CSS 600/ECON 895
Introduction to Computational Social Science
Fall 2020

Syllabus

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Course Overview

This course is a graduate-level survey of computational approaches to social science research, with emphasis on methods, tools, software frameworks, and complexity theory as these apply to the investigation of social phenomena. For our purposes, "the social sciences" include anthropology, communication, economics and finance, geography, history, linguistics, political science, sociology, and social psychology, informed by developments in psychology, cognitive science, neuroscience, and related branches of behavioral science.

Computational social science (CSS) is a new interdisciplinary frontier in the social sciences. As an introduction to the subject, the course has the following *objectives*:

1. to understand the *motivation* for the use of computational models in social science theory and research, including some historical aspects (Why conduct computational research in the social sciences?);
2. to learn about the variety of CSS *research programs* across the social science disciplines, through a survey of social simulation models (What has CSS accomplished thus far?);
3. to understand the *distinct contribution* that CSS can make by providing specific insights about society, social phenomena at multiple scales, and the nature of social complexity (What is the relation between computational social science and the social sciences more generally).
4. to provide *foundations* for more advanced work in subsequent courses or projects for those students who already have or will develop a long-term interest in computational social science (e.g., CSS 605 Object-Oriented Modeling in Social Science, CSS 610 Computational Analysis of Social Complexity, and other courses in the CSS graduate program).

CSS 600 is a co- or pre-requisite for most other CSS courses and all students entering the CSS Ph.D. program or MAIS CSS concentration take it in their first semester. Depending on a student's interests and learning objectives, this course can be taken as:

1. a single course, to learn about computational social science;
2. an elective to satisfy requirements of another degree (e.g., MPA, ECON, CSI);
3. part of a "computational concentration" that is part of some other degree;
4. the first of five courses required for the Certificate in Computational Social Sciences;
5. the first of the three required core courses for Computational Social Science concentration in the MAIS in Interdisciplinary Studies;
6. as the first-year core of the Ph.D. degree in Computational Social Science (the first such degree in the world).

No particular computer science, programming, or advanced mathematics skills are necessary for this course, since it is specifically designed as an introductory survey. However, some background and "maturity" in computing and mathematics is desirable. The main requirements to take this course and perform well are:

- Interest in some area of real-world social investigation where computational approaches have been applied (e.g., the environment, financial markets, war and

peace, origins of civilization, or other area of application).
- Curiosity about the nature and purpose of computational modeling in the various domains of the social sciences: Why do social simulations in the first place? What are they for? What can they tell us about the way in which various social processes operate? What are their main strengths and limitations?
- Basic skills in critical thinking and analytical reasoning (learning concepts, fundamental principles, and how to apply them to specific domains).
- Motivation to learn from case studies, research projects, and demonstrations.
- Willingness to create models.

Some unhelpful misconceptions of computational social science are the following: that all computational modeling is quantitative or numerical; that qualitative analysis is not involved in computational modeling; that numbers, as opposed to ideas, are the basic elements of modeling; that computational models provide no new knowledge beyond what an intelligent mind can discover without models; that computer models are unethical, because "they replace human decision-makers"; that CSS is Orwellian; and so forth. We will discuss other misconceptions in class.

Some methodological questions to be dealt with include the following: What is the purpose of computational modeling in the social sciences? What are the key distinctions between theory, methods, and applications in CSS? How are computational models constructed? How are they developed and evaluated? Which scientific problems or puzzles are best solved through computational modeling, as opposed to other approaches (e.g., statistical or mathematical)? What is the difference between "top down" and "bottom up" models, and models of the "third way"? Which major policy areas (e.g., national security, transportation, environmental, welfare, homeland security, education, science and technology, public health, etc.) are most appropriate for computational modeling? What are the main simulation modeling tools available today, and which may be envisioned for the future? To which types of empirical phenomena do the best CSS approaches apply? What are the main advantages and limitations of each type of model? Which are the classic works and which are the future directions in CSS? What are the main unique insights provided by computational methods in the social sciences? These and other topics will be explored through lectures, demonstrations, and assigned readings.

Course Logistics

Class Sessions

Time: Monday: 4:30–7:10pm, Aug. 24-Dec. 7 (except Labor Day, Sep. 7)
Modality: Online using Zoom. See class website for details on how to join the synchronous sessions.

Office Hours and Contact

I will hold office hours on Zoom (Tuesdays from 2:00-3:30PM; Fridays from 11:30AM-1:00PM). I am also available via appointment. You email me either through Blackboard or directly. If the latter, please include CSS600 as part of the subject line. This helps me to identify emails related to the course. During the work week, I will respond within 24 hours; on weekends, it may take longer. See class website for details on how to join office hours and for my contact information.

Class Website

After you have registered for the course and I have made it available, you will have access to a Blackboard website for this course. It is in your interest to become intimately familiar with this website. It contains a copy of this syllabus, along with much additional material, including:

- Course announcements
- My contact information, i.e., email address and zoom links to my office hours.
- Zoom links to, and recordings of, the weekly synchronous sessions
- A course calendar
- Access to the Blackboard email tool (can be used to contact me and other students)
- Access to grades for graded material
- Electronic copies of required and optional readings not from the required textbooks (other than full books indicated as optional readings)
- Information on software to be used in the class
- Course assignments (which are to be submitted through the website)
- An overview of each session, including topics to be covered, required and optional readings, videos, models, assignments, and class notes.
- Links for providing anonymous feedback, getting help on Blackboard and Zoom, and information on GMU library resources.

Please note that class notes will not be available until after each class.

You should check this website regularly for updates. I will generally inform you of important updates via course announcements or email.

Textbooks:

Required

- **Gilbert, N. and Troitzsch, K.G. (2005)**, Simulation for the Social Scientist (2nd Edition), Open University Press, Milton Keynes, UK. (Written by two leading European computational social scientists.)
- **Miller, J.H. and Page, S.E. (2007)**, Complex Adaptive Systems, Princeton University Press, Princeton, NJ.
- **Simon, H.A. (1996),** The Sciences of the Artificial (3rd Edition), MIT Press,

Cambridge, M. A. (This is arguably the classic statement of the philosophy of computational social science, by one of the founders of the field.)

Optional

- **Epstein, J.M. and Axtell, R. (1996)**, Growing Artificial Societies: Social Science from the Bottom Up, MIT Press, Cambridge, MA.
- **Cioffi-Revilla, C. (2017)**, Introduction to Computational Social Science: Principles and Applications, Springer, New York, NY.
- **Page, Scott E. (2018**), The Model Thinker: What You Need to Know to Make Data Work for You, Basic Books, New York, NY.
- **Schelling, T.C. (1978),** Micromotives and Macrobehavior, WW Norton and Company, New York, NY.

I will try to help find ways for you to obtain electronic copies of the textbooks online for free, but you may also wish to purchase hard copies of some of these for your personal library.

Additional readings and other material

In addition to readings from the textbooks, this course will include additional readings and other material (e.g. videos). Some of these will be labelled as required; others will be listed as optional. It is expected that you will review the required material prior to the class session for which it is assigned. I will provide electronic copies of, or links to, all additional material, other than full books listed as optional.

Software

We will be using the NetLogo software throughout the semester (see https://ccl.northwestern.edu/netlogo/). This is a fairly user-friendly software that can be used to develop models using a number of the approaches covered in this course. Other software may also be introduced during the semester.

Assessment and Grading

Participation will count for 10% of the grade. Students will get the most out of the class by keeping up with all assigned readings in advance of classroom discussions, and by participating in class discussion. I will also be looking for you to provide feedback on the project proposals and presentations (see research project below) of other students.

Homework assignments will be used for assessing the student's grasp of weekly readings and lecture topics. These will count for 40% of the grade (5 homeworks in total with each accounting for 8%). Homework assignments are to be turned in by the start of the next class, i.e., by 4:30 PM the week after they are assigned. Please submit your assignments on the course website. **Late homework assignments will not be accepted without prior approval by the instructor.**

A ***take-home mid-term*** will count for 10% of the grade. You will have a week to complete this. Please submit your assignments on the course website. **Late submissions will not be accepted without prior approval by the instructor.**

A ***research project*** (proposal, presentation, and final material - paper and code) will count as the remaining 40% of the grade. Students are expected to work in groups of two to three and one grade per group will be given (please speak to me if you wish to do the project by yourself). The research paper will focus on either use or development of a computational model in an area of student interest (e.g., microeconomics, international relations, environmental policy, social hierarchy, economic development, historical dynamics, finance). The research paper will cover four main themes: (a) a description of the model; (b) systematic experimentation with the model; (c) presentation of model results, and (d) a summary of the model's capabilities and what was achieved with it. Specific guidelines and tips for preparing the research paper will be made available separately. A 1-page proposal will be presented in class part way through the semester (Nov. 2); a final presentation will be made during the final exam period (Dec. 7); all final materials are to be submitted a week after the presentations (Dec. 14). **Late submissions will not be accepted without prior approval by the instructor.**

Components of Final Grade

Class Participation:	10%
Homework Assignments	40%
Take-home Midterm:	10%
Research Project:	40%

Scale (points = percentage)

95-100 = A+
88-94 = A
82-87 = A-
76-81 = B+
70-75 = B
64-69 = B-
58-63 = C
<58 = F

Course and University Policies

Incomplete grades

Following the university policies, an "Incomplete" grade (IN) **may** be assigned to a student who is passing a course but who may be unable to complete scheduled course work due to a cause **beyond** reasonable control. Any requests for an incomplete grade must be submitted i**n writing** during the last week of classes, and should indicate the reason for the request. If an IN grade is granted, it is **your responsibility** to contact the instructor at the end of the semester to make proper arrangements for completing any missing work. For further details on the IN grade please visit: https://registrar.gmu.edu/topics/incomplete/.

Attendance and Class Etiquette

Although all class session will be recorded and made available for later viewing, you are encouraged to attend these live. **Attendance at the meeting during the Final Exam Slot is considered mandatory, as students will evaluate the presentations of their peer groups.** Please try to join on time and mute your microphone when you are not speaking. This will help to prevent extraneous noise. Although I prefer you use the raise hand feature and letting me call on you, as long as it does not become a problem, it is also okay if you simply unmute and speak when you have a question or are responding to a query.

Academic Honesty and Collaboration

The integrity of the University community is affected by the individual choices made by each of us. GMU has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted, other than clearly specified group work, be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct.

Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please see me.

Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, endnotes, and references. Paraphrased material must also be cited. I am agnostic about the specific reference style used, as long it is consistent and complete, i.e., I am able to find the reference with minimal effort using standard sources, e.g. the GMU libraries. A simple listing of books, articles, or url addresses is not sufficient.

As in many classes, a number of projects in this class are designed to be completed within your study group. With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product.

Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers on drafts of the work; however, it is not appropriate to give your paper to someone else to revise. You are responsible for

making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently. Furthermore, it is unacceptable to use a model or a paper developed for another class in this class.

The *unattributed re-use of computer models is also not acceptable*. If one does use code from another model, please ensure the code that is used is accredited to the original model (just as you would do to a reference in a paper).

Disability Statement
If you have a documented learning disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with Disability Services (SUB I, Rm. 4205; 993-2474; http://ds.gmu.edu) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Sexual Harassment, Sexual Misconduct, and Interpersonal Violence
As a faculty member and designated "Responsible Employee," I am required to report all disclosures of sexual assault, interpersonal violence, and stalking to Mason's Title IX Coordinator per university policy 1412. If you wish to speak with someone confidentially, please contact the Student Support and Advocacy Center (703-380-1434), Counseling and Psychological Services (703-993-2380), Student Health Services, or Mason's Title IX Coordinator (703-993-8730; cde@gmu.edu).

Privacy
Students must use their MasonLive email account to receive important University information, including communications related to this class. I will not respond to messages sent from or send messages to a non-Mason email address.

Student Support Resources
George Mason University has a number of academic support and other resources to facilitate student success (e.g., Counseling and Psychological Services, Learning Services, University Career Services, the Writing Center, etc.). See http://www.gmu.edu/ for more details.

Tentative Course Schedule and Outline

Please find below the tentative outline for each week of the course. Optional materials will be listed on the course website. The 'official' outlines will be provided on the class website, so please check this often.

Session 1 (August 24th): Introduction to Common Types of Social Science Models

- **Discuss**: Syllabus; Social science models and the use of modern computation by social scientists; Various meanings of "complexity" and "emergence".
- **Demos**: Selection of models in NetLogo.
- **In-Class Assignment**: Install NetLogo on your own computer and run sample programs
- **Suggested readings**: Cioffi-Revilla (2010); Lazer et al. (2009); Watts (2013); Weinberger (2011).
- **Homework #1** made available: Discuss what is Computational Social Science

Session 2 (August 31st): Modeling and Computational Social Science

- **Read**: Axelrod (1997); Cioffi-Revilla (2002); Gilbert and Troitzsch (2005: chap. 1, 2) Miller and Page (2007: chap. 3, 5); Rauch (2002); Simon (1996: chap. 1).
- **Discuss**: Do computational approaches represent a "third way" of doing science (in addition to empirical and theoretical/mathematical approaches)?
- **Demos**: Zero-intelligence (ZI) traders.
- **Homework #1 due by start of class**
- **Homework #2** made available: Computational experiments with Mark McCabe's ZI model -> comparative statics of supply and demand from the bottom up.

(September 7th): No Class due to Labor Day Recess

Session 3 (September 14th): Complexity Ideas and Complex Adaptive Systems (CAS); Social Science Simulation Software

- **Read**: Cioffi-Revilla (2017: chap. 1; Simon (1996: chap. 7, 8); Gilbert and Troitzsch (2005: appendix A); Hanson (2001); Miller and Page (2007: Part I, chapter 4, appendix A).
- **Discuss**: Emergence; Near-decomposability; Hierarchical systems; Spontaneous order; Self-organization; Scaling and power laws; Self-organized criticality; Percolation.
- **Demos**: Ant and termite models, herding and opinion dynamics, mostly in NetLogo.
- **Homework #2 due by start of class**
- **Homework #3** made available: Work through NetLogo tutorials.

Session 4 (September 21st): Introduction to NetLogo

- **Discuss**: Basic NetLogo Functionality.
- **Demos**: Selection of NetLogo Models.
- **Homework #3 due by start of class**

Session 5 (September 28th): Systems dynamics (SD) Models

- **Read**: Gilbert and Troitzsch (2005: chap. 3); NetLogo "Systems Dynamics Guide"; Simon (1996: chap. 5, 6).
- **Discuss**: Relation of systems dynamics models to mathematical models; Advantages

and limits of system dynamics models.
- **Demos**: Various NetLogo systems dynamics models.
- **Homework #4** made available: Experiments with an SD and ABM epidemic model in NetLogo -> variation of parameters, critical points in the parameter space.

Session 6 (October 5th): Microsimulation Models, and Discrete Event Simulation (DES)
- **Read**: Gilbert and Troitzsch (2005: chap. 4-6); (2012); Silver (2008).
- **Discuss**: Relation between microsimulation and DES and systems dynamics. Electoral college predictions from state polls.
- **Demos**: Various NetLogo models of DES, electoral college predictions from state polls
- **Homework #4 due by start of class**
- **No Homework**: work on projects

Session 7 (October 12th): Cellular Automata Models
- **Read**: Gilbert and Troitzsch (2005: chap. 7); Miller and Page (2007: chap. 7, 8); von Neumann (1968).
- **Discuss**: Self-reproducing automata (von Neumann); ALife; Diffusion-limited aggregation.
- **Demos**: 1D and 2D CAs; Game of Life; Sandpiles; Percolation; Voter models; City formation models; Forest fire models; Glider (most models in NetLogo).
- **Homework #5** made available: Experiments with "standing ovation" CA in NetLogo -> distinct "regimes" in model output.

Session 8 (October 19th): Agent-based Models and Multi-agent Systems
- **Read**: Gilbert and Troitzsch (2005: chap. 8, 9); Miller and Page (2007: chap. 6, 9, appendix B); LeBaron et al. (1999) ; Crooks and Heppenstall (2012); optional: Epstein and Axtell (1996).
- **Discuss**: Relation of agent systems to previously-studied approaches.
- **Demos**: Current work in the Computational Social Science Program and the Center for Social Complexity.
- **Homework #5 due by start of class.**
- **Mid-term take-home exam** made available**.**

Session 9 (October 26th): Computational Experimentation and Output Analysis
- **Read**: Axtell and Epstein (1994); Axtell et al. (1996); Balci (1998); Crooks et al. (2008).
- **Discuss**: Validation (internal, external); Verification; Robustness; Ontologies.
- **Demo**: BehaviorSpace facilities in NetLogo.
- **Mid-term take-home exam due by start of class.**
- **Homework**: work on 1-page project proposal

Session 10 (November 2nd): Project Proposal Presentations and Cognitive Architectures for Agents and Learning (Dr. Bill Kennedy, tentative)
- **Read**: Handout on cognitive architectures. Simon (1996: chap. 2–4); Sun (2009); Grey, et al. (2005); Kennedy (2012).
- **Discuss**: Simple versus cognitive agents; Bounded rationality; Satisficing; Finite automata playing games; "Zero-intelligence" agents; SOAR and ACT-R; Difference

between individual and social learning; Machine learning; Evolutionary learning.
- **Demo**: Spectrum of cognitive agent models.
- **Project Proposal Presentations**: (hand in 1-page project proposal)
- **No Homework**: work on projects

Session 11 (November 9th): Data Driven Modeling and Agents (Dr. Hamdi Kavak, tentative)
- **Read**: Gilbert and Troitzsch (2005: chap 10); Cioffi-Revilla (2017: chap. 3, 4).
- **Discuss**: Role of Machine Learning and Data Analysis in CSS.
- **Demos**: Current Machine Learning and Data Analysis within CDS.
- **No Homework**: work on projects

Session 12 (November 16th): Agents and Economics (Dr. Rob Axtell, tentative)
- **Read**: Axtell (1999); Axtell and Epstein (1999); Axtell (2001); Axtell (2005).
- **Discuss**: Agent-based models for economic issues.
- **Demos**: Computational implementation of various games played within populations, including prisoner's dilemma played by tit-for-tat; evolutionary models of Kristen Lindgren; El Farol problem.
- **No Homework**: work on projects

Session 13 (November 23rd): Social Network Models
- **Read**: Cioffi-Revilla (2017: chap. 4); Barabási and Bonabeau (2003); Borgatti et al. (2009); Watts (1999); optional: Newman (2003).
- **Discuss**: The sense in which social networks generalize spatial networks; lattices, "small-worlds" and random graphs.
- **Demos**: Various works from the CSS Program and Center for Social Complexity.
- **No Homework**: work on projects

Session 14 (November 30th): TBD
- **No Homework**: work on projects

Session 15 (December 7th): Final Exam Slot: In class presentation of projects.
- **Presentation slides should be submitted before class**

December 14th): All project materials are due by end of day.

Note: Recording of any kind (audio, video), reuse of course materials, and further dissemination of the course content is not permitted unless prior written consent of the professor and George Mason University has been given or if recording is part of an approved accommodation plan.