**Computational Modeling of Complex Socio-Technical Systems**

08-810

Syllabus

Spring 2012

12 Course Units

Prof. Kathleen M. Carley

E-Mail: kathleen.carley@cs.cmu.edu

Phone: x8-6016

Office: Wean 5130

Office Hours: by appointment

T.A.: Geoffrey Morgan

Lectures: Monday, Wednesday 9:00 - 10:20 am, GHC 4211

Labs: Thursday, 4:30 - 5:20 pm, GHC 4211

PLEASE NOTE THAT THERE WILL BE NO CLASS THE WEEK OF MARCH 12 DUE TO SPRING BREAK.

All course information is available on-line via CMU Blackboard: http://www.cmu.edu/blackboard

## DESCRIPTION:

We live and work in complex adaptive and evolving socio-technical systems. These systems may be complex for a variety of reasons. For example, they may be complex because there is a need to coordinate many groups, because humans are interacting with technology, because there are non routine or very knowledge intensive tasks, and so on. At the heart of this complexity is a set of adaptive agents who are connected or linked to other agents forming a network and who are constrained or enabled by the world they inhabit. Computational modeling can be used to help analyze, reason about, predict the behavior of, and possibly control such complex systems of "networked" agents.

This course is based on the simulation of complex socio-technical systems. This course teaches the student how to design, analyze, and evaluate such computational models. It will introduce several styles of simulation including agent based and system dynamics. Examples of applications of these tools to various problems such as epidemiology, organizational adaptation, information diffusion, impact of new technology on groups, and so on, will be discussed. The course should be appropriate for graduate students in all areas. This course does not teach programming. Issues covered include: common computational approaches such as multi-agent systems, general simulation and system dynamics, heuristic based optimization procedures including simulated annealing and genetic algorithms, representation schemes for complex systems (particularly, groups, organizations, tasks, networks and technology), analysis techniques such as virtual experiments and response surface mapping, docking (model-to-model analysis), validation and verification, and social Turing tests. Illustrative models will be drawn from recent publications in a wide variety of areas including distributed artificial intelligence, knowledge management, dynamic network analysis, computational organization theory, computational sociology, computational epidemiology, and computational economics.

## TOPICS TO BE COVERED:

\* common computational approaches such as multi-agent systems, general simulation and system dynamics \* heuristic based optimization procedures including simulated annealing and genetic algorithms \* representation schemes for complex systems (particularly, groups, organizations, tasks, networks and technology) \* analysis techniques such as virtual experiments and response surface mapping, docking (model-to-model analysis) \* validation and verification, and social Turing tests. \* illustrative models will be drawn from recent publications in a wide variety of areas including distributed artificial intelligence, knowledge management, dynamic network analysis, computational organization theory, computational sociology, computational epidemiology, and computational economics.

## PREREQUISITES:

The prerequisite will be basic understanding of statistics - undergraduate level.

## METHOD OF EVALUATION:

Grading will be based on a set of programming assignments, validation assignments, and a major project.

### Grading Breakdown

|  |  |
| --- | --- |
| Weekly Discussion & attendance – | 5% (failure to attend or discuss can make this go negative) |
| Assignments – 4 – | 40% (10% each but failure to turn one in is -10%) |
| Comments on other’s presentation of final project | 5% each (total 10%) |
| Topic Presentation | 5% |
| Presentation of Project - | 10% |
| Final Paper & Project – | 35% |
| Paper & Project sub-parts (what 35% entails) |  |
| References – includes and moves beyond literature from course | Creativeness |
| Data – virtual or real | Justification of model |
| Demonstrates understanding of computational modeling concepts | Good interpretation of results |
| Of journal quality | Clear concise abstract |
| Simulation Model and Virtual Experiment Done | Organization |
| Good analysis | Effort, Reasonableness |

Assignments turned in after the end of the term will be subject to a reduction in grade. Class members are expected to attend class, engage in discussions, read material and finish all assignments. Students are encouraged to relate the final project to on-going research. Details should be discussed with instructor.

Illustrative final projects include:

* Development of new model and associated virtual experiments.
* Validation of existing model and new virtual experiments.
* Extensive virtual experimentations and theory building with existing model.
* Docking (model-to-model comparison) of two or more existing models.
* Extensive critique and meta-analysis of existing models possibly including new runs using said models.
* Application of existing model to new area
* Robustness analysis of statistical procedures using simulate data.
* Development and testing of “dynamic measures” or “visualization procedures” for existing models.
* Development and testing of “dynamic measures” or “visualization procedures” using simulated data..
* Making two or more models inter-operable and demonstrating said inter-operability.

## UNIVERSITY POLICY ON CHEATING AND PLAGIARISM

It is extremely important that the home-works, assignments, papers and tests that you turn in during the course reflect your own understanding. To copy answers from another person not only denies you the necessary feedback on whether or not you really understand the material, but it also compromises your integrity. In addition, those who do not succumb to cheating feel that they are “getting the short end of the stick” when they see others getting away with it. For these reasons we expect everyone to behave with integrity. And, to support those who do, we will institute measures to apprehend students who are cheating. For example, to control the alteration of graded exams, we will sporadically make copies of exams before returning them. Any discrepancy between the copy and an exam turned in for re-grading will be taken as clear evidence of cheating. In addition, because the crowded lecture hall makes it possible to copy answers from another students’ paper during an exam, we may distribute several different versions of written exams, rotating between versions.

Cheating is an extremely serious action. University policy requires that any student caught cheating will receive an R and that the facts of the case be reported to the Dean of Student Affairs. Multiple cases of cheating can be grounds for expulsion from CMU. Students are encouraged to discuss homework and laboratory projects but the submitted solutions must involve only an individual’s effort. To make that more clear, you are permitted, and even encouraged to discuss problem set solutions with your fellow students at the level of “what equations should I be using to solve that kind of problem” or “how do I interpret that problem”. However, students should never copy directly from another student’s problem set. Any student who copies from someone else’s homework, quiz, test, or exam solutions, or any student who willingly allows another student to copy his or her work, or any student who submits someone else’s work as their own will be deemed guilty of cheating.

In this class, without explicit permission of the instructor, the following do not count as original work and would constitute cheating:

* Turning in the same or largely similar paper to two classes.
* Joint work on a problem set.
* Copying material from the web without citing it correctly.
* Plagiarism, including – copying images, graphs, and tables from published work.

**REQUIRED TEXTS:**

1. **Law, A., *Simulation Modeling and Analysis,* 2007, McGraw Hill, ISBN: 978-0-07-298843-7, edition: 4. (SMA)**

2. **Sterman, J., *Business Dynamics: Systems thinking and modeling for a complex world*, 2000, Irwin/McGraw-Hill, ISBN: 9780072389159. (BD)**

3. **Gilbert N. and Troitzsch, K., *Simulation for the Social Scientist*, 2005, Open University Press, ISBN: 9780335216000, edition: 2. (SSS)**

## REQUIRED AND BACKGROUND READINGS:

There are also a series of non-textbook readings; all papers are available via Blackboard.

A tentative ordering of material for each lecture is provided in the course outline. Please read the required items for the week BEFORE the Monday class. In addition, as needed, additional material will be added, or the readings changed based on the background of the participants.

## PROGRAMMING:

Students can do programming in any language or using any operating system; however, existing tools are in C and C++.

Agent based models may be built in a system such as RePast, NetLogo, Swarm or Mason.

Machine learning models do NOT constitute a simulation and will not be counted as acceptable for the final project. However, machine learning can be used to test, analyze or validate a simulation model by assessing it’s output and/or the relation to real empirical data.

**Computational Modeling of Complex Socio-Technical Systems: Course Outline**

08-810 Spring 2012

(Please read the required items BEFORE class)

## Legend

SMA = Law, A., [Simulation Modeling and Analysis](http://content.imamu.edu.sa/Scholars/it/VisualBasic/306537540.pdf)

BD = Sterman, J., [Business Dynamics: Systems thinking and modeling for a complex world](http://web.mit.edu/jsterman/www/BusDyn2.html)

SSS = Gilbert, N. and Troitzsch, K., [Simulation for the Social Scientist](http://cress.soc.surrey.ac.uk/s4ss/links.html)

|  |  |  |
| --- | --- | --- |
| **Date** | **Title** | **Notes** |
|  |  |  |

## Week 1: Introduction & Overview

|  |  |  |
| --- | --- | --- |
| M 1/16 | Homework #1 Out- Implementation and extension |  |
| W 1/18 | SMA – ch 1 – (skim) (Basic Simulation Modeling) | Required |
|  | SSS – ch 1 (Simulation and Social Science) | Required |
|  | SSS – ch 2 (Simulation as a method) | Required |
|  | Jeffrey R. Young (1998) "Using computer Models to Study the Complexities of Human society" | Background |
|  | Casti, John L. (1997) Would-Be Worlds: How Simulation is Changing the Frontiers of Science. | Background |
|  | J. G. March and R. M. Cyert (1992) A Behavioral Theory of the Firm. | Background |
|  | Relevant Web Sites |  |
|  | Gilbert & Troitzsch: Book website: <http://cress.soc.surrey.ac.uk/s4ss/links.html> | Background |
|  |  |  |
|  | CLASSIC MODELS |  |
|  | - The Garbage Can Model |  |
|  | A Garbage Can Model of Organizational Choice. Administrative Sciences Quarterly, 17(1), 1-25. Cohen, M.D., March, J.G. and J.P. Olsen. (March 1972). | Required |
|  | Beyond Garbage Cans: An AI Model of Organizational Choice. Administrative Science Quarterly, 34, 38-67. Masuch M. and LaPotin. (1989). | Background |
|  | Kathleen Carley, 1986, "Efficiency in a Garbage Can: Implications for Crisis Management." Pp. 195-231 in James March & Roger Weissinger-Baylon (Eds.), Ambiguity and Command: Organizational Perspectives on Military Decision Making .Boston, MA: Pitman. | Background |
|  | Padgett, J. (1980). Managing Garbage Can Hierarchies. Administrative Science Quarterly, 25(4): 583-604. | Background |
|  |  |  |
|  | The NK Model |  |
|  | Kauffman, S.A., 1993, The Origins of Order, Oxford University Press, Oxford pp. 36-45. | Required |
|  | Levinthal,D.A. 1997, Adaptation on Rugged Landscapes, Management Science, 43: 934-950. | Background |
|  | Kauffman, S.A. and S. Johnsen, 1991, Co-Evolution to the Edge of Chaos: Coupled Fitness Landscapes, Poised States, and Co-Evolutionary Avalanches, *Artificial Life II*, Santa Fe Institute. | Background |
|  | Weinberger, E.D. and S.A. Kauffman 1989. The NK Model of rugged fitness landscapes and its application to maturation of the immune response. Journal of Theoretical Biology, 141: 211-245. | Background |
|  | Yuan, Y. & McKelvey, B. (2004). Situated Learning Theory: Adding rate and complexity effects via Kauffman’s NK model. *Nonlinear Dynamics, Psychology, and Life Sciences, 8*, 65-102. | Background |
|  |  |  |
|  | The Segregation Model |  |
|  | Schelling, T (1969) Models of segregation. American economic review 59. Pp. 488-493. | Required |
|  | Schelling, T (1971) Dynamic models of segregation. Journal of mathematical sociology 1. Pp. 143-186. | Required |
|  | Schelling, T (1978) Micromotives and Macrobehavior. | Background |
|  | Sakoda, J M (1971) The checkerboard model of social interaction. Journal of mathematical sociology 1. Pp. 119-132*.* | Background |
|  | A Description of the Schelling Model of Racial Segregation by Bruce Edmonds. <http://bruce.edmonds.name/taissl/taissl-appendix.htm> | Background |
|  | The Schelling Segregation Model  Demonstration Software by Chris Cook. <http://www.econ.iastate.edu/tesfatsi/demos/schelling/schellhp.htm> | Background |
|  |  |  |
| R 1/19 | Lab |  |

## Week 2: Agent Based Models

|  |  |  |
| --- | --- | --- |
| M 1/23 | Assignment #1, parts 3&4 due before class |  |
| W 1/25 | Agent Based Modeling |  |
|  | SSS – ch 8 (Multi-agent Models) | Required |
|  | SSS – ch 9 (Developing Multi-Agent Systems) | Required |
|  | Tesfatsion; Agent-Based Computational Economics (ACE) http://www.econ.iastate.edu/tesfatsi/aintro.htm | Required |
|  | P. Langley and J. Laird, 2002, Cognitive Architectures: Research Issues and Challenges. | Required |
|  | J. Boyd (1987) A discourse on winning and losing. Air University, Maxwell Air Force Base | Background |
|  | M. Macy and R. Willer, 2001, From Factors to Actors: Computational Sociology and Agent Based Modeling. | Background |
|  | Kauffman S. 1995. At home in the Universe, Oxford and New York. Oxford University Press, pages 232-264 | Background |
|  | D. Dixon and W. Reynolds, The BASP Agent Based Modeling Framework: Applications, Scenarios and Lessons Learned. | Background |
|  | C. Hemelrijk and H. Kunz (2003), Introduction to Special Issue on Collective Effects of Human Behavior, Vol. 9, No. 4, pp. 339-341. | Background |
|  | M. Janssen and W. Jager (2003), Simulating market dynamics: Interactions between consumer psychology and social networks, Artificial Life, Vol. 9, No. 4, pp. 343-356. | Background |
|  | Y. Louzoun, S. Solomon, J. Goldenberg and D. Mazursky (2003), World-size global markets lead to economic instability, Artificial Life, Vol. 9, No. 4, pp. 357-370. | Background |
|  | K. Smith, S. Kirby and H. Brighton (2003), Iterated learning: A framework for the emergence of language, Artificial Life, Vol. 9, No. 4, pp. 371-386. | Background |
|  | W. Zuidema and G. Weatermann (2003), Evolution of an optical lexicon under constraints from embodiment, Artificial Life, Vol. 9, No. 4, pp. 387-402. | Background |
|  | G. Gumerman, A. Swedlund, J. Dean and J. Epstein (2003), The evolution of social behavior in the prehistoric American southwest, Artificial Life, Vol. 9, No. 4, pp. 435-444. | Background |
|  | Toolkits and Meta Languages |  |
|  | Laird, J.E., Newell, A., and P.S. Rosenbloom, 1987. ``Soar: An architecture for general intelligence.'' Artificial Intelligence, 33:(1): 1-64. <http://www.cs.cmu.edu/afs/cs/project/soar/public/www/brief-history.html> |  |
|  | Soar Cognitive Architecture - <http://sitemaker.umich.edu/soar> |  |
|  | Nelson Minar, Roger Burkhart, Chris Langton, Manor Askenazi, 1996,  “The Swarm Simulation System: A Toolkit for Building Multi-Agent Simulations." Santa Fe Institute Working Paper No. 96-06-042. |  |
|  | Marcus Daniels, 1999. "Integrating Simulation Technologies With Swarm," Agent Simulation: Applications, Models, and Tools Conference, University of Chicago and Argonne National Laboratory, Chicago IL, October 15-16, 1999. |  |
|  | SWARM - <http://www.swarm.org/> |  |
|  | RePast -<http://repast.sourceforge.net/> |  |
|  | Sugarscape - <http://sugarscape.sourceforge.net/> |  |
|  | Ascape – <http://ascape.sourceforge.net/> |  |
|  | MASON - <http://www.cs.gmu.edu/~eclab/projects/mason/> |  |
|  | Other toolkits - <http://www.casos.cs.cmu.edu/computational_tools/tools.html> |  |
|  |  |  |
| R 1/26 | Lab |  |

## Week 3: Construct – Diffusion in ABM

|  |  |  |
| --- | --- | --- |
| M 1/30 | Assignment #1, parts 1&2 due before class; Assignment #2 out |  |
| W 2/1 | Kathleen Carley, 1991, "A Theory of Group Stability." *American Sociological Review*, 56(3): 331-354. | Required |
|  | Brian R. Hirshman, Kathleen M. Carley and Michael J. Kowalchuck, 2007, “Loading Networks in Construct,” Carnegie Mellon University, School of Computer Science, Institute for Software Research, Technical Report, CMU-ISRI-07-116. | Required |
|  | Brian R. Hirshman, Kathleen M. Carley and Michael J. Kowalchuck, 2007, “Specifying Agents in Construct,” Carnegie Mellon University, School of Computer Science, Institute for Software Research, Technical Report, CMU-ISRI-07-107. | Required |
|  | Craig Schreiber and Kathleen M. Carley, 2004. “Construct - A Multi-agent Network Model for the Co-evolution of Agents and Socio-cultural Environments.” Carnegie Mellon University, School of Computer Science, Institute for Software Research International, Technical Report CMU-ISRI-04-109. | Required |
|  | Kathleen M. Carley, 1999, "On the Evolution of Social and Organizational Networks." In Steven B. Andrews and David Knoke (Eds.) Vol. 16 special issue of Research in the Sociology of Organizations. on *"Networks In and Around Organizations*." JAI Press, Inc. Stamford, CT, pp. 3-30. | Background |
|  | Kathleen Carley, 1990, "Group Stability: A Socio-Cognitive Approach." Pp. 1-44 in Lawler E., Markovsky B., Ridgeway C. & Walker H. (Eds.) *Advances in Group Processes: Theory and Research*. Vol. VII. Greenwhich, CN: JAI Press. | Background |
|  | David S. Kaufer & Kathleen M. Carley, 1993, Communication at a Distance: The Effect of Print on Socio-Cultural Organization and Change, Hillsdale, NJ: Lawrence Erlbaum Associates. | Background |
|  | Kathleen M. Carley & David Krackhardt, 1996, “Cognitive inconsistencies and non-symmetric friendship.” Social Networks, 18: 1-27. | Background |
|  | Craig Schreiber and Kathleen Carley, 2003, The Impact of Databases on Knowledge Transfer: Simulation Providing Theory, NAACSOS conference proceedings, Pittsburgh, PA. | Background |
|  | Craig Schreiber and Kathleen Carley, 2003, Going Beyond the Data: Empirical Validation Leading to Grounded Theory, NAACSOS conference proceedings, Pittsburgh, PA. First runner up for the NAACSOS graduate student paper award. | Background |
|  | Construct - <http://www.casos.cs.cmu.edu/projects/construct/> | Background |
|  |  |  |
| R 2/2 | Lab |  |

## Week 4: Analyzing Computational Models

|  |  |  |
| --- | --- | --- |
| M 2/6 | Analyzing Computational Models – 1 system |  |
| W 2/8 | SMA – ch 9 (Output Data Analysis for a Single System) | Required |
|  | SMA – ch 12 (Experimental Design and Optimization) | Required |
|  | Raymond H. Myers, Douglas C. Montgomery, 2002  Response Surface Methodology: Process and Product Optimization Using Designed Experiments, 2nd Edition, Wiley. | Background |
|  | Biles, W.E., and J.J. Swain (1979), Mathematical Programming and the Optimization of Computer Simulations, In: Mathematical Programming Study II - Engineering Optimization, M. Avriel and R.S. Dembo (ED.), pp. 189-207. | Background |
|  | Biles, W.E., and M.L. Lee (1978), A Comparison of Second-Order Response Surface Methods for Optimizing Computer Simulations, 1978 Fall ORSA/TIMS National Meeting, Los Angeles, 28 p. | Background |
|  | Ignall, E.J. (1972), On Experimental Designs for Computer Simulation Experiments, Management Science,# Vol. 18, No. 7, pp. 384-388. | Background |
|  | Montgomery, D.C., and W.M. Bettencourt (1977), Multiple Response Surface Methods in Computer Simulation, Simulation, Vol. 29, No. 4, pp. 113-121. | Background |
|  | See engineering statistics handbook e.g. ch. 5.3 -  <http://www.itl.nist.gov/div898/handbook/pri/section3/pri3.htm> | Background |
|  | Luis Antunes, Helder Coelho, Joao Balso, and Ana Respicio, 2007, “e\*plore v.0: Principia for Strategic Exploration of Social Simulation Experiments Design Space,” in S. Takahashi, D. Sallach and J. Rouchier (Eds.) Advancing Social Simulation: The First World Congress. Tokyo, Japan: Springer, pp. 295 - 306. | Background |
|  | John H. Miller, 1998, "Active Nonlinear Tests (ANTs) of Complex Simulation Models," *Management Science*, 44(6): 820-830. | Background |
|  | McCulloh, Ian & Carley, Kathleen M . (2008). Social Network Change Detection. Carnegie Mellon University, School of Computer Science, Institute for Software Research, Technical Report CMU-CS-08-116. | Background |
|  |  |  |
|  | Analyzing Computational Models – N systems |  |
|  | Kathleen M. Carley, 1999, "On Generating Hypotheses Using Computer Simulations." *Systems Engineering*, 2(2): 69-77. | Required |
|  | R.Axtell, R.Axelrod, J. M.Epstein, and M. D.Cohen. Aligning simulation models: A case study and results. Computational and Mathematical Organization Theory, 1(2): 123--142, 1996. | Required |
|  | Burton, R. M. and B. Obel (1995). "Validation and Docking: An Overview, Summary and Challenge." Computational and Mathematical Organization Theory 1(1): 57-71. | Required |
|  | JPC Kleijnen (2008) Simulation experiments in practice: statistical design and regression analysis. Journal of Simulation (2008) 2, 19-27 | Required |
|  | SMA - ch 10 pp 548-576 (Comparing Alternative Systems Configurations) | Required |
|  | Li-Chiou Chen, Kathleen M. Carley, Douglas Fridsma, Boris Kaminsky, Alex Yahja. Model alignment of anthrax attack simulations. CASOS working paper. | Background |
|  | Kathleen Carley, Johan Kjaer-Hansen, Allen Newell & Michael Prietula, 1992. "Plural-Soar: a Prolegomenon to Artificial Agents and Organizational Behavior ," in Artificial Intelligence in Organization and Management Theory, eds. Michael Masuch & Massimo Warglien, Amsterdam: North-Holland, Ch. 4. | Background |
|  |  |  |
| R 2/9 | Lab |  |

## Week 5: System Dynamics

|  |  |  |
| --- | --- | --- |
| M 2/13 | Assignment #3 out- develop and run a simple SD model |  |
| W 2/15 | SSS – ch 3 (System Dynamics and World Models) | Required |
|  | BD – ch 1 (Learning in and about Complex Systems) | Required |
|  | BD – ch 2 (2.1,2.2,2.3,2.5) (System Dynamics in Action) | Required |
|  | BD – ch 4 (Structure and Behavior of Dynamic Systems) | Required |
|  | BD – ch 10 (10.1, 10.2, 10.3) (Path Dependence and Positive Feedback) | Required |
|  | BD – ch 8 (Closing the Loop: Dynamics of Simple Structures) | Background |
|  | BD – ch 9 (S-Shaped Growth: Epidemics, Innovation Diffusion, and the Growth of New Products) | Background |
|  | Sastry, Anjali, 2001. Understanding dynamic complexity in organizational evolution: A system dynamics apporach. In A. Lomi and E. Larsen (Eds.), Dynamics of Organizations: Computational Modeling and Organization Theories. Cambridge, MA: MIT Press. | Background |
|  | Michael Goodman and Richard Karash, "Six Steps to Thinking Systemically", The Systems Thinker, Vol 6, No 2, March 1995 <http://www.appliedsystemsthinking.com/supporting_documents/PracticeSixSteps.pdf> | Background |
|  | Tabor, M. "Dynamics in the Phase Plane." §1.3 in *Chaos and Integrability in Nonlinear Dynamics: An Introduction.* New York: Wiley, pp. 13-20, 1989. | Background |
|  | System Archetypes, William Braun (2002).Tabor, M. "Dynamics in the Phase Plane." §1.3 in *Chaos and Integrability in Nonlinear Dynamics: An Introduction.* New York: Wiley, pp. 13-20, 1989. | Background |
|  | System Archetypes, William Braun (2002).. | Background |
|  | *Background Materials and Links* | Background |
|  | Beer Game. The BeerGame is a logistics game that was originally developed by MIT in the 60s and has since been played all over the world by people at all levels, from students to presidents of big multinational groups. Now it is your turn. <http://www.masystem.com/beergame> | Background |
|  | Beer Game. Developed by MIT Forum for Supply Chain Innovation. <http://beergame.mit.edu/> | Background |
|  | Simple Beer Distribution Game Simulator. Download here a free management flight simulator version of the Beer Distribution Game. This simulator was developed by Matthew Forrester and AT Kearney, and is provided here at no charge. The simulator runs on PCs (sorry no Macintosh version). <http://web.mit.edu/jsterman/www/SDG/MFS/simplebeer.html> | Background |
|  | Beer Game: Vensim equations. Chapter 4: The Beer Game. Business Process Analysis Workshops: System Dynamics Models. <http://www.public.asu.edu/~kirkwood/sysdyn/SDWork/SDWork.htm> | Background |
|  | Forrester Consulting: System Dynamics Links. <http://www.forresterconsulting.com/Resources.html> | Background |
|  | The System Dynamics Review journal. <http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1099-1727> | Background |
|  | Ventana Systems, Inc. http://www.vensim.com/ Ventana publishes Vensim which is used for constructing models of business, scientific, environmental, and social systems. | Background |
|  | ISEE Systems: STELLA & iThink Software. http://www.hps-inc.com/ | Background |
|  | delta performance systems: Examples of systems dynamics thinking. http://www.dpsnet.com/system/example.htm | Background |
| R 2/16 | Lab |  |

## Week 6: Validation

|  |  |  |
| --- | --- | --- |
| M 2/20 | Kathleen M. Carley Validating Computational Models. Working Paper. | Required |
| W 2/22 | SMA – ch 5 pp 243-274 (Building Valid, Credible, and Appropriately Detailed Simulation Models) | Required |
|  | SMA – ch 6 pp 275-387 (Selecting Input Probability Distributions) | Required |
|  | BD – ch 21 | Required |
|  | Kathleen Carley & Allen Newell, 1994, "The Nature of the Social Agent." *Journal of Mathematical Sociology*, 19(4): 221-262. | Required |
|  | Louie & Carley (2008). Balancing the criticisms: Validating multi-agent models of social systems. Simulation Modeling Practice and Theory 16 (2008) 242–256 |  |
|  | Bedau, M. A. (1999) Can unrealistic computer models illuminate theoretical biology? Proc. GECCO '99 Workshop. Morgan Kaufmann. 20-23. | Background |
|  | Di Paolo, E. A., J. Noble, S. Bullock (2000) Simulation models as opaque thought experiments. Proc. Artificial Live VII. MIT Press. 497-506. | Background |
|  | <http://www.cogs.susx.ac.uk/users/ezequiel/papers.html>  listed under Conference publications | Background |
|  | Richard Burton and Borge Obel, 1995, The Validity of Computational Models in Organization Science: From Model Realism to Purpose of the Model. Computational and Mathematical Organization Theory. 1(1): 57-72. | Background |
|  | Kathleen M. Carley, 1996, "A Comparison of Artificial and Human Organizations." *Journal of Economic Behavior and Organization*. 31: 175-191. | Background |
|  | Osman Balci , Robert G. Sargent, A methodology for cost-risk analysis in the statistical validation of simulation models, Communications of the ACM, v.24 n.4, p.190-197, April 1981 | Background |
|  | Banks, J., D. Gerstein, and S.P. Seares (1987). Modeling Processes, Validation, and Verification of Complex Simulations: A Survey, Methodology and Validation, Simulation Series, Vol. 19, No. 1. The Society for Computer Simulation, pp. 13-18. | Background |
|  | 1984 DOD Simulations: Improved Assessment Procedures Would Increase the Credibility of Results(1987). United States General Accounting Office, PEMD-88-3. | Background |
|  | Bernard P. Zeigler, Theory of Modeling and Simulation, Krieger Publishing Co., Inc., Melbourne, FL, 1984 | Background |
|  | Robert G. Sargent, Verification, validation, and accreditation: verification, validation, and accreditation of simulation models, Proceedings of the 32nd conference on Winter simulation, December 10-13, 2000, Orlando, Florida (note there is a proceedings each year) | Background |
|  | Giannanasi, F., Lovett, P., and Godwin, A.N., “Enhancing confidence in discrete event simulations”, *Computers in Industry*, *Vol. 44* (pp 141-157), 2001. | Background |
|  | Kelton, W. David, Sadowski, Randall W., and Sadowski, Deborah A., Simulation with Arena, 2nd Ed., WCB McGraw-Hill, 2001. | Background |
|  | Mars, P., Chen, J., and Nambiar, R. (1996) *Learning Algorithms: Theory and Applications in Signal Processing, Control, and Communications*. Baton Rouge, CRC Press. | Background |
|  | Sadoun, B. “Applied system simulation: a review study”, *Information Sciences*, 124, pp 173-192, (2000) | Background |
|  | Sterman, John D., Business Dynamics: Systems Thinking and Modeling for a Complex World, Irwin McGraw-Hill, 2000. | Background |
|  | D Krackhardt 2000 "Modeling Structures of Organizations." In David R. Ilgen & Charles L. Hulin & D. R. Ilgen (eds.) Computational Modeling of Behavior in Organizations: The Third Scientific Discipline. Washington, DC: American Psychological Association. | Background |
|  | Technology for the US Navy and Marine Corps Volume 9: <http://www.nap.edu/catalog/5869.htm> | Background |
|  | Modeling and Simulation in Manufacturing: <http://www.nap.edu/catalog/10425.html> | Background |
|  | GamePipe vision paper: <http://gamepipe.isi.edu/pubs/GamePipe9.1.pdf> | Background |
|  |  |  |
| R 2/23 | Lab |  |

## Week 7: Games

|  |  |  |
| --- | --- | --- |
| M 2/27  W 2/29 | Il-Chul Moon, Kathleen M. Carley, Mike Schneider, and Oleg Shigiltchoff (2005), Detailed Analysis of Team Movement and Communication Affecting Team Performance in the America s Army Game, Technical report, CMU-ISRI-05-129. |  |
|  | Zyda, Michael (2004). AMERICA’S ARMY PC Game Vision and Realization. San Francisco, January 2004 http://gamepipe.usc.edu/~zyda/pubs/YerbaBuenaAABooklet2004.pdf |  |
|  | Ducheneaut, N. and Moore, R.J. (2004). "The social side of gaming: a study of interaction patterns in a massively multiplayer online game." In  conference proceedings on computer-supported cooperative work (CSCW 2004) (pp. 360-369). November 6-10, 2004, Chicago, IL.  http://www.parc.com/research/publications/details.php?id=5223 |  |
|  | Ducheneaut, N., Yee, N., Nickell, E., and Moore, R.J. (2007). "The life and  death of online gaming communities: A look at guilds in World of Warcraft." In conference proceedings on human factors in computing systems (CHI 2007) (pp. 839-848). April 28-May 3, San Jose, CA. Paper  <http://www2.parc.com/csl/members/nicolas/documents/CHI2007-Guilds.pdf> |  |
|  | Ducheneaut, N., Yee, N., Nickell, E., and Moore, R.J. (2006). "Alone  Together? Exploring the Social Dynamics of Massively Multiplayer Games." In conference proceedings on human factors in computing systems (CHI 2006) (pp.407-416). April 22-27, Montreal, Canada.  http://www.parc.com/research/publications/details.php?id=5599 |  |
|  | Kollock, Peter, and Marc Smith. 1996. "Managing the Virtual Commons:  Cooperation and Conflict in Computer Communities." Pp. 109-128 in  Computer-Mediated Communication: Linguistic, Social, and Cross-Cultural Perspectives, edited by Susan Herring. Amsterdam: John Benjamins. http://www.sscnet.ucla.edu/soc/faculty/kollock/papers/vcommons.htm |  |
|  | Nardi, B. and Harris, J. 2006, Strangers and friends: Collaborative play in  World of Warcraft, In Proceedings of the Conference on Computer-supported Cooperative Work, pp.149-158  Paper URL: http://darrouzet-nardi.net/bonnie/pdf/fp199-Nardi.pdf |  |
| R 3/1 | Lab |  |

## Week 8: Optimization and Search Procedures

|  |  |  |
| --- | --- | --- |
| M 3/5 | Due – 1 page description of proposed final project |  |
|  | Simulated Annealing |  |
| W 3/7 | Kathleen M. Carley & David M. Svoboda, 1996, “Modeling Organizational Adaptation as a Simulated Annealing Process.” *Sociological Methods and Research*, 25(1): 138-168. | Required |
|  | Kirkpatrick, S., C.D. Gelatt and M.P. Vecchi. 1983. “Optimization by Simulated Annealing.” *Science* 220(4598): 671-680. | Required |
|  | Holland, John H. 1992. Genetic Algorithms, *Scientific American* 267 (July): 66-72. | Required |
|  | Chattoe, Edmund (1998). Just How (Un)realistic are Evolutionary Algorithms as Representations of Social Processes? Journal of Artificial Societies and Social Simulation 1:3 (1998). | Required |
|  | Narzisi G., Mysore V. and Mishra B. Multi-Objective Evolutionary Optimization of Agent Based Models: an application to emergency response planning. The IASTED International Conference on Computational Intelligence (CI 2006), Proceedings by ACTA Press, pp. 224-230, November 20-22, 2006 San Francisco, California, USA | Required |
|  | OrgAhead - Kathleen Carley, OrgAhead overview slides. | Required |
|  | N. Metropolis, A.W. Rosenbluth, M.N. Rosenbluth, A.H. Teller, and E. Teller. "Equations of State Calculations by Fast Computing Machines". Journal of Chemical Physics, 21(6):1087-1092, 1953. | Background |
|  | A. Das and B. K. Chakrabarti (Eds.), Quantum Annealing and Related Optimization Methods. Lecture Note in Physics, Vol. 679, Springer, Heidelberg (2005) | Background |
|  | E. Weinberger, Correlated and Uncorrelated Fitness Landscapes and How to Tell the Difference, Biological Cybernetics, 63, No. 5, 325-336 (1990). | Background |
|  | V. Cerny, A thermodynamical approach to the traveling salesman problem: an efficient simulation algorithm. Journal of Optimization Theory and Applications, 45:41-51, 1985 | Background |
|  | Axelrod, 1987, "The evolution of strategies in the Iterated Prisoner's Dilemma." Pp. 32-41 in Lawrence Davis (ed) *Genetic Algorithms and simulated annealing.* London: Pitman; Los Altos CA. Morgan Kaufmann. | Background |
|  | Holland, John H. 1975. *Adaptation in Natural and Artificial Systems*. Ann Arbor, MI: University of Michigan Press. Ch. 2-3. | Background |
|  | A Network Optimization Approach for Improving Organizational Design, CASOS Technical Report, Kathleen M. Carley and Natalia Y. Kamneva, January 2004, CMU-CS-04-102. | Background |
|  | Crowston K. (1994). Evolving Novel Organizational Forms, In Carley K. and Prietula M. (Eds.) *Computational Organization Theory*, Lawrence Erlbaum Associates, Hillsdale, NJ. | Background |
|  | Computational Organization Theory – chapter 3 | Background |
|  | Carley K., 1992, Organizational Learning and Personnel Turnover. Organization Science, 3(1), 20-46. | Background |
|  | Genetic crossover Images <http://www.obitko.com/tutorials/genetic-algorithms/> | Background |
|  | Genetic algorithms - <http://www.solver.com/gabasics.htm> | Background |
|  | Simulated annealing -<http://wombat.doc.ic.ac.uk/foldoc/foldoc.cgi?Adaptive+Simulated+Annealing> | Background |
|  | Simulated annealing - <http://www.cs.sandia.gov/opt/survey/sa.html> | Background |
|  |  |  |
| R 3/8 | Lab |  |

## Spring Break

|  |  |  |
| --- | --- | --- |
| M 3/12 | No Class |  |
| W 3/14 | No Class |  |
| R 3/15 | No Lab |  |

## Week 9: Student Presentations

|  |  |  |
| --- | --- | --- |
| M 3/19 | Presentations |  |
| W 3/21 | Presentations |  |
| R 3/22 | Lab |  |

## Week 10: Linking Relational Analysis to and Modeling Action

|  |  |  |
| --- | --- | --- |
| M 3/26  W 3/28 | TBA |  |
|  |  |  |
| R 3/29 | Lab |  |

## Week 11: Learning & Adaptation (Learning and Information Diffusion) - Tentative

|  |  |  |
| --- | --- | --- |
| M 4/2  W 4/4 | Vriend, Nicolaas (2000), “An Illustration of the Essential Difference Between Individual and Social Learning, and its Consequence for Computational Analyses,” /Journal of Economic Dynamics and Control/, Vol. 24, pp. 1-19. | Required |
|  | BD – ch 15 (Modeling Human Behavior: Bounded Rationality or Rational Expectations?) | Required |
|  | SSS – ch 10 (Learning and Evolutionary Models) | Required |
|  | Carley & Svoboda, 1996. Kathleen M. Carley & David M. Svoboda, 1996, Modeling Organizational Adaptation as a Simulated Annealing Process. Sociological Methods and Research, 25(1): 138-168 | Required |
|  | Smart, Bill. Reinforcement Learning: A User's Guide. | Required |
|  | Harrison, J.R. and G.R. Carroll. 1991. Keeping the Faith: A Model of Cultural Transmission in Formal Organizations. Administrative Science Quarterly, 36, 552-582. | Background |
|  | Axelrod 1997 The dissemination of culture: A model with Local Convergence and Global Polarization. *Journal of Conflict Resolution*. 41: 203-226. | Background |
|  | Michael W. Macy, James A. Kitts and Andreas Flache, Culture Wars and Dynamic Networks: A Hopfield Model of Emergent Structure. | Background |
|  | Kathleen M. Carley, Ju-Sung Lee and David Krackhardt, 2001, Destabilizing Networks, *Connections* 24(3):31-34. | Background |
|  | Glance, N.S. and Huberman B.A., 1994, "The Dynamics of Social Dilemmas" *Scientific American* March: 76-81. | Background |
|  | Levinthal, D. and J.G. March (1981), “A Model of Adaptive Organizational Search,” *Journal of Economic Behavior and Organization* 2: 307-333. | Background |
|  | Kathleen M. Carley & Ju-Sung Lee, 1998, Dynamic Organizations: Organizational Adaptation in a Changing Environment.Ch. 15 (pp. 269-297) in Joel Baum (Ed.) Advances in Strategic Management, Vol. 15, Disciplinary Roots of Strategic Management Research. JAI Press. Pp. 269-297. | Background |
|  | Lant, T.L. and S.J. Mezias, 1992, “An Organizational Learning Model of Convergence and Reorientation,” *Organization Science*, 3(1): 47-71. | Background |
|  | Glance, N.S. and Huberman B.A., 1994, Social Dilemmas and Fluid Organizations, In Carley K. and Prietula M. (Eds.) *Computational Organization Theory*, Hillsdale, NJ: Lawrence Erlbaum Associates. | Background |
|  | Kathleen M. Carley and Vanessa Hill, 2001, “Structural Change and Learning Within Organizations”. In Dynamics of Organizations: Computational Modeling and Organizational Theories. Edited by Alessandro Lomi and Erik R. Larsen, MIT Press/AAAI Press/Live Oak, Ch. 2. pp 63-92. | Background |
|  | Lant, T., 1994, Computer Simulations of Organizations as Experiential Learning Systems: Implications for Organizational Theory. CH. 9 in Computational Organization Theory | Background |
|  | Kollman, K. Miller, J., Page, S, 1992, "Adaptive Parties in Spatial Elections" *American Political Science Review*, 86(4): 929-937. | Background |
|  | Padgett, John F., 1997, “The Emergence of Simple Ecologies of Skill: A Hypercycle Approach to Economic Organization.” In *The Economy as a Complex Evolving System*, edited by B. Arthur, S. Durlauf and D. Lane. Santa Fe Institute Studies in the Sciences of Complexity. | Background |
|  | Machine Learning, Tom Mitchell, McGraw Hill, 1997. | Background |
|  | Machine learning - <http://www.ics.uci.edu/~mlearn/MLRepository.html> | Background |
|  | Artificial intelligence - <http://www-2.cs.cmu.edu/afs/cs.cmu.edu/project/ai-repository/ai/0.html> | Background |
|  |  |  |
| R 4/5 | Lab |  |

## Week 12: Alternative Modeling ParadigmsDiscrete Event Simulation

|  |  |  |
| --- | --- | --- |
| M 4/9 | *Discrete Event, Bayesian, Markov* | TBA |
| W 4/11 | Law, A. (2007). Simulation Modeling & Analysis, 4th Ed. McGraw Hill, pp 6-70. | Required |
|  | Arnold H. Buss, Kirk A. Stork (1996) Discrete Event Simulation On The World Wide Web Using Java. Proceedings of the 1996 Winter Simulation Conference. pp 780-785 | Background |
|  | J. B. Jun, S. H. Jacobson, J. R. Swisher (1999) Application of Discrete-Event Simulation in Health Care Clinics: A Survey. The Journal of the Operational Research Society, Vol. 50, No. 2, (Feb., 1999), pp. 109- 123. | Background |
|  | MS Fayez, A Kaylani, D Cope, N Rychlik and M Mollaghasemi. (2008)  Managing airport operations using simulation. Journal of Simulation (2008) 2, 41-52 | Background |
|  | Thomas J. Schriber, Daniel T. Brunner (2005) Inside Discrete-Event Simulation Software: How It Works And Why It Matters. Proceedings of the 2005 Winter Simulation Conference. pp 167-177 | Required |
|  | Bayesian - TBA | Required |
|  | Markov - TBA | Required |
|  |  |  |
| R 4/12 | Lab |  |

## Week 13: Special Topics - TBA

|  |  |  |
| --- | --- | --- |
| M 4/16 |  |  |
| W 4/18 |  |  |
| R 4/19 | Lab |  |

## Week 14: Student Final Projects Presentations

|  |  |  |
| --- | --- | --- |
| M 4/23 | Student Presentations |  |
| W 4/25 | Student Presentations (as necessary) |  |
| R 4/26 | Lab |  |

## Week 15: Special Topics - TBA

|  |  |  |
| --- | --- | --- |
| M 4/28 |  |  |
| W 4/30 | Future Directions |  |
| R 5/1 | Lab |  |