (2005) argues that when social capital is optimized, brokerage and closure operate together.

Activity and closure processes in empirical social networks can be well represented using current specifications for exponential random graph models. But explicit parameterization of brokerage has to date been undeveloped. Burt's (2005) argument implies that brokerage is a form of interaction between closure and activity. By presenting a hierarchy of dependence assumptions for exponential random graph models, we show that brokerage configurations to represent this interaction can be derived from newer dependence hypotheses that extend current practice.

In particular, we introduce *edge-triangle* configurations, representing the expression of ties away from closed structures to other parts of the network. By simulation, we provide examples of different types of network brokerage: brokerage through hubs or a core of nodes; brokerage distributed across the network through overlapping group membership; and brokerage through bridging ties. We introduce new graph indices to measure the presence of such effects within the network. We fit the new models to an empirical example of work collaboration among managers in a government instrumentality. We show how the combination of parameters for activity, closure and brokerage can provide a richer interpretation of the social processes that underpin the network as well as a better fit of important network characteristics. **Collaborators: Philippa Pattison[1], Tom Snijders[2], Peng Wang[1] ([1] University of Melbourne, Australia [2] University of Oxford, UK, & University of Groningen, Netherlands)*

Statistical Modeling & Social Networks



Garry Robins is a mathematical psychologist at the University of Melbourne, Australia. His research deals with quantitative models for social and relational systems, with a focus on exponential random graph models for social networks. His research has won awards from the Psychometric Society, the American Psychological Association and the International Network for Social Network Analysis (the Freeman Award for the scientific study of social structure.) His methodological work has led to involvement in a wide range of empirical collaborations in areas as diverse as network epidemiology, criminal and terrorist networks, organisational structures, environmental governance, political and economic networks, biological networks, team-based processes, and community-wide networks.

More Than a Pretty Picture: Visual Thinking in Network Science

Visual imagery is a key element of social network research, but often left under-specified. In this talk I review some of the history of social network graphics and identify a set of principled features for effective social network graphics, with particular interest paid to diffusion and dynamic network visualization problems.

James Moody is an Associate Professor of Sociology at Duke University. His research focuses on the structural dynamics of social networks. The substantive contexts of his work range widely, from high school social network structure to the spread of HIV/AIDs in developing nations. His current projects include a book on the visual history of social networks, collaborations with colleagues at Penn State and Stanford on the dynamics of youth networks, and mapping the dynamics of science collaboration networks to identify the social contexts of good ideas.

Complexity Conference Presentation Winners

The following oral presentation winners will present their research during the conference sessions:

Sagar Sahasrabudhe - Physics & Astronomy, Northwestern University
Rescuing Ecosystems from Extinction Cascades

Christian Hildebrand - Marketing, University of Trier
Customer Equity & Community Management in Complex Networks

John Sheppard - Biomedical Engineering, Northwestern University
Aging Effects on Cortical Network Connectivity During Speech Perception in Noise: A Graph Theoretical Analysis

Agent-Based Computational Modeling in Public Health: From Playground to Planet

Following an epigrammatic review of classical mathematical epidemiology, Epstein will present selected applications of agent-based computational modeling to public health, across a range of hazards and scales, including: (1) a playground level infectious disease model (2) a county-level smallpox model calibrated to 20th century European outbreak data, and used to design containment strategies (3) two city-level hybrid models (of New Orleans and Los Angeles) combining high performance computational fluid dynamics and agent-based modeling to simulate/optimize evacuation dynamics given airborne toxic chemical releases (4) a 300 million agent model of the United States, used to simulate infectious disease dynamics and emergency surge capacity at national scale, and (4) The Global Epidemic Model (GEM) developed for the National Institutes of Health to study pandemic influenza transmission and containment on a planetary scale.

Joshua M. Epstein, Ph.D. is a senior fellow in economic studies and Director of the Center on Social and Economic Dynamics at the Brookings Institution. He is also an external professor at the Santa Fe Institute. He received a Ph.D. in political science from the Massachusetts Institute of Technology in 1981. His primary research is in modeling complex social, economic, and biological systems using agent-based computational methods and nonlinear dynamical systems. He has taught computational and mathematical modeling at Princeton University and the Santa Fe Institute Summer School. He was awarded an NIH Director's Pioneer Award in 2008 to pursue behavior epidemiology. Epstein is a recognized leader in the field of agent-based computational modeling, which applies computer simulation to explain and project the dynamics of infectious diseases such as small pox and pandemic flu, and chronic diseases such as obesity and smoking. These techniques are being used to design novel public policies for disease mitigation and disaster preparedness at all scales and levels of government, from local to global. Dr. Epstein has championed the view that behavioral factors are integral to the dynamics of disease, but have been largely ignored in previous models. The Large-Scale Agent Model, built under his direction, won the 2008 Award for Outstanding Achievement in Analysis from the National Training and Simulation Association. His book, *Generative Social Science: Studies in Agent-Based Computational Modeling*, was published by Princeton University Press in 2006.

Behavioral Geography for Crowd Animation

The special effects industry has, for some time, made use of computer animation to script and render synthetic characters as stand-ins for actors on movie sets. Traditionally, development of these characters has focused on visual acuity, with their behavior limited to quick bursts of choreographed movements and gestures. More recently, there has been a move toward replacing whole crowds of actors and stand-ins digitally and the number of characters in effects sequences, as well as audience and directors' expectations for their realism, has led animators to automatic generation of actor proxies to replace manual posing and scripting in production pipelines. The special effects industry has turned to agent-based modeling in response to these growing demands for added functionality and the technology is now used for automatically generating behaviorally-plausible synthetic characters. The fidelity of animated crowds is most acute when the models driving them reproduce the geography of their behaviors appropriately by placing people in the right places, at the right times, doing the right things. Much of the built-in realism ascribed to special effects agents relates to their behavioral geography, particularly in representing the intricacies of how agents think about their surroundings, how they interact physically with their environment, how they plan their activity, and how they choreograph movement through built and social infrastructure based on that information. The heuristics classically used to achieve these behaviors in special effects sequences are quite simplistic and abstract and special effects technology could benefit from the infusion

Behavioral Geography for Crowd Animation (continued)

of realistic behavioral geography into agent design. Similarly, academic experimentation with agent-based modeling in computational social science could profit from the infusion of technologies from the special effects industry, particularly in adopting schemes for representing agent characters in greater detail, in distributing the computation of large volumes of interactive agents, and in animating them in simulation. In this talk, I will introduce the work that I have been pursuing in developing realistic behavioral geography for agents and in connecting those agents to technologies used in special effects pipelines. I will demonstrate the usefulness of this approach in simulating academic scenarios related to human movement and crowd formation in dense urban environments.

Dr. Paul M. Torrens is an Associate Professor in the School of Geographical Sciences and Urban Planning at Arizona State University and Director of its Geosimulation Research Laboratory. He is also affiliated with the University's Center for Social Dynamics and Complexity and the GeoDa Center for Geospatial Analysis and Computation. Paul's work has featured in a diverse array of outlets, from traditional academic publications to popular media such as *Vanity Fair, Popular Mechanics, Forbes*, and *Discover Magazine*. His projects have been supported by the U.K. Economic and Social Research Council, the U.S. National Science Foundation, the Herberger Foundation, Science Foundation Arizona, Autodesk, Inc., and Alias Research. His work earned him a *Faculty Early Career Development Award* from the U.S. National Science Foundation in 2007 and he was awarded the *Presidential Early Ca`reer Award for Scientists and Engineers* by President George W. Bush in 2008. The Presidential Early Career Award is the highest honor that the U.S. government bestows upon young scientists; Paul is the first geographer to receive the Award.

Complexity Conference Poster Session

Visit Duncan Forum to view this year's excellent poster submissions, including the following poster prize recipients:

Daniel Grady & Christian Thiemann - Electrical Sciences & Applied Mathematics, Northwestern University
Tour de Sys: The Traveler's View of a Network

Ryan C. Kennedy - Computer Science & Engineering, Univ. of Notre Dame
Effectively Integrating GIS Data into an Agent-Based Epidemiological Model

Dr. Jerry Rhee - Pediatrics, Feinberg School of Medicine, Northwestern University
Towards an Integrated Model of Vertebrate Cornea Maturation

Jie Sun - Mathematics, Clarkson University
Model Reduction of Coupled Chaotic Oscillators

Dr. Samarth Swarup - Virginia Bioinformatics Institute, Virginia Tech
Simulating Social Information Diffusion Using a Synthetic Population

Michelle Hoda Wilkerson-Jerde & Abigail Jacobs - Learning Sciences, Northwestern University
Getting the Whole Picture: Tracking Expert Learning Over Time with Networks

Agent-Based Modeling

Modelling Real World Social Processes: The Example of the English Housing Market

What happens when one tries to follow the numerous methodological prescriptions about how one should develop an agent-based model, such as 'keep it simple', 'identify macro-level stylised facts', 'model micro-level behaviour', 'develop iteratively' and so on? This talk will show that these prescriptions do work, but the kind of model they produce is somewhat different to many that are to be found in the literature. The point will be illustrated with a description of a model built in NetLogo, in which the aim was to simulate the instabilities displayed in the housing market in England (and elsewhere in the developed world). The model incorporates a simplified version of the actual processes of buying and selling that households typically engage in and demonstrates that the observed aggregate performance of the housing market can be reproduced without resort to conventional economic assumptions about markets.

Nigel Gilbert is Professor of Sociology at the University of Surrey. He has an international reputation as a pioneer in the use of computer simulation in the social sciences and is the author of a textbook in that field and many research papers. He is past President of the European Social Simulation Association and founder-editor of the Journal of Artificial Societies and Social Simulation. He has a first degree in Engineering Science from Cambridge. Since graduation, he has aimed to link engineering and the social sciences and his work was honoured with election as a Fellow of the Royal Academy of Engineering in 1999. He is still the only practicing social scientist to be a Fellow of the Royal Academy. His research interests encompass the sociology of scientific knowledge (understanding how scientists generate reliable knowledge), science policy (strategies for the management of science), and privacy in contemporary societies. He is the editor of one of the textbooks on sociological research methods most widely used in UK universities. He is Director of the Centre for Research in Social Simulation at the University of Surrey, which undertakes research on a range of topics in which agent-based simulation is the core method. These include QLectives, a European Commission Integrated Project for which he is coordinator, PATRES, EMIL, and NEMO, all funded by the European Commission, and SIMIAN, a project to provide and advance the state of the art in social simulation funded by the UK Economic and Social Research Council. In the 1980s, he pioneered the development of interactive programs for claimants to use to assess their entitlement to welfare benefits and this later led to very large collaborative projects on the application of expert systems to social security administration. In the 1990s, he was instrumental in the setting up of one of the first web-based electronic academic journals, which is now a primary journal in British sociology. Professor Gilbert is a director of two small companies which he helped to found.

NetLogo

Researchers and developers from the Center for Connected Learning and Computer-Based Modeling will be available to demonstrate the NetLogo software and to answer any questions. NetLogo (Wilensky, 1999) was developed with the generous support of the National Science Foundation (REC-9632612, REC-9814682).

Please see Rm.160 for a detailed schedule.

Social Networks on Large-Scale Electronic Databases

*Resistance is Futile: Cultural Assimilation and the Signal Importance of Noise**

How can minority cultures resist assimilation into a global monolith in an increasingly "small world"? Paradoxically, Robert Axelrod found that local convergence can actually preserve global diversity if cultural influence is combined with homophily, the principle that "likes attract." However, follow-up studies showed that this diversity collapses under random cultural perturbation. The source of this fragility turns out to be a hidden assumption in Axelrod's model that cultural influence is interpersonal (dyadic). If we substitute the more empirically plausible assumption that influence is social (i.e. people can be influenced by several network neighbors at the same time), computational experiments show that cultural diversity then becomes highly robust to noise. Axelrod also assumed a "large-world" network. A second study examines the rate and extent of cultural diffusion when noise is introduced into a strongly clustered network structure, such that network distances are greatly reduced. Surprisingly, while information and disease spread faster as the world gets smaller, the opposite appears to be the case for costly, risky, or controversial cultural innovations. Finally, Axelrod assumed a fixed network. What if people can change neighbors or neighborhoods but cannot change the attributes (e.g. ethnicity) that drive network dynamics? Thomas Schelling showed that ethnic segregation can persist even in populations that tolerate diversity. A third study extends Schelling's experiment by examining what happens if people do not simply tolerate diversity but actually prefer it. The results pose a Zen-like paradox: When ethnic preferences are sufficiently weak relative to chance, integration occurs in a population that prefers segregation, and when ethnic preferences are sufficiently strong, segregation occurs in a population that prefers integration. Taken together, these three studies suggest that random perturbation of personal attributes and social relations does not necessarily reduce cultural differentiation, and under some conditions, can actually increase it. **Collaborators: Andreas Flache[1], Damon Centola[2], and Arnout van de Rijt[3]. ([1]University of Groningen, [2]MIT Sloan School of Management, [3]SUNY Stony Brook)*

Michael Macy is Goldwin Smith Professor of Sociology and Director of the NSF-funded Social Dynamics Laboratory at Cornell (http://hsd.soc.cornell.edu). He is also a non-resident Senior Fellow at the Brookings Institution. Prof. Macy pioneered the use of agent-based computational models in sociology, focusing on how local interactions in complex networks can generate unexpected and unintended collective dynamics (http://people.cornell.edu/pages/mwm14). His research team uses computational models, on-line laboratory experiments, and the digital traces of on-line social interactions to look for elementary principles of social order and change. A recent study found that "small world" networks that are optimal for the spread of information and disease can inhibit the spread of risky or costly collective actions characterized by high thresholds of adoption. A new study tests Granovetter's theory of the "strength of weak ties" using a nearly complete record of all business, residential, and mobile telephone calls for an entire country, matched with socio-economic indicators. Another new project uses all existing book reviews from Amazon.com and Amazon.JP to see if reviewers are influenced by previous reviews, and whether this varies between individualist and collectivist cultures.

Open Data and Open Code for S&T Assessment

More than 45 years ago Derek J. de Solla Price suggested that science be studied using scientific methods. Today, there exist massive amounts of science and technology (S&T) data, several hundred algorithms relevant for the analysis, modeling, and visualization of these datasets, and sufficient computing power to conduct large-scale studies of the structure and evolution of science. However, a large percentage of "science of science" studies use proprietary tools to analyze proprietary datasets. This makes it difficult if not impossible to repeat and confirm results, compare alternative approaches, or run the same algorithms on a new dataset.

Open Data and Open Code for S&T Assessment (continued)

This talk introduces and exemplifies different components of an evolving Science of Science Cyberinfrastructure (http://sci.slis.indiana.edu): The Scholarly Database (SDB) (http://sdb.slis.indiana.edu) that provides free access to 23 million scholarly records and the Sci2 Tool which reads SDB data and supports the identification of activity bursts, the extraction and display of co-author/inventor/investigator networks, and topical analysis, among others.

Katy Börner is the Victor H. Yngve Professor of Information Science at the School of Library and Information Science, Adjunct Professor in the School of Informatics, Core Faculty of Cognitive Science, Research Affiliate of the Biocomplexity Institute, Fellow of the Center for Research on Learning and Technology, Member of the Advanced Visualization Laboratory, and Founding Director of the Cyberinfrastructure for Network Science Center (http://cns.slis.indiana.edu) at Indiana University. She is a curator of the Places & Spaces: Mapping Science exhibit (http://scimaps.org). Her research focuses on the development of data analysis and visualization techniques for information access, understanding, and management. She is particularly interested in the study of the structure and evolution of scientific disciplines; the analysis and visualization of online activity; and the development of cyberinfrastructures for large scale scientific collaboration and computation. She is the co-editor of a Springer book on 'Visual Interfaces to Digital Libraries', a special issue of PNAS on 'Mapping Knowledge Domains' (2004), and a Journal of Informetrics special issue entitled 'Science of Science: Conceptualizations and Models of Science' (2009). She holds a MS in Electrical Engineering from the University of Technology in Leipzig, 1991 and a Ph.D. in Computer Science from the University of Kaiserslautern, 1997.

Information Flow in Trading Networks

We use network analysis to quantify the flow of information through financial markets. Using unique ultra high frequency data, we compute network and financial variables for transactions that occurred during August 2008 in the nearby E-mini S&P 500 futures contract - the cornerstone of price discovery for the S&P 500 Index. We find that network variables presage the information represented by financial variables. Most notably, we find that network variables strongly Granger-case intertrade duration and trading volume, suggesting that network metrics serve as primitive measures of information flow. Finally, we find that the dynamics of returns and volatility are rooted in the network mechanics of the information arrival process - as evidenced both in our data and the results of an agent-based simulation model.

Lada A. Adamic is an assistant professor in the School of Information and the Center for the Study of Complex Systems at the University of Michigan. Her research interests center on information dynamics in networks: how information diffuses, how it can be found, and how it influences the evolution of a network's structure. She worked previously in Hewlett-Packard's Information Dynamics Lab. Her projects have included identifying expertise in online question answer forums, studying the dynamics of viral marketing, and characterizing the structure in blogs and other online communities.

Post-Conference Workshop

Network Workbench Tool

Katy Börner
School of Library & Information Science
Indiana University
Time: 1:00pm - 5:00pm, September 3, 2009
Location: Lower Level Classroom, Chambers Hall, 600 Foster Street
Cost: $75.00

This four-hour, hands-on workshop introduces the Network Workbench (NWB) Tool, the Cyberinfrastructure Shell, and the NWB Community Wiki developed in the NSF funded Network Workbench project. See http://nwb.slis.indiana.edu.

The NWB Tool is a network analysis, modeling, and visualization toolkit for physics, biomedical, and social science research. It is a standalone desktop application and can install and run on Windows, Linux x86 and Mac OSX. The tool provides easy access to more than 140 algorithms and diverse sample datasets for the study of networks. The loading, processing, and saving of four basic file formats (GraphML, Pajek .net, XGMML and NWB) and an automatic conversion service among those formats are supported. Additional algorithms and data formats can be integrated into the NWB Tool using wizard driven templates thanks to the Cyber infrastructure Shell (CIShell).

CIShell is an open source, software framework for the integration and utilization of datasets, algorithms, tools, and computing resources. Although the CIShell and the NWB tools are developed in JAVA, algorithms developed in other programming languages such as FORTRAN, C, and C++ can be easily integrated.

The Network Workbench Community Wiki is a place for users of the NWB tool, CIShell, and other CIShell-based programs to request, obtain, contribute, and share algorithms and datasets. The developer/user community can work together and create additional tools/services to meet both their own needs and the needs of their scientific communities at large. All algorithms and datasets that are available via the NWB tool have been well documented in the NWB Community Wiki.

Pre-registration is required! Register at northwestern.edu/nico/complexity-conference or at the conference registration desk.

NICO

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