PHYS 597A: Graphs and networks in systems biology

Project assignment 1, due Tuesday March 18

It is now time to decide on your term project topics. As a reminder, you will give an in-class presentation on your projects during the last two weeks of the semester, and write a paper due on the Monday after classes end.

Three types of papers are envisioned

(i) A comprehensive and critical review of the literature on a network-related topic. For example, a review of search problems in networks, a review of constructing protein-protein interaction networks and analyzing their properties, a review of dynamic modeling of biological networks etc.

(ii) The development of a new network model or method that either combines previous ideas in a novel way or proposes new ideas for network modeling. The model will be analyzed with the methods learned in class and compared to other models.

(iii) An original project that is related to networks. It can be based on your thesis research. For example, it could be the construction of an interaction network for a biological process or social organization, analysis of its properties and comparison to other biological/social networks.

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. Barthélémy 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://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/`

   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 patterms.

   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. Walleczek (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. Engineering networks: 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.