Computational Modeling of Complex Socio-Technical Systems

17-821, 17-621
Syllabus
Fall 2024
12 Course Units

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Lectures: Monday, Wednesday 2:00 PM – 3:20 PM
Classroom: Scaife Hall, Room 238 and on Zoom
Dates: Beginning Aug 26, 2024, Every week on Mon and Wed, until Dec 6, 2024
**There will be no class scheduled for Labor Day on September 2nd.
**There will be no classes on October 14th and 16th for Fall Break
**There will be no classes on November 27th for Thanksgiving Break
**Demo sessions will be organized as needed for specific technologies – construct, system dynamics, and abms – times TBA and these are optional

ZOOM CONNECTION DETAILS

Join Zoom Meeting
https://cmu.zoom.us/j/95085925127?pwd=m1PBpRaJj3ZKYARm0BfS9gd3ViaRoN.1

Meeting ID: 950 8592 5127
Passcode: 233877

VIRTUAL/REMOTE PARTICIPATION EXPECTATIONS:

In this class, we will be using Zoom for synchronous (same time) sessions. The link is available on Canvas https://canvas.cmu.edu/courses/40729.

Please make sure that your Internet connection and equipment are set up to use Zoom and able to share audio and video during class meetings. Let Prof. Carley know if there is a gap in your technology set-up, kathleen.carley@cs.cmu.edu, as soon as possible, and we can see about finding solutions.

Sharing video: In this course, being able to see one another helps to facilitate a better learning environment and promote more engaging discussions. Therefore, our default will be to expect students to have their cameras on during lectures and discussions. However, I also completely understand there may be reasons students would not want to have their cameras on. If you have any concerns about sharing your video, please email me as soon as possible kathleen.carley@cs.cmu.edu and we can discuss possible adjustments. Note: You may use a background image in your video if you wish; just check in advance that this works with your device(s) and internet bandwidth.

During our class meetings, please keep your mic muted unless you are sharing with the class or your breakout group.
If you have a question or want to answer a question, please use the chat or the "raise hand" feature (available when the participant list is pulled up). I or the TA will be monitoring these channels in order to call on students to contribute. It is required that you participate in the classes, asking questions and providing your insights.

At several points you will each be doing presentations. In this case, you will be made the presenter and will be sharing your powerpoint slides.

Class participation is a key part of the class. Questions and answering other's questions are part of that participation.

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/

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES:

If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at access@andrew.cmu.edu.

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 and failure to participate in class discussions can make this go negative by up to -15%)
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	1% 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
Virtual Experiments Described in Table	Description
Model Description - Image, Pseudo code, or chart	Description
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.
- Extension and validation of existing model including conducting new virtual experiments.
- Docking (model-to-model comparison) of two or more existing models.
- Extensive critique and meta-analysis of existing models including new runs using said models.
- Adaptation of an existing model to a 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.

Note – all final projects will entail substantial programming in order to develop, extend or modify a model, and to parse and compare the simulated data with real world data. Make sure you budget your *time to ensure you build and test your model and go through a spiral development process with multiple virtual experiments as discussed in the class.*

LATE/MAKE-UP WORK POLICY

Unless otherwise stated, assignments are due on the day listed. However, I recognize that sometimes "life happens." In these instances, you may use your allotted four flex days. These days allow you to submit an assignment up to four days late without penalty, or 4 assignments one day late. You can use these days for any assignment and for any reason. You do not need to provide me with the reason: simply email myself and the TA and tell us how many of your flex days you would like to use.

Once you've exhausted your flex days, then point deductions will occur for any assignment submitted after the deadline. An assignment submitted within 24 hours the due date will only be eligible for 80% of the maximum number of point allotted. Assignments submitted more than 24 hours after the due date will only be eligible for 60% of the maximum number of points allotted. If you experience extenuating circumstances (e.g., you are hospitalized) that prohibit you from submitting your assignments on time, please let me know. I will evaluate these instances on a case-by-case basis.

POLICY ON USING GENERATIVE AI FOR CLASS ASSIGNMENTS

You are welcome to use generative AI programs (ChatGPT, DALL-E, etc.) in this class. These programs can be powerful tools for learning and other productive pursuits, including completion of some assignments in less time, helping you generate new ideas, or serving as a personalized learning tool.

However, your responsibilities as a student remain the same. You must follow the academic integrity guidelines of the university and of this class. If you use one of these generative AI tools to develop content for an assignment, you are required to cite the tool's contribution to your work. In practice, cutting and pasting content from any source without citation is plagiarism. Likewise, paraphrasing content from a generative AI without citation is plagiarism. Similarly, using any generative AI tool without appropriate acknowledgement will be treated as plagiarism. The university's policy on plagiarism applies to all uncited or improperly cited use of work, whether that work is created by human beings alone or in collaboration with a generative AI.

In this class, you may use generative AI programs to:

- Brainstorm new ideas
- Develop example outlines or approaches to your work
- Research topics, or generate different ways to talk about a problem

You may not use generative AI programs to:

- Generate content that you cut and paste into an assignment with a written component without quotations and a citation
- Generate content that is not adequately paraphrased without a citation
- Generate bibliographies for topics that you haven't researched yourself
- Generate other content (images, video, others) unless expressly permitted and following provided guidance
- Otherwise use or present generative AI content that you pass off as your own work, when really it is not

Finally, it is important that you recognize that large language models frequently provide users with incorrect information, create professional-looking citations that are not real, generate contradictory statements, incorporate copyrighted material without appropriate attribution, and can sometimes integrate biased concepts. Code generation models may produce inaccurate outputs. Image generation models may create misleading or offensive content.

While you may use these tools in the work you create for this class, it is important to note that you understand you are ultimately responsible for the content that you submit. Work that is inaccurate, biased, unethical, offensive, plagiarized, or incorrect will be penalized.

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 if permission is given the appropriate reference must be added and a footnote with license information.

Use of LLMs – LLMs can be used to do the following (note if you do so, this must be described in footnote):

- Write code
- Debug code
- Label groups

LLMs must not be used to:

- Write an interpretation of results
- Write section on implication of your results
- Do the literature review

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 Canvas.

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 NetLogo, 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 is fine.

Agent based models can be built in any programming language or may be built in a system such as RePast, NetLogo, Swarm or Mason. For a review on the state of the art in simulation tools, see:

> Abar, S., Theodoropoulos, G. K., Lemarinier, P., & O'Hare, G. M. (2017). Agent based modelling and simulation tools: a review of the state-of-art software. *Computer Science Review*, *24*, 13-33.

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 the 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 https://www.cmu.edu/casos-center/research/tools/construct.html	Construct
ORA https://www.cmu.edu/casos-center/research/tools/ora-lite.html	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

USEFUL LINKS

At https://terna.to.it/simul/SIsaR.html you can find an Agent-Based Model of the Diffusion of Covid-19, with Susceptible, Infected, symptomatic, asymptomatic, and Recovered people. The model uses structural data of Piedmont, an Italian region, but you can calibrate it for other areas following the Info sheet.

Computational Modeling of Complex Socio-Technical Systems: Course Outline
17-821, 17-621 Fall 2024
(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

Lecture 1 - Introduction

M 8/26	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

Lecture 2 – Simple & Intellective

W 8/28	*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

Week 2: Analyzing Simulation Models

Lecture 3 – Virtual Experiments & Response Surfaces

M 9/2	*No class due to holiday*	
W 9/4	*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 - 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

Week 3: System Dynamics, System Dynamics applications

Lecture 4 – System Dynamics

M 9/9	System Dynamics	
	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
	Ivanov, Dmitry. "Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case." *Transportation Research Part E: Logistics and Transportation Review* 136 (2020): 101922.	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

Lecture 5 – System Dynamic Applications

W 9/11	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
	Martinez-Moyano, Ignacio J., Eliot Rich, Stephen Conrad, David F. Andersen, and Thomas R. Stewart. "A behavioral theory of insider-threat risks: A system dynamics approach." *ACM Transactions on Modeling and Computer Simulation (TOMACS)* 18, no. 2 (2008): 1-27.	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 4: Agent Based Models, Construct and Diffusion

Lecture 6 – Agent Based Modeling

M 9/16	*Agent Based Modeling*	
	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
	Weissman, Gary E., Andrew Crane-Droesch, Corey Chivers, ThaiBinh Luong, Asaf Hanish, Michael Z. Levy, Jason Lubken et al. "Locally informed simulation to predict hospital capacity needs during the COVID-19 pandemic." *Annals of internal medicine* (2020)	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

Lecture 7 – Construct

W 9/18	*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
	Dipple, Stephen & Murdock, Isabel & Carley, Kathleen M. (2024). Construct User Guide 2024. Carnegie Mellon University, School of Computer Science, Software and Societal Systems Department, Technical Report CMU-S3D-24-105.	Required (skim)
	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 5: Analysis & Validation

Lecture 8 – Analysis & Docking

M 9/23	Analysis	
	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
	Kathleen M. Carley, 1999, "On Generating Hypotheses Using Computer Simulations." *Systems Engineering*, 2(2): 69-77.	Rquired
	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

Lecture 9 – Validation

W 9/26	***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
	Keijzer, Marijn A., and Michael Mäs. The strength of weak bots. Online Social Networks and Media 21 (2021): 100106	

Week 6: Cognitive Models

Lecture 10 – Cognitive Models

M 9/30	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) 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
	Ross, Björn, Laura Pilz, Benjamin Cabrera, Florian Brachten, German Neubaum, and Stefan Stieglitz. "Are social bots a real threat? An agent-based model of the spiral of silence to analyse the impact of manipulative actors in social networks." European Journal of Information Systems 28, no. 4 (2019): 394-412.	

Lecture 11 – Cybersecurity Models

W 10/2		Agent-Based Dynamic-Network
	Dobson, G. B., & Carley, K. M. (2017). Cyber-FIT: an agent-based modelling approach to simulating cyber warfare. In International Conference on Social Computing, Behavioral-Cultural Modeling and Prediction and Behavior Representation in Modeling and Simulation (pp. 139-148). Springer, Cham.	Required
	Shin, J., Carley, L. R., Dobson, G. B., & Carley, K. M. (2023, December). Beyond Accuracy: Cybersecurity Resilience Evaluation of Intrusion Detection System against DoS Attacks using Agent-based Simulation. In 2023 Winter Simulation Conference (WSC) (pp. 118-129). IEEE.	Required
	Shin, J., Carley, L. R., Dobson, G. B., & Carley, K. M. (2023, May). Modeling and simulation of the human firewall against phishing attacks in small and medium-sized businesses. In 2023 Annual Modeling and Simulation Conference (ANNSIM)(pp. 369-380). IEEE.	Required

Week 7: Applications Diffusion & Social Change

Lecture 12 - Applications

M 10/7	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
	Kollman, K. Miller, J., Page, S, 1992, "Adaptive Parties in Spatial Elections" *American Political Science Review*, 86(4): 929-937.	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

Lecture 13 – Applications

W 10/9	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, “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
	Dipple, S., Jia, T., Caraco, T. et al. Assortative Mating: Encounter-Network Topology and the Evolution of Attractiveness. Sci Rep 7, 45107 (2017). https://doi.org/10.1038/srep45107.	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 Organization Theory*, Hillsdale, NJ: Lawrence Erlbaum Associates.	Background
	Axelrod 1997 The dissemination of culture: A model with Local Convergence and Global Polarization. *Journal of Conflict Resolution*. 41: 203-226.	Background

	Glance, N.S. and Huberman B.A., 1994, "The Dynamics of Social Dilemmas" *Scientific American* March: 76-81.	Background
	Aiyappa, R., Flammini, A., & Ahn, Y. Y., 2024, "Emergence of simple and complex contagion dynamics from weighted belief networks" *Science Advances*, *10*(15), eadh4439.	

Week 8: FALL BREAK NO CLASSES 10/14-10/18

Week 9: Modeling the Organization, Learning Models

Lecture 14 - Applications

M 10/21	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
	Lant, T.L. and S.J. Mezias, 1992, "An Organizational Learning Model of Convergence and Reorientation," *Organization Science*, 3(1): 47-71.	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
	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
	Collier, N. & Ozik, J., 2022, "Distributed Agent-based Simulation with REPAST4PY,"In Proceedings of the 2022 Winter Simulation Conference.	

Lecture 15 – Applications

W 10/23	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. Organization Science, 3(1), 20-46.	Student Presentation
	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
	Guzmán Rincón, Alfredo, Ruby Lorena Carrillo Barbosa, Nuria Segovia-García, and David Ricardo Africano Franco. "Disinformation in social networks and bots: simulated scenarios of its spread from system dynamics." Systems 10, no. 2 (2022): 34.	

Week 10: Additional Modeling Issues

Lecture 16 – Other Types of Modeling

M 10/28	*Discrete Event, Petri-net (Influence), Markov*	
	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

Lecture 17 – Student Presentations

W 10/30	Student Presentations	Student Presentation

Week 11: Multi-Modeling and Multi-Level Modeling

Lecture 18 - Interoperability

M 11/4	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 National Academies of Sciences, Engineering, and Medicine. 2016. *From Maps to Models: Augmenting the Nation's Geospatial Intelligence Capabilities*. Washington, DC: The National Academies Press. https://doi.org/10.17226/23650.	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
	Jiang, J., & Ferrara, E., 2023, "Social-LLM: Modeling User Behavior at Scale using Language Models and Social Network Data." *arXiv preprint arXiv:2401.00893*.	

Lecture 19 – Modeling Online Behavior

W 11/6	**Online Information Diffusion and Social Influence:**	
	Weng, L., Flammini, A., Vespignani, A., & Menczer, F. (2012). Competition among memes in a world with limited attention. Scientific reports, 2, 335.	Student Presentation

	Schweitzer, F., & Garcia, D. (2010). An agent-based model of collective emotions in online communities. The European Physical Journal B, 77(4), 533-545.	Student Presentation
	Rand, William, Jeffrey Herrmann, Brandon Schein, and Neža Vodopivec. "An agent-based model of urgent diffusion in social media." *Journal of Artificial Societies and Social Simulation* 18, no. 2 (2015): 1.	Student Presentation
	Carragher, P., Ng, L. H. X., & Carley, K. M., 2023, September, "Simulation of Stance Perturbations." In *International Conference on Social Computing, Behavioral-Cultural Modeling and Prediction and Behavior Representation in Modeling and Simulation* (pp. 159-168). Cham: Springer Nature Switzerland.	Student Presentation

Week 12: Synthetic Data, Optimization and Search Procedures

Lecture 20 – Synthetic Data

M 11/11		
	Ghaffarzadegan, Navid, Aritra Majumdar, Ross Williams, and Niyousha Hosseinichimeh. "Generative agent-based modeling: an introduction and tutorial." *System Dynamics Review* 40, no. 1 (2024): e1761.	Student Presentation
	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

Lecture 21 – Optimization

W 11/13	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-algorithms/	Background
	Genetic algorithms - http://www.solver.com/gabasics.htm	Background

Week 13: Validation Example

Lecture 22 - TBD

M 11/18	***TBD***	
W 11/20	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
	Cooley, Philip, and Eric Solano. "Agent-based model (ABM) validation considerations." In *Proceedings of the Third International Conference on Advances in System Simulation (SIMUL 2011)*, pp. 134-139. 201	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
	M. J. North and C. M. Macal, Managing Business Complexity: discovering strategic solutions with agent-based modeling and simulation, New York: Oxford University Press, 2007, chapter 11, pages 226 - 233	Background
	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
	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

Thanksgiving Break Monday 11/25 – 11/27

Week 14: Student Final Projects Presentations

M 12/2 Presentations

W 12/4 Presentations

LAST DAY OF CLASSES December 6, 2024