Computational Modeling of Complex Socio-Technical Systems

08-810, 08-621
Syllabus
Fall 2016
12 Course Units

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Lectures: Monday, Wednesday 3:30 PM – 5:20 PM
**There will be no class scheduled for Labor Day September 5th
**There will be no classes scheduled on Wednesday November 23rd for the Thanksgiving Holiday
**Recitation sections will be organized as needed for specific technologies – construct, system dynamics, and abms – times TBA and this area optional

All course information is available on-line via CMU Blackboard: http://www.cmu.edu/blackboard
For a taste of what the course can be like: A fun little explainer and tutorial on Schelling's Dynamic Segregation Model, with a tie in for the need for awareness about diversity. http://ncase.me/polygons/

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. 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 is a basic understanding of statistics - undergraduate level. Programming is not required but it is helpful.

Take care of yourself.

Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling" Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:
CaPS: 412-268-2922
Re:solve Crisis Network: 888-796-8226

If the situation is life threatening, call the police:
On campus: CMU Police: 412-268-2323
Off campus: 911

If you have questions about this or your coursework, please contact Prof. Kathleen M. Carley kathleen.carley@cs.cmu.edu

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 by up to -10%)
Assignments – 4 –	40% (10% each but failure to turn one in is -15% which will lower your grade half to a full level)
Comments on other's presentations, and questions	5% each (total 10%) (failure to comment or ask questions on at least half the presentations is – 5%)
Presentation of Papers	5% (failure to present is -15%)
Presentation of Your Project -	10% (failure to present is -15%)
Final Paper & Project –	35% (failure to do a paper and project is -50%)
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, but are not limited to:

- 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 data that you simulate.
- 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

You are expected to read and attend to the information in - University Policy on Academic Integrity. The full policy is available by clicking the hyperlinked text above. Additional information about the university process for handling violations and links to resources is also available via this comprehensive website: http://www.cmu.edu/academic-integrity/index.html .

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. It is also important that the work represents your work. Thus, any unauthorized assistance in doing the course project or homework is also considered 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 another class or classes.
- Joint work with another student on a problem set or final project.
- Copying material from the web without citing it correctly.
- Plagiarism, including – copying images, graphs, and tables from published work.
- Failure to correctly cite material produced by others.
- Utilizing source code developed by others or drawn from the web for your project without explicit prior permission of the instructor, and appropriate reference.

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 and model development in any language or using any operating system; however, most tools are in Java, Python, or C++. To analyze the model's results it is recommended that if you are using networks you should use ORA, if standard statistics R or any statistical toolkit.

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

System dynamic models can be done in any of the packages, e.g. Stella and iThink

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 its output and/or the relation to real empirical data. Just doing so, however, will not be considered sufficient for a course project.

Illustrative toolkits you might be interested in:

Soar Cognitive Architecture - http://soar.eecs.umich.edu/	Cognitive
ACT-R http://act-r.psy.cmu.edu/software/	Cognitive
SWARM - http://www.swarm.org/	ABM
RePast -http://repast.sourceforge.net/	ABM
Sugarscape - http://sugarscape.sourceforge.net/	ABM
Ascape – http://ascape.sourceforge.net/	ABM
NetLogo - https://ccl.northwestern.edu/netlogo/	ABM
MASON - http://www.cs.gmu.edu/~eclab/projects/mason/	ABM
Construct	Construct
ORA	Network Analysis
Stella & iThink - http://iseesystems.com/store/products/	System Dynamics

Ventana Systems, Inc. http://www.vensim.com/ Ventana publishes Vensim which is used for constructing models of business, scientific, environmental, and social systems.	System Dynamics
ISEE Systems: STELLA & iThink Software. http://www.iseesystems.com/	System Dynamics
https://en.wikipedia.org/wiki/Comparison_of_system_dynamics_software	System Dynamics & More

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
BD = Sterman, J., Business Dynamics: Systems thinking and modeling for a complex world
SSS = Gilbert, N. and Troitzsch, K., Simulation for the Social Scientist

Week 1: Introduction & Overview, Classic Models, Analysis

M 8/29	What is Simulation? *Homework #1 Out- Implementation and extension*	
	SMA – ch 1 – (skim) (Basic Simulation Modeling)	Required
	SSS – ch 2 (Simulation as a method)	Required
	SSS – ch 1 (Simulation and Social Science)	Background
	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
	Geoffrey Morgan & Carley, Kathleen M., 2012, "Modeling Formal and Informal Ties within an Organization: A Multiple Model Integration," *The Garbage Can Model of Organizational Choice: Looking Forward at Forty. Edited by* Alessandro Lomi and Richard Harrison (Ed.). 36: Emerald Group Publishing Ltd.	Background
	Kathleen M. 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
	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

W 8/30	*Analyzing Computational Models*	
	SMA – ch 9 (Output Data Analysis for a Single System)	Required
	SMA – ch 12 (Experimental Design and Optimization)	Required
	JPC Kleijnen (2008) Simulation experiments in practice: statistical design and regression analysis. Journal of Simulation (2008) 2, 19-27	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 -	Background

	http://www.itl.nist.gov/div898/handbook/pri/section3/pri3.htm	
	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
	Susan M. Sanchez and Thomas W. Lucas. 2002. Exploring the world of agent-based simulations: simple models, complex analyses: exploring the world of agent-based simulations: simple models, complex analyses. In *Proceedings of the 34th conference on Winter simulation: exploring new frontiers* (WSC '02). Winter Simulation Conference 116-126.	Background

Week 2: Cognitive Models

M 9/5	*Assignment #1, due Midnight 9/5/2016*	
W 9/7	Soar, Act-R, Social Cognition	
	Langley, P., Laird, J. E., & Rogers, S. (2009). Cognitive architectures: Research issues and challenges. Cognitive Systems Research, 10(2), 141-160.	Required
	Anderson, J. R., Matessa, M., & Lebiere, C. (1997). ACT-R: A theory of higher level cognition and its relation to visual attention. Human-Computer Interaction, 12(4), 439-462.	Required
	Geoffrey P. Morgan, Kenneth Joseph, & Kathleen M. Carley (2015-under review) The Power of Social Cognition	Required
	P. Langley and J. Laird, 2002, Cognitive Architectures: Research Issues and Challenges.	Background
	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	Background
	Anderson, J. R. (1996). ACT: A simple theory of complex cognition. American Psychologist, 51(4), 355.	Background
	Laird, J. E. (2008). Extending the Soar cognitive architecture. Frontiers in Artificial Intelligence and Applications, 171, 224.	Background
	Johnson, T. R. (1997, August). Control in ACT-R and Soar. In Proceedings of the Nineteenth Annual Conference of the Cognitive Science Society (pp. 343-348).	Background

Week 3: Agent Based Models, Construct and Diffusion

M 9/12	*Agent Based Modeling* *Assignment 2 Out*	
	Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. *Proceedings of the National Academy of Sciences*, *99*(suppl 3), 7280-7287.	Required
	Davidsson, Paul (2002). "Agent Based Social Simulation: A Computer Science View". *Journal of Artificial Societies and Social Simulation* **5** (1)	Required
	Macy, M. W., & Willer, R. (2002). From factors to actors: Computational sociology and agent-based modeling. *Annual review of sociology*, 143-166. Stable URL: http://www.jstor.org/stable/3069238	Required
	SSS – ch 8 (Multi-agent Models)	Background
	C.M. Macal & M.J. North, 2010. Tutorial on Agent-Based Modelling and Simulation, Journal of Simulation, 4(3): 151-162.	Background
	SSS – ch 9 (Developing Multi-Agent Systems)	Background
	Tesfatsion; Agent-Based Computational Economics (ACE) http://www.econ.iastate.edu/tesfatsi/aintro.htm	Background
	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.	Background
W 9/14	*Construct & Diffusion*	
	Kathleen M. Carley, Michael K. Martin and Brian Hirshman, 2009, "The Etiology of Social Change," Topics in Cognitive Science, 1.4:621-650.	Required
	Kathleen M. Carley, 1990, "Group Stability: A Socio-Cognitive Approach," Advances in Group Processes: Theory and Research. Edited by Lawler E., Markovsky B., Ridgeway C. and Walker H. (Eds.), Vol. VII. Greenwhich, CN: JAI Press, 7: 1-44.	Required
	Kathleen M. Carley, Michael J. Lanham, Kenneth Joseph, Michael Kowalchuck, and Geoffrey P. Morgan, 2014, "Construct User's Guide", School of Computer Science, Institute for Software Research, Technical Report CMU-ISR-14-105R .	Background
	Michael J. Lanham, Kenneth Joseph, Geoffrey P. Morgan, and Kathleen M. Carley, 2014, "Construct — Developing and Building CASOS' Simulation Development Environments", School of Computer Science, Institute for Software Research, Technical Report CMU-ISR-14-115.	Background

Week 4: System Dynamics, System Dynamics applications

M 9/19	System Dynamics Assignment #3 out- develop and run a simple SD model	
	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)	Background
	BD – ch 10 (10.1, 10.2, 10.3) (Path Dependence and Positive Feedback)	Background
	BD – ch 8 (Closing the Loop: Dynamics of Simple Structures)	Background
	Tabor, M. "Dynamics in the Phase Plane." §1.3 in *Chaos and Integrability in Nonlinear Dynamics: An Introduction.* NY: Wiley, pp. 13-20, 1989.	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
	Sterman, John D., Business Dynamics: Systems Thinking and Modeling for a Complex World, Irwin McGraw-Hill, 2000.	Background
W 9/21	System Dynamic Applications	
	Stata, R., & Almond, P. (1989). Organizational learning: The key to management innovation. *The training and development sourcebook*, *2*, 31-42.	Student Presentation
	González, J. A., Montes, C., Rodríguez, J., & Tapia, W. (2008). Rethinking the Galapagos Islands as a complex social-ecological system: implications for conservation and management. Ecology and Society, 13(2), 13.	Student Presentation
	Daim, T. U., Rueda, G., Martin, H., & Gerdsri, P. (2006). Forecasting emerging technologies: Use of bibliometrics and patent analysis. Technological Forecasting and Social Change, 73(8), 981-1012.	Student Presentation
	The Beer Game	Background
	Beer Game. Logistics game 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://supplychain.mit.edu/supply-chain-games/beer-game/	Background
	Simple Beer Distribution Game Simulator. Free management flight simulator version of the Beer Distribution Game. This simulator was developed by Matthew Forrester and AT Kearney. PC only 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

Week 5: Agent Based Dynamic-Network Simulation, Social Change

M 9/25	Agent-Based Dynamic-Network	
	Rahmandad, H., & Sterman, J. (2008). Heterogeneity and network structure in the dynamics of diffusion: Comparing agent-based and differential equation models. *Management Science*, *54*(5), 998-1014.	Student Presentation
	Lynne Hamill and Nigel Gilbert (2009), Social Circles: A Simple Structure for Agent-Based Social Network Models *Journal of Artificial Societies and Social Simulation* vol. 12, no. 2 3 http://jasss.soc.surrey.ac.uk/12/2/3.html	Student Presentation
	Michael W. Macy, James A. Kitts and Andreas Flache, Culture Wars and Dynamic Networks: A Hopfield Model of Emergent Structure.	Student Presentation
	Kathleen M. Carley, Ju-Sung Lee and David Krackhardt, 2001, Destabilizing Networks, *Connections* 24(3):31-34.	Background
	Lanham, M. J., Morgan, G. P., & Carley, K. M. (2011, June). Data-driven diffusion modeling to examine deterrence. In *Network Science Workshop (NSW), 2011 IEEE* (pp. 1-8). IEEE.	Background
W 9/27	Social Change	
	Abrahamson, E., & Rosenkopf, L. (1997). Social network effects on the extent of innovation diffusion: A computer simulation. *Organization science*, *8*(3), 289-309.	Student Presentation
	Barrett, C. L., Bisset, K. R., Eubank, S. G., Feng, X., & Marathe, M. V. (2008, November). EpiSimdemics: an efficient algorithm for simulating the spread of infectious disease over large realistic social networks. In *Proceedings of the 2008 ACM/IEEE conference on Supercomputing* (p. 37). IEEE Press.	Student Presentation
	Larry Lin, Kathleen M. Carley, and Shih-Fen Cheng, 2016-forthcoming, "An Agent-Based Approach to Human Migration Movement," In Proceedings of the 2016 Winter Simulation Conference T. M. K. Roeder, P. I. Frazier, R. Szechtman, E. Zhou, T. Huschka, and S. E. Chick, eds.	Student Presentation
	BD – ch 9 (S-Shaped Growth: Epidemics, Innovation Diffusion, and the Growth of New Products)	Background
	Kenneth Joseph, Kathleen M. Carley, David Filonuk, Geoffrey P. Morgan, and Jürgen Pfeffer, 2014. Arab Spring: From News Data to Forecasting. *Social Network Analysis and Mining*. Online publication, February 2014, 4(1), Springer Vienna.	Background
	Glance, N.S. and Huberman B.A., 1994, Social Dilemmas and Fluid Organizations, In Carley K. and Prietula M. (Eds.) *Computational*	Background

	Organization Theory, Hillsdale, NJ: Lawrence Erlbaum Associates.	
	Axelrod 1997 The dissemination of culture: A model with Local Convergence and Global Polarization. *Journal of Conflict Resolution*. 41: 203-226.	Background
	Kollman, K. Miller, J., Page, S, 1992, "Adaptive Parties in Spatial Elections" *American Political Science Review*, 86(4): 929-937.	Background
	Glance, N.S. and Huberman B.A., 1994, "The Dynamics of Social Dilemmas" *Scientific American* March: 76-81.	Background

Week 6: Modeling the Organization, Learning Models

M 10/3	Modeling the Organization	
	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	Student Presentation
	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.	Student Presentation
	Levinthal, D. and J.G. March (1981), "A Model of Adaptive Organizational Search," *Journal of Economic Behavior and Organization* 2: 307-333.	Student Presentation
	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
	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
	Crowston K. (1994). Evolving Novel Organizational Forms, In Carley K. and Prietula M. (Eds.) *Computational Organization Theory*, LEA, Hillsdale, NJ.	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
W 10/5	Learning in Simulations	
	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.	Student Presentation
	Pyka, A., Gilbert, N. & Ahrweiler, P. (2007). Simulating knowledge-generation and distribution processes in innovation collaborations and networks. Cybernetics and Systems: An International Journal, 38(7), 667-693.	Student Presentation
	Axelrod, 1987, "The evolution of strategies in the Iterated Prisoner's Dilemma." Pp. 32-41 in Lawrence Davis (ed) *Genetic Algorithms and Simulated Annealing.* Los Altos CA. Morgan Kaufmann.	Student Presentation
	Carley K., 1992, Organizational Learning and Personnel Turnover.	Background

	Organization Science, 3(1), 20-46.	
	Mars, P., Chen, J., and Nambiar, R. (1996) *Learning Algorithms: Theory and Applications in Signal Processing, Control, and Communications*. Baton Rouge, CRC Press.	Background
	BD – ch 15 (Modeling Human Behavior: Bounded Rationality or Rational Expectations?)	Background
	SSS – ch 10 (Learning and Evolutionary Models)	Background
	Smart, Bill. Reinforcement Learning: A User's Guide.	Background

Week 7: Additional Modeling Issues

M 10/10	*Discrete Event, Petri-net (Influence), Markov*	TBA
	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
	Jensen, K. (1987). Coloured petri nets. In Petri nets: central models and their properties (pp. 248-299). Springer Berlin Heidelberg.	Required
	Chib, S., & Greenberg, E. (1996). Markov chain Monte Carlo simulation methods in econometrics. Econometric theory, 12(03), 409-431.	Required
	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
	Law, A. (2007). Simulation Modeling & Analysis, 4th Ed. McGraw Hill, pp 6-70.	Background
	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
	Sonnenberg, F. A., & Beck, J. R. (1993). Markov models in medical decision making a practical guide. *Medical decision making*, *13*(4), 322-338.	Background
W 10/12	Kathleen M. Carley, 1999, "On Generating Hypotheses Using Computer Simulations." *Systems Engineering*, 2(2): 69-77.	Student Presentation
	TBA	Student Presentation
	TBA	Student Presentation

Week 8: Multi-Modeling and Multi-Level Modeling

M 10/17	Interoperability	
	Carley, K. M., Morgan, G., Lanham, M., & Pfeffer, J. (2012). Multi-modeling and socio-cultural complexity: reuse and validation. *Advances in Design for Cross--Cultural Activities*, *2*, 128.	Required
	Levis, A. H. (2015). Multi-formalism modeling of human organization. In *Proceedings 29th European Conference on Modelling and Simulation* (pp. 19-31).	Required
	Model Interoperability – Appendix from NAS Models of the World	Required
	Levis, A. H., Zaidi, A. K., & Rafi, M. F. (2012). Multi-modeling and Meta-modeling of Human Organizations. *Advances in Design for Cross-Cultural Activities*, 148.	Background
W 10/19	Multi-Modeling	
	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.	Student Presentation
	TBA	Student Presentation
	TBA	Student Presentation

Week 9: Synthetic Data, Optimization and Search Procedures

M 10/24	*Due – 1 page description of proposed final project*	
	Kenneth Joseph, Wei Wei and Kathleen M. Carley, 2013, An agent-based model for simultaneous phone and SMS traffic over time, In proceedings of 6th International Conference on Social Computing, Behavioral-Cultural Modeling and Prediction, SBP 2013; Washington, DC; United States; 2 April 2013 through 5 April 2013, Lecture Notes in Computer Science, 7812: 65-74.	Student Presentation
	Kathleen M. Carley, Douglas Fridsma, Elizabeth Casman, Alex Yahja, Neal Altman, Li-Chiou Chen, Boris Kaminsky and Demian Nave, 2006. "BioWar: Scalable Agent-based Model of Bioattacks," *IEEE Transactions on Systems, Man and Cybernetics-Part A*, 36(2):252-265.	Student Presentation
	L. R. Carley and Eric Malloy, "Synthetic Generation of Geolocated Over-Time Social Network Communications Trails," being submitted to *Social Network Analysis and Mining (SNAM).*	Student Presentation
W 10/26	Optimization	
	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	Background
	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
	Holland, John H. 1975. Adaptation in Natural and Artificial Systems. Ann Arbor, MI: University of Michigan Press. Ch. 2-3.	Background
	Genetic crossover Images http://www.obitko.com/tutorials/genetic-	Background

	algorithms/	
	Genetic algorithms - http://www.solver.com/gabasics.htm	Background

Week 10: Validation

M 10/31	***Validation***	
	SMA – ch 5 pp 243-274 (Building Valid, Credible, and Appropriately Detailed Simulation Models)	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	Required
	Bharathy, G.K. and B. Silverman, 2010, Validating agent based social systems models, In Proceedings of the 1010 Winter Simulation Conference, edited by B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan and E. Yucesan, Pascataway, NJ, IEEE Inc.	Required
	Kathleen M. Carley Validating Computational Models. Working Paper.	Background
	Bedau, M. A. (1999) Can unrealistic computer models illuminate theoretical biology? Proc. GECCO '99 Workshop. Morgan Kaufmann. 20-23.	Background
	SMA - ch 10 pp 548-576 (Comparing Alternative Systems Configurations)	Background
	SMA – ch 6 pp 275-387 (Selecting Input Probability Distributions)	Background
	BD – ch 21	Background
	Fortino, G., Garro, A., & Russo, W. (2005, November). A Discrete-Event Simulation Framework for the Validation of Agent-based and Multi-Agent Systems. In *WOA* (pp. 75-84).	Background
W 11/2	Validation	
	Burton, R. M. and B. Obel (1995). "Validation and Docking: An Overview, Summary and Challenge." Computational and Mathematical Organization Theory 1(1): 57-71.	Student Presentation
	Li-Chiou Chen, Kathleen M. Carley, Douglas Fridsma, Boris Kaminsky and Alex Yahja, 2006. "Model Alignment of Anthrax Attack Simulations," *Decision Support Systems*, special issue on Intelligence and Security Informatics, 41(3):654-668.	Student Presentation
	Craig Schreiber and Kathleen M. Carley, 2004. "Going Beyond the Data: Empirical Validation Leading to Grounded Theory," *Computational and Mathematical Organization Theory*, 10(2):155-164.	Student Presentation
	Di Paolo, E. A., J. Noble, S. Bullock (2000) Simulation models as opaque thought experiments. Proc. Artificial Live VII. MIT Press. 497-506. http://users.sussex.ac.uk/~ezequiel/opaque.pdf	Background

	Kathleen M. Carley, 1996, "A Comparison of Artificial and Human Organizations." *Journal of Economic Behavior and Organization*. 31: 175-191.	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
	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
	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
	Sadoun, B. "Applied system simulation: a review study", *Information Sciences*, 124, pp 173-192, (2000)	Background
	Modeling and Simulation in Manufacturing and Defense Systems Acquisition: http://www.nap.edu/catalog/10425.html	Background

Week 11: Student Final Projects Presentations

M 11/7 Presentations

W 11/9 Presentations

Week 12: Student Final Projects Presentations

M 11/14 Presentations

W 11/16 Presentations

Week 13: Student Final Projects Presentations

M 11/21

W 11/23 No classes – Thanksgiving Break

Week 14: Student Final Projects Presentations

M 11/28 Student Presentations

W 11/30 Student Presentations

Week 15: Special Student Final Projects Presentations , Future Directions

M 12/5 Student Presentations (as necessary)

W 12/7 Future Directions