

# Info I709: Advanced Seminars II in Informatics: Complex Networks and Systems

## Description

Contemporary Informatics approaches and related theories. This Ph.D. seminar will be held as reading and discussion courses, divided into sections. This means that the courses will to a large extent be self- and/or group-study oriented with support from faculty. More advanced readings and discussion than INFO-I 609. This seminar course is designed to present and discuss the history, methodology and impact of complex networks and systems research. Key literature, mostly from the last 20 years or so, will be covered.

## Course Evaluation

Students are expected to read and annotate the materials presented, and present several of the key readings. **Participation and Discussion: 50%; Lead Discussions: 50%.**

## Schedule (Fall 2018)

**Week I (08/20):** Introduction, organization and schedule.

### Week II (08/27): Power laws

M. E. J. Newman, Power laws, [Pareto distributions and Zipf's law Links to an external site.](#) Contemporary Physics 46, 323 (2005).

A. Clauset et al., [Power-law distributions in empirical data Links to an external site.](#) SIAM Review 51, 661 (2009).

M. Mitzenmacher, [A brief history of generative models for power law and lognormal distributionsLinks to an external site.](#) Internet Mathematics 1 (2), 226-251 (2004).

L. A. Adamic, [Zipf, Power-laws, and Pareto - a ranking tutorialLinks to an external site.](#)

C. R. Shalizi, [Power Law Distributions, 1/f Noise, Long-Memory Time SeriesLinks to an external site.](#), Notebooks.

### **Week III (09/03): no class (Labor Day)**

### **Week IV (09/10): Economic complexity**

- R. N. Mantegna and H. E. Stanley. [Scaling behaviour in the dynamics of an economic index](#)[Links to an external site.](#) Nature 376, 46-49 (1995).
- M. H. R. Stanley et al., [Scaling behaviour in the growth of companies](#)[Links to an external site.](#) Nature 379, 804-806 (1996).
- C. A. Hidalgo et al., [The Product Space Conditions the Development of Nations](#)[Links to an external site.](#) Science 317, 482 (2007).
- C. A. Hidalgo and R. Hausmann, [The building blocks of economic complexity](#). [Links to an external site.](#) PNAS 106, 10570 (2009).
- M. Cristelli et al., [The Heterogeneous Dynamics of Economic Complexity](#)[Links to an external site.](#) PLOS ONE 10, e0117174 (2015).

### **Week V (09/17): Science of cities**

- H. A. Makse et al., [Modelling urban growth patterns](#). [\(Links to an external site.\)](#)[Links to an external site.](#) Nature 377, 608 (2002).
- L. M. A. Bettencourt et al., [Growth, innovation, scaling, and the pace of life in cities](#). [Links to an external site.](#) PNAS 104, 7301 (2007).
- L. M. A. Bettencourt, [The Origins of Scaling in Cities](#). [Links to an external site.](#) Science 340, 1438 (2013).
- L. M. A. Bettencourt and G. West, [A unified theory of urban living](#). [Links to an external site.](#) Nature 467, 912 (2010).
- M. Batty, [The Size, Scale, and Shape of Cities](#). [Links to an external site.](#) Science 319, 769 (2008).

### **Week VI (09/24): Science of science**

- S. Redner. [How popular is your paper? an empirical study of the citation distribution](#)[Links to an external site.](#) The European Physical Journal B-Condensed Matter and Complex Systems 4, 131-134 (1998).
- F. Radicchi, S. Fortunato, and C. Castellano. [Universality of citation distributions: Toward an objective measure of scientific impact](#)[Links to an external site.](#) PNAS 105, 17268-17272 (2008).
- B. Uzzi, S. Mukherjee, M. Stringer and B. F. Jones, [Atypical combinations and scientific impact](#)[Links to an external site.](#) Science 342, 468-472 (2013).
- D. Wang, C. Song, and A.-L. Barabasi. [Quantifying long-term scientific impact](#)[Links to an external site.](#) Science 342, 127-132 (2013).

Q. Ke et al., [Defining and identifying Sleeping Beauties in science. Links to an external site.](#) PNAS 112, 7426-7431 (2015).

R. Sinatra et al., [Quantifying the evolution of individual scientific impact. Links to an external site.](#) Science 354, aaf5239 (2016).

### **Week VII (10/01): Collective motion**

C. W. Reynolds, [Flocks, Herds, and Schools: A Distributed Behavioral Model. Links to an external site.](#) Computer Graphics 21(4), 25-34 (1987)

T. Vicsek et al., [Novel Type of Phase Transition in a System of Self-Driven Particles. Links to an external site.](#) Phys. Rev. Lett. 75, 1226-1229 (1995).

M. Ballerini et al., [Interaction ruling animal collective behavior depends on topological rather than metric distance: Evidence from a field study. Links to an external site.](#) PNAS 105, 1232-1237 (2008)

D. Helbing, I. Farkas, T. Vicsek, [Simulating dynamical features of escape panic. Links to an external site.](#) Nature 407, 487-490 (2000).

Z. Néda, E. Ravasz, Y. Brechet, T. Vicsek, A.-L. Barabási, [The sound of many hands clapping. Links to an external site.](#) Nature 403, 849-850 (2000).

I. Farkas, D. Helbing, T. Vicsek, [Mexican waves in an excitableLinks to an external site..](#) Nature 419, 131 (2002).

### **Week VIII (10/08): Mobility**

T.T. Hills et al., [Exploration versus exploitation in space, mind, and society \(Links to an external site.\)Links to an external site..](#) Trends in Cognitive Sciences 19, 46 (2015)

G.M. Viswanathan et al., [Lévy flight search patterns of wandering albatrosses \(Links to an external site.\)Links to an external site..](#) Nature 381, 413 (1996).

A.M. Edwards et al., [Revisiting Lévy flight search patterns of wandering albatrosses, bumblebees and deer \(Links to an external site.\)Links to an external site..](#) Nature 449, 1044 (2007).

G.M. Viswanathan et al., [Optimizing the success of random searches \(Links to an external site.\)Links to an external site..](#) Nature 401, 911 (1999).

D. Brockmann et al., [The scaling laws of human travel \(Links to an external site.\)Links to an external site..](#) Nature 439, 462 (2005).

M.C. González et al., [Understanding individual human mobility patterns \(Links to an external site.\)Links to an external site..](#) Nature 453, 779 (2008).

C. Song et al., [Limits of Predictability in Human Mobility \(Links to an external site.\)Links to an external site..](#) Science 327, 1018 (2010).

### **Week IX (10/15): Game theory**

R. Axelrod and W. D. Hamilton, [The Evolution of Cooperation.Links to an external site](#). Science 211, 1390 (1981).

E. Fehr and S. Gächter, [Altruistic punishment in humans. Links to an external site](#). Nature 415, 137 (2002).

M. A. Nowak, [Five Rules for the Evolution of Cooperation. Links to an external site](#). Science 314, 1560 (2006).

D. Cesarini et al., [Heritability of cooperative behavior in the trust game. Links to an external site](#). PNAS 105, 3721 (2008).

J. H. Fowler and N. A. Christakis, [Cooperative behavior cascades in human social networks.Links to an external site](#). PNAS 107, 5334 (2010).

C. Gracia-Lázaro et al., [Heterogeneous networks do not promote cooperation when humans play a Prisoner's Dilemma. Links to an external site](#). PNAS 109 (32), 12922-12926 (2012).

### **Week X (10/22): Opinion dynamics and segregation**

C. Castellano, S. Fortunato, V. Loreto, [Statistical physics of social dynamicsLinks to an external site](#). Reviews of Modern Physics 81, 591-646 (2009).

R. Axelrod, [The dissemination of culture - A model with local convergence and global polarization.Links to an external site](#). Journal of Conflict Resolution 41(2), 203-226 (1997).

G. Deffuant, D. Neau, F. Amblard, G. Weisbuch, [Mixing beliefs among interacting agentsLinks to an external site](#). Advances in Complex Systems 3, 87-98 (2000).

R. Hegselmann and U. Krause, [Opinion dynamics and bounded confidence models, analysis, and simulationLinks to an external site](#). Journal of Artificial Societies and Social Simulation (JASSS) 5, no. 3 (2002).

T. Schelling, [Dynamic models of segregation.Links to an external site](#). Journal of Mathematical Sociology 1, 143 (1971). -

Y. Xie and X. Zhou, [Modeling individual-level heterogeneity in racial residential segregationLinks to an external site](#). PNAS 109, 11646-11651 (2012).

### **Week XI (10/29): Network structure**

D. J. Watts and S. H. Strogatz. [Collective dynamics of 'small-world' networks.Links to an external site](#). Nature 393, 440-442 (1998).

A.-L. Barabási and R. Albert. [Emergence of scaling in random networks.Links to an external site](#). Science, 286, 509-512 (1999).

M. E. J. Newman, S. H. Strogatz and D. J. Watts, [Random graphs with arbitrary degree distributions and their applications.Links to an external site](#). Phys. Rev. E 64, 026118 (2001).

P. S. Dodds et al., [An Experimental Study of Search in Global Social Networks.Links to an external site](#). Science 301, 827-829 (2003).

M. S. Granovetter, [The Strength of Weak Ties](#). [Links to an external site.](#) American Journal of Sociology 78, 1360-1380 (1973).  
R. Albert et al., [Diameter of the world-wide web](#). [Links to an external site.](#) Nature 401, 130-131 (1999).

### **Week XII (11/05): Network robustness**

D. Stauffer and A. Aharony, [Introduction to percolation theory](#) ([Links to an external site.](#))[Links to an external site.](#) (Taylor & Francis, 1984)  
R. Cohen et al., [Resilience of the Internet to random breakdowns](#) ([Links to an external site.](#))[Links to an external site.](#) Phys. Rev. Lett. 85, 4626 (2000)  
D.S. Callaway et al., [Network Robustness and Fragility: Percolation on Random Graphs](#) ([Links to an external site.](#))[Links to an external site.](#) Phys. Rev. Lett. 85, 5468 (2000)  
R. Cohen et al., [Breakdown of the Internet under intentional attack](#) ([Links to an external site.](#))[Links to an external site.](#) Phys. Rev. Lett. 86, 3682 (2001)  
R. Albert et al., [Error and attack tolerance of complex networks](#) ([Links to an external site.](#))[Links to an external site.](#) Nature 405, 378 (2002)  
B. Karrer et al., [Percolation on sparse networks](#) ([Links to an external site.](#))[Links to an external site.](#) Phys. Rev. Lett. 113, 208702 (2014)

### **Week XIII (11/12): Dynamics on networks I**

R. Pastor-Satorras and A. Vespignani, [Epidemic spreading in scale-free networks](#). [Links to an external site.](#) Physical Review Letters 86, 3200-3203 (2001).  
D. Brockmann and D. Helbing, [The hidden geometry of complex network-driven contagion phenomena](#). [Links to an external site.](#) Science 342, 1337-1342 (2013).  
N. A. Christakis and J. H. Fowler (2010). [Social network sensors for early detection of contagious outbreaks](#). [Links to an external site.](#) PLoS one 5(9), e12948 (2010).  
Kempe et al., [Maximizing the Spread of Influence through a Social Network](#). ([Links to an external site.](#))[Links to an external site.](#) Proceedings of the ninth ACM SIGKDD international conference on Knowledge discovery and data mining (2003).  
M. Kitsak et al, [Identification of influential spreaders in complex networks](#) ([Links to an external site.](#))[Links to an external site.](#), Nat. Phys. 6, 888 (2010).  
R. Cohen et al., [Efficient immunization strategies for computer networks and populations](#) ([Links to an external site.](#))[Links to an external site.](#) Physical Review Letters. 91, 247901 (2003).  
F. Morone and H.A. Makse, [Influence maximization in complex networks through optimal percolation](#) ([Links to an external site.](#))[Links to an external site.](#), Nature 524, 65 (2015).

## **Week XIV (11/19): no class (Thanksgiving break)**

## **Week XV (11/26): Dynamics on networks II**

J. M. Kleinberg, [Navigation in a small world](#)[Links to an external site.](#). Nature 406, 845 (2000).

M. Boguna et al. [Navigability of complex networks](#) [\(Links to an external site.\)](#)[Links to an external site.](#). Nat. Phys. 5, 74-80 (2009)

M. Boguna et al. [Sustaining the internet with hyperbolic mapping](#) [\(Links to an external site.\)](#)[Links to an external site.](#). Nat. Commun. 1, 62 (2010)

S. Brin and L. Page, [The anatomy of a large-scale hypertextual Web search engine](#)[Links to an external site.](#). Computer Networks 30, 107–117 (1998).

J. Kleinberg [Authoritative sources in a hyperlinked environment](#) [\(Links to an external site.\)](#)[Links to an external site.](#). Journal of the ACM. 46, 604–632 (1999)

## **Week XVI (12/03): Multilayer networks**

S. V. Buldyrev et al., [Catastrophic cascade of failures in interdependent networks](#) [\(Links to an external site.\)](#)[Links to an external site.](#), Nature 464, 025 (2010)

F. Radicchi and A. Arenas, [Abrupt transition in the structural formation of interconnected networks](#) [\(Links to an external site.\)](#)[Links to an external site.](#), Nat. Phys. 9, 717 (2013)

F. Radicchi, [Percolation in real interdependent networks](#) [\(Links to an external site.\)](#)[Links to an external site.](#), Nat. Phys. 11, 597 (2015)

M. Kivelä et al., [Multilayer Networks](#) [\(Links to an external site.\)](#)[Links to an external site.](#). J. Complex Netw. 2, 203-271 (2014)

S. Boccaletti et al., [The structure and dynamics of multilayer networks](#) [\(Links to an external site.\)](#)[Links to an external site.](#). Physics Reports 544, 1 (2014)