

# CMPSC 497E: Graphs and networks in systems biology

## Project assignment 1, due Tuesday Oct. 20

It is now time to decide your term project topics. As a reminder, you will write a term paper due on the Monday after classes end. Your term paper should be a comprehensive and critical review of the literature on a network-related topic. Examples include a review of search problems in networks, a review of constructing metabolic networks and analyzing their properties, a review of dynamic modeling of biological networks etc.

The goal of this assignment is to help you select your research topic. A list of topics is given below. For each topic several leads (papers, websites) are given, follow them to find other relevant references. Choose a topic from these, or propose your own. If you have a hard time deciding, feel free to consult me by email.

Write a short motivation for your proposed work, including a list of references.

## Suggested project topics

### 1. Select one from the following types of network models

- modeling growth/capacity constraints  
L. A. N. Amaral, A. Scala, M. Barthélemy and H. E. Stanley, PNAS 97, 11149 (2000)  
<http://amaral.chem-eng.northwestern.edu/>  
S. N. Dorogovtsev, J. F. F. Mendes, Phys. Rev. E 62, 1842  
<http://sweet.ua.pt/~f2064/>
- competition in evolving networks  
G. Bianconi, A.-L. Barabási, Europhys. Lett. 54, 436  
<http://www.nd.edu/~networks>
- optimization principles  
S. S. Manna, A. Kabakcioglu, *Scale-free Network on Euclidean Space Optimized by Rewiring of Links*. Phys. A, 36, L279 (2003)

V Colizza, JR Banavar, A Maritan, A Rinaldo, *Network Structures from Selection Principles*. Physical Review Letters, 92, 198701 (2004).

- community structure in social networks  
<http://www.santafe.edu/~mark/pubs.html>  
[http://www.hpl.hp.com/personal/Lada\\_Adamic/](http://www.hpl.hp.com/personal/Lada_Adamic/)  
<http://xxx.lanl.gov/abs/cond-mat/0309488>

2. Path finding strategies on complex networks

L. A. Braunstein, S. V. Buldyrev, R. Cohen, S. Havlin, H. E. Stanley, *Optimal Paths in Disordered Complex Networks*, lanl/cond-mat/0305051

[http://www.hpl.hp.com/personal/Lada\\_Adamic/](http://www.hpl.hp.com/personal/Lada_Adamic/)

Bernardo A. Huberman, Lada A. Adamic, *Information Dynamics in the Networked World*, lanl/cond-mat/0308321

Hari P. Thadakamalla, Reka Albert and Soundar Kumara *Search in weighted complex networks*. Phys. Rev. E 72 , 066128 (2005)

3. Protein-protein, protein-gene interaction networks and what they can tell us

Giot *et al*, *A protein interaction map of Drosophila melanogaster*. Science. 2003 Dec 5; 302(5651): 1727-36

Li *et al*. *A map of the interactome network of the metazoan C. elegans*. Science. 2004 Jan 23; 303(5657): 540-3.

Tong Ihn Lee *et al*, *Transcriptional Regulatory networks in Saccharomyces cerevisiae*, Science 298, 799 (2002)

Pritsker M, *et al*. 2004 *Whole-genome discovery of transcription factor binding sites by network-level conservation*. Genome Res. 14:99108.

4. Metabolism: Design of topology and kinetics of local networks; global analysis of flux patterns.

Melndez-Hevia E, Waddell TG, Montero F 1994 *Optimization of metabolism: the evolution of metabolic pathways toward simplicity through the game of the pentose phosphate cycle*. J. Theor. Biol. 166, 201-220.

Mittenthal JE, et al. 2001 *A new method for assembling metabolic networks, with application to the Krebs citric acid cycle*. J. Theor. Biol. 208, 361-382.

Papin JA, et al. 2003, *Metabolic pathways in the post-genome era*. Trends in Biochem. Sci. 28, 250-258.

Schilling CH, et al. 2000, *Theory for the systemic definition of metabolic pathways and their use in interpreting metabolic function from a pathway-oriented perspective*. J. Theor. Biol. 203, 229-248.

Stelling J, et al. 2002 *Metabolic network structure determines key aspects of functionality and regulation*. Nature 420, 190-193.

#### 5. Dynamics and design of signaling networks

Kolch W et al. 2005, *When kinases meet mathematics: the systems biology of MAPK signaling*. FEBS Letters 579, 1891-1895.

Yi T-M, et al. 2000, *Robust perfect adaptation in bacterial chemotaxis through integral feedback control*. PNAS 97, 4649-4653.

Rao CV, et al. 2004, *Design and diversity in bacterial chemotaxis: A comparative study in Escherichia coli and Bacillus subtilis*. PLoS Biology Vol. 2, No. 2.

Barolo S, Posakony JW, 2002, *Three habits of highly effective signaling pathways: principles of transcriptional control by developmental cell signaling*. Genes & Development 16, 1167-1181.

#### 6. Common properties of biological networks

E. Alm and A. P. Arkin, *Biological Networks*, Current Opinion in Structural Biology 13, 193 (2003)

Hartwell L, Hopfield JJ, Leibler S, Murray AW, *From molecular to modular cell biology* Nature 1999; 402.

Hiroaki Kitano, *Systems Biology: a brief overview*, Science 295, 1662 (2002).

Zoltán N. Oltvai and Albert-László Barabási, *Life's complexity pyramid* Science 298, 763-764 (2002).

Csete M, Doyle J, 2004 *Bow ties, metabolism and disease*. Trends in Biotechnology 22(9), 446-450.

Stelling J, et al. 2004 *Robustness of cellular functions*. Cell 118, 675-685.

7. Modeling regulation in biochemical reaction networks

Adam P. Arkin, *Signal Processing in Biochemical Reaction Networks* in Self-Organized Biological Dynamics and Nonlinear Control, J. Walczek (ed), Cambridge Univ. Press, 2000.

3. Harley H. McAdams and Adam Arkin, *Simulation of prokariotic genetic circuits*, Annual Review of Biophysics and Biomolecular Structure 27, 199-224 (1998).

<http://genomics.lbl.gov/index.html>

8. Modeling the cell cycle

Novak B, Pataki Z, Ciliberto A, Tyson JJ. *Mathematical model of the cell division cycle of fission yeast*, Chaos. 2001 Mar; 11(1): 277-286

<http://leibniz.biol.vt.edu/>

Fangting Li, Tao Long, Ying Lu, Qi Ouyang, Chao Tang, *The Yeast Cell-Cycle Network Is Robustly Designed*, lanl/q-bio.MN/0310010

<http://www.neci.nec.com/homepages/tang/>

9. Modeling stochastic processes

D. T. Gillespie. *Exact stochastic simulation of coupled chemical reactions* J. Phys. Chem, 81:2340-2361, 1977.

Kierzek AM, *STOCKS: STOChastic Kinetic Simulations of biochemical systems with Gillespie algorithm*, Bioinformatics. 2002 Mar; 18(3): 470-81

Kaern M, et al. 2005 *Stochasticity in gene expression: From theories to phenotypes*. Nat. Rev. Genet. 6, 451-464.

10. Synthetic biology

Benner SA, Sismour AM 2005 *Synthetic biology*. Nat. Rev. Genet. 6, 533-543.

Endy D 2005, *Foundations for engineering biology*. Nature 438, 449-453.

Kobayashi H, *et al.* 2004, *Programmable cells: Interfacing natural and engineered gene networks*. PNAS 101, 8414-8419.

Noireaux V, Libchaber A, 2004, *A vesicle bioreactor as a step toward an artificial cell assembly*. PNAS 101, 17669-17674.

11. Propose your own.