MNGT0783 Simulation for the Social Sciences

Doctoral programme, Term 3, 2004.
(3 hours/week over 5 weeks)

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Course web page: www.agsm.edu.au/~bobm/teaching/SimSS.html

1. Rationale for the Course

The purpose of the course is to introduce research students to tools of simulation in the social sciences and some applications, in economics, in strategy, in applied psychology, and in policy.

Goals: To acquaint doctoral students with some of the many approaches to simulation in the social sciences, their strengths and weaknesses, and their appropriateness for particular kinds and areas of research.

"'Simulation means driving a model of a system with suitable inputs and observing the corresponding outputs.' (Bratley, Fox & Schrage 1987, ix). While this definition is useful, it does not suggest the diverse purposes to which simulation can be put. These purposes include: prediction, performance, training, entertainment, education, proof and discovery."

"Simulation is a third way of doing science. Like deduction, it starts with a set of explicit assumptions. But unlike deduction, it does not prove theorems. Instead, a simulation generates data that can be analyzed inductively. Unlike typical induction, however, the simulated data comes from a rigorously specified set of rules rather than direct measurement of the real world. While induction can be used to find patterns in data, and deduction can be used to find consequences of assumptions, simulation modeling can be used as an aid in intuition."

"Simulation is a way of doing thought experiments. While the assumptions may be simple, the consequences may not be at all obvious. The large-scale effects of locally interacting agents are called "emergent properties" of the system. Emergent properties are often surprising because it can be hard to anticipate the full consequences of even simple forms of interaction." (Axelrod, 2003)

2. Units of credit:

2 units (15 hours of class contact time).

3. Pre-requisites, Co-requisites, Exclusions:

None.

4. Learning objectives

The primary aim of the course is to expose students to the use of simulation in the social sciences as a "third way of doing science, in contrast to both induction and deduction" (Axelrod 2003). "Simulation can be an effective tool for discovering surprising consequences of simple assumptions."

The course will not teach programming, instead students will learn how to describe what they plan to do by writing a grant proposal to obtain funding to pursue a

simulation approach to gaining understanding of a problem in their field of research.

This half-unit course is to critically acquaint doctoral students with some of the many approaches to simulation in the social sciences, their strengths and weaknesses, and their appropriateness for particular kinds and areas of research. Simulation can be thought of as a third way of doing science, in contrast to both induction and deduction. By the end of the course, students will be able to:

- contrast such simulation techniques as system dynamics, microsimulation (including Monte Carlo), multi-level simulation, cellular automata, distributed AI (including genetic algorithms), and learning models;
- understand how to go about performing computer experiments on the simulation model of the phenomenon being studied;
- understand how to analyse the results and present them in a way others can readily understand;
- critique simulation studies in areas that might include: strategy, economics, planning, law, organization theory, political science, applied psychology, and public policy.

5. Assessment:

Grading is based on the clarity, rigour, and appropriate research designs and analysis of four written deliverables.

1. A one-page pre-proposal describing a Computer Laboratory research project that could be completed in less than a year.
2. A draft of a full 10−15-page single-spaced grant proposal describing your project. I shall give guidance to the proposals. (See example of an NSF grant proposal under Other Links on the web page.)
3. An *individual* review of two resarch proposals per student (not your own, of course). I shall provide guidance on the reviews. *Grades for this componenr are based on the quality and clarity of your comments as a reviewer,* ***not*** *on the comments your proposal receives.*
4. A final version of the research proposal, incorporating suggestions from the reviewers.

Assessment grades to be used: A B C F

6. Textbook

The required text will be:

> Nigel Gilbert and K. G. Troitzsch, *Simulation for the Social Scientist,* Open University Press, 1999.

Course Organisation

The course is dived between lecture and discussion. Lectures emphasize latest

computational techniques, modelling, examples, and computational laboratory methodological issues. Discussions emphasize student projects and ideas, the development and appropriate use of simulation techniques.

I shall distribute a list of readings for discussion in the next class (with some handouts). I welcome suggestions for discussion from you.

Lecture Topics

Week	*Date*	*Lecture Topics*
1	July 20	Introduction to Computer Laboratories and simulation. Simulation: basic concepts, grand challenges. G&T: Ch 1, 2
2	July 27	Shayne Gary leads a discussion on System Dynamics. G&T: Ch 3
3	Aug 3	Micro-analysis and Cellular automata G&T: Ch 4, 7
4	Aug 10	Agent-based models G&T: Ch 8
5	Aug 17	Learning and evolutionary models: the Genetic Algorithm. G&T: Ch 9 Conclusion.

Incomplete Annotated Bibliography:

(See also the course web page, www.agsm.edu.au/~bobm/teaching/SimSS.html.)

[1] Robert Axelrod, Replication of Agent-Based Models, Appendix A of his *The Complexity of Cooperation: Agend-Based Models of Competition and Collaboration,* Princeton University Press, 1997.

[2] Robert Axelrod, Resources for Agent-Based Modelling, Appendix B of his *The Complexity of Cooperation: Agend-Based Models of Competition and Collaboration,* Princeton University Press, 1997.

[3] Bratley, P., Fox, B. & Schrage, L. (1987). *A Guide to Simulation*. Second Edition. New York: Springer-Verlag.

[4] Epstein, J. & Axtell, R. (1996). *Growing artificial societies: social science from the bottom up*. Washington, DC: Brookings and Cambridge, MA: MIT Press.

"Growing Artificial Societies is a groundbreaking book that posits a new mechanism for studying populations and their evolution. By combining the disciplines of cellular automata and "artificial life", Joshua M. Epstein and Robert Axtell have developed a mechanism for simulating all sorts of emergent behavior within a grid of cells managed by a computer. In their simulations, simple rules governing individuals' "genetics"" and their competition for foodstuffs result in

highly complex societal behaviors. Epstein and Axtell explore the role of seasonal migrations, pollution, sexual reproduction, combat, and transmission of disease or even "culture" within their artificial world, using these results to draw fascinating parallels with real- world societies. In their simulation, for instance, allowing the members to "trade" increases overall well-being but also increases economic inequality. In Growing Artificial Societies, the authors provide a workable framework for studying social processes in microcosm, a thoroughly fascinating accomplishment."

[5] Ilgen, D. R., & Hulin, C. L. (Eds.) (2000). *Computational modeling of behavior in organizations: The third scientific discipline.* Washington, DC: American Psychological Association.

"Behavior in organizations is complex and dynamic in ways that are not easily observable or predictable. Computational modeling is a promising research method that bridges the gap between field and laboratory, demonstrating the effects of complex interactions. Among the advantages of conducting research in "virtual organizations" is that it frees the researcher from time constraints and allows the study of behavior that would not easily be manipulated in real life. Modeling is economical. It enables, even forces, researchers to confront the logic of their theories even before data are collected. Despite the advantages of this methodology, those studying industrial/organizational behavior have been slow to adopt computational modeling, and standard methods books aimed at advanced undergraduates, graduate students and researchers rarely cover computational modeling as a research method on the same level as experimental or individual differences regression methods. "

"This edited book addresses the reluctance of researchers to use computational modeling, advocating the wider use of this tool. Contributing authors describe their pioneering work in using computational modeling to study a wide range of problems such as employee withdrawal; faking on personality tests; the formation, continuation and dissolution of groups; and organizational change."

[6] Kenneth Judd, *Numerical Methods in Economics,* Cambridge: MIT Press, 1998.

[7] Kauffman, S., (1995). *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*. Oxford and New York: Oxford University Press. See especially 252-64.

[8] Alessandro Lomi, Erik R. Larsen (Editors), *Dynamics of Organizations: Computational Modeling and Organizational Theories*, New York: AAAI Press, 2001. ISBN: 0262621525

"An organization is more than the sum of its parts, and the individual components that function as a complex social system can be understood only by analyzing their collective behavior. This book shows how state-of-the-art simulation methods, including genetic algorithms, neural networks, and cellular automata, can be brought to bear on central problems of organizational theory related to the emergence, permanence, and dissolution of hierarchical

macrostructures. The emphasis is on the application of a new generation of equation- and agent-based computational models that can help students of organizations to reformulate their basic research questions starting from assumptions about how to link--rather than separate--different levels of organizational analysis."

[9] James G. March, Charles A. Lave *Introduction to Models in the Social Sciences,* New York: HarperCollins, 1975.

"What is a model? How do you construct one? What are some common models in the social sciences? How can models be applied in new situations? What makes a model good? Focusing on answers to these and related questions, this multidisciplinary introduction to model building in the social sciences formulates interesting problems that involve students in creative model building and the process of invention. The book describes models of individual choice, exchange, adaptation, and diffusion. Throughout, student participation in analytical thinking is encouraged."

[10] Poundstone, W. (1985). *The Recursive Universe: Cosmic Complexity and the Limits of Scientific Knowledge*. Chicago, IL: Contemporary Books.

[11] Michael Prietula, Kathleen Carley, and Leslie Gasser (Editors) , *Simulating Organizations: Computational Models of Institutions and Groups*, New York: AAAI Press, 1998. ISBN: 026266108X

"The globalization of the economy, increasing number of transnational organizations, and rapid changes in robotics, information, and telecommunication technologies are just a few of the factors significantly altering organizational time scales, forms, complexity, and environments. Time scales have shrunk, new organizational forms are emerging, and organizational environments are expanding and mutating at unprecedented rates. Computational modeling affords opportunities to both understand and respond to these complex changes. Paralleling developments in the physical sciences, computational modeling is emerging in the social and organizational sciences. Organizational researchers are using computational models to gain insights into organizational phenomena and to explore dynamic processes and configurations that are difficult or impossible to investigate with other methods. Many interesting insights have already resulted from this research, such as how group cooperation arises or dissipates in social dilemma settings, and how honesty and benevolence affect behavior in a group task. On the practical side, computational modeling is increasingly effective for organizational design, analysis, and reengineering. Although a great deal of work remains to be done, the era is approaching when both theorists and practitioners will routinely state theories, design organizations, and derive their implications using widely shared computational tools. This volume brings together a range of work from many of the leading researchers in the field."

[12] Herbert Simon, *The Sciences of the Artificial,* Cambridge: MIT Press, 2nd ed., 1981.

[13] Sterman, J. D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw-Hill.

[14] Schelling, T. (1978). *Micromotives and macrobehavior*. New York: W. W. Norton. (See especially 137-55.)

[15] Ramzi Suleiman (Editor), Klaus G. Troitzsch (Editor), G. Nigel Gilbert (Editor) *Tools and Techniques for Social Science Simulation,* Publisher: Physica Verlag; 1st edition (May 15, 2000), ISBN: 379081265X. This book provides an overview of soical science simulation as a tool for modelling and theory building. It is shown how simulation may be applied to the analysis of social and economic problems using techniques such as multi-agent simulation, cellular automata and multi-level modelling. Particular attention is paid to the sensitivity analysis of model parameters. The book also describes the architecture and user interfaces of several simulation tools. The book is based on an international conference that brought together social scientists and computer scientists engaged in a wide range of simulation approaches. It represents a report on the state of the art in social science simulation.