Semester projects
Principles of Complex Systems
Course 300, Fall, 2008

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Semester projects

Requirements:
1. ≈ 5 minute introduction to project (fourth week)
2. 15 to 20 minute final presentation
3. Report: ≥ 5 pages (single space), journal-style

Narrative hierarchy

Presenting at many scales:
- 1 to 3 word encapsulation, a soundbite,
- a sentence/title,
- a few sentences,
- a paragraph,
- a short paper,
- a long paper,
- . . .
Investigate the self-similarity of complex networks:

- “Self-similarity of complex networks”
  Song et al. (2005a) [16]
- “Origins of fractality in the growth of complex networks”
  Song et al. (2006a) [17]
- “Skeleton and Fractal Scaling in Complex Networks”
  Go et al. (2006a) [8]
- “Complex Networks Renormalization: Flows and Fixed Points”
  Radicchi et al. (2008a) [15]

Develop and elaborate an online experiment to study some aspect of social phenomena
- e.g., cheating, cooperation, influence, decision-making, etc.

Study collective creativity arising out of social interactions
- Productivity, wealth, creativity, disease, etc. appear to increase superlinearly with population
- Start with Bettencourt et al.’s “Growth, innovation, scaling, and the pace of life in cities” [2]

- How do products depend on each other, and how does this network evolve?
project topics:

- Explore proposed measures of system complexity.

- Investigate and review Cybernetics, a forerunner to Complex Systems.

- Explore Dunbar’s number.
  - See here and here for some food for thought regarding large-scale online games and Dunbar’s number. [http://www.lifewithalacrity.com]

- Read and review Herbert Simon’s “Sciences of the Artificial” (or more Simon’s work more generally).
project topics:

- Investigate the life and work of Frank Harary (_embeddings), graph theory champion.

- Investigate and report on General Systems Theory.

- Vague/Large: Study spreading of anything where influence can be measured.

- Study collective tagging (or folksonomy)
  - e.g., del.icio.us, flickr
  - See work by Bernardo Huberman et al. at HP labs.
Project topics:

▶ Study games (as in game theory) on networks.
▶ For cooperation: Review Martin Nowak’s recent piece in Science: “Five rules for the evolution of cooperation.”[14]
▶ Much work to explore: voter models, contagion-type models, etc.

Project topics:

▶ Semantic networks: explore word-word connection networks generated by linking semantically related words.
▶ More general: Explore language evolution
▶ One paper to start with: “The small world of human language” by Ferrer i Cancho and Solé[7]

Project topics:

▶ Investigate Service Science, which doesn’t sound very good but IBM believes will be bigger than computer science.
▶ Definition: “Service Science, Management, and Engineering (SSME) is an interdisciplinary approach to the study, design, and implementation of service systems—complex systems in which specific arrangements of people and technologies take actions that provide value for others.”

Project topics:

▶ Investigate safety codes (building, fire, etc.).
▶ What kind of relational networks do safety codes form? How have they evolved?
project topics:

- Statistics: Study Peter Hoff’s (and others’) work on latent variables.
- Idea: explain connection pattern in a network through hidden individual or dyadic variables
- This method has been applied to the study of international relations networks.


- Bejan asks why we see branching network flow structures so often in Nature—trees, rivers, etc.

- Read and critique “Historical Dynamics: Why States Rise and Fall” by Peter Turchin. [18]
- Can history Clyodynamics (ERA), Psychohistory, ...
- Also see “Secular Cycles” (ERA).
project topics:

- Explore work by Doyle, Alderson, et al. as well as Pastor-Satorras et al. on the structure of the Internet.

- Review: Study Castronova's and others' work on massive multiplayer online games. How do social networks form in these games? [3]

- Study Michael Kearns and others' work on Cobot. Very cool.

- Study Kearns et al.'s experimental studies of people solving classical graph theory problems [12]
- “An Experimental Study of the Coloring Problem on Human Subject Networks”
- (Possibly) Run some of these experiments for our class.
Semester projects
The Plan
Suggestions for Projects
References

project topics:

▶ Study **phyllotaxis**, how plants grow new buds and branches.
▶ Some delightful mathematics appears involving the Fibonacci series.
▶ Excellent work to start with: “Phyllotaxis as a Dynamical Self Organizing Process: Parts I, II, and III” by Douady and Couder [4, 5, 6]

project topics:

▶ Biology: Study leaf network patterns.
▶ Key on very interesting work by Xia.
▶ Classic Monge problem: how to move stuff from one place to another.
▶ Bulk flow versus network flow.

project topics:

▶ Vague/Large: Study Amazon’s recommender networks.

project topics:

▶ Vague/Large: Study Netflix’s open data (movies and people form a bipartite graph).
Vague/Large:
Study how the Wikipedia’s content is interconnected.

Vague/Large:
Study social networks as revealed by email patterns, Facebook connections, etc.
“Community Structure in Online Collegiate Social Networks” Traud et al., 2008.
http://arxiv.org/abs/0809.0690

Vague/Large:
How do countries depend on each other for water, energy, people (immigration), investments?

Vague/Large:
How is the media connected? Who copies whom?
project topics:

- Vague/Large:
  Investigate memetics, the ‘science’ of memes.

- Vague/Large:
  How does advertising work collectively? For example, does one car manufacturers’ ads indirectly help other car manufacturers?

- Vague/Large:
  Anything interesting to do with evolution, biology, ethics, religion, history, influence, food, international relations, . . .
project topics:

- Vague/Large: Study spreading of neologisms.

- Vague/Large: Study spreading of anything where influence can be measured.

References I


References II


References III

R. Ferrer i Cancho and R. Solé.
The small world of human language.

Skeleton and fractal scaling in complex networks.

The product space conditions the development of nations.

Network scaling reveals consistent fractal pattern in hierarchical mammalian societies.

References IV

S. Kauffman.
The Origins of Order.

M. Kearns, S. Suri, and N. Montfort.
An experimental study of the coloring problem on human subject networks.

G. Kossinets and D. J. Watts.
Empirical analysis of evolving social networks.

M. A. Nowak.
Five rules for the evolution of cooperation.

References V

F. Radicchi, J. J. Ramasco, A. Barrat, and S. Fortunato.
Complex networks renormalization: Flows and fixed points.

C. Song, S. Havlin, and H. A. Makse.

C. Song, S. Havlin, and H. A. Makse.
Origins of fractality in the growth of complex networks.

P. Turchin.
Historical Dynamics: Why States Rise and Fall.