

Introduction to Computational Modeling of Social Systems (851-0593-00)

Thanks to the revolution in information technology, computational modeling is increasingly used as a tool to study social systems. This seminar focuses exclusively on agent-based modeling, which is a particular type of computational methodology that allows the researcher to create, analyze, and experiment with artificial worlds populated by agents that interact in non-trivial ways. In such “complex adaptive systems,” computation is used to simulate the cognitive processes and behavior of agents in order to explore emergent macro phenomena, i.e., structural patterns that are not reducible to, or even understandable in terms of, properties of the micro-level agents.

Seminar available as elective course “Pflichtwahlfach” or as PhD course.

Time: Winter Semester 2004/2005; Tuesday 17:00-19:00

Place: [HG E 41](#)

Contents overview

The course starts with an introduction to the rationale and principles of agent-based modeling, followed by a brief survey of object-oriented programming in Java. The remainder of the semester focuses on a Java-based simulation framework called RePast. Throughout the semester, examples drawn from political science, economics, and sociology will be covered.

Prerequisites

Prior knowledge of programming is not required but will be helpful for this course.

Performance evaluation

Students will be required to complete a series of exercises handed out throughout the course.

Software

The course material is based on Java and RePast, but students are allowed to produce code in a package of their own choosing.

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Resources

Recommended readings about agent-based modeling

- Axelrod, Robert. 1997. *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*. Princeton: Princeton University Press.
- Casti, John L. 1997. *Would-Be Worlds: How Simulation Is Changing the Frontiers of Science*. New York: Wiley.
- Cederman, Lars-Erik. 1997. *Emergent Actors in World Politics: How States and Nations Develop and Dissolve*. Princeton: Princeton University Press.
- Epstein, Joshua M. and Robert Axtell. 1996. *Growing Artificial Societies: Social Science From the Bottom Up*. Cambridge, Mass.: MIT Press.
- Holland, John H. 1995. *Hidden Order: How Adaptation Builds Complexity*. Reading, Mass.: Addison-Wesley.

Recommended web pages on complexity and computational modeling

- The Santa Fe Institute, the “Mecca of complexity studies”: <http://www.santafe.edu/>
- The Center for the Study of Complex Systems at the University of Michigan: <http://www.pscs.umich.edu/> See especially Rick Riolo’s home page: <http://www.pscs.umich.edu/PEOPLE/rlr-home.html> for details on agent-based modeling, and Robert Axelrod’s page: <http://www-personal.umich.edu/~axe/> for general references to complexity.
- The Center on Social and Economic Dynamics, Brookings Institution: <http://www.brook.edu/dybdocroot/ES/dynamics/models/>
- The European web sites on “Computer simulation of societies” <http://www.soc.surrey.ac.uk/research/simsoc/> and the “European Social Simulation Association” <http://essa.eu.org/> offer interesting links.
- Leigh Tesfatsios provides a comprehensive web page on computational economics: <http://www.econ.iastate.edu/tesfatsi/ace.htm>
- See also the *Journal of Artificial Societies and Social Simulation*: <http://jasss.soc.surrey.ac.uk/JASSS.html> and the *Journal for Computational and Mathematical Theory* (CMOT) <http://www.kluweronline.com/issn/1381-298X> (from where PDF files can be downloaded)

Java resources

We will rely extensively on the following textbook, which offers the best introduction for those who already have previous programming experience, especially in C and C++:

- Eckel, Bruce. 2003. *Thinking in Java*. Upper Saddle River, NJ: Prentice Hall.
See also <http://www.mindview.net/>

Alternatively, a very good introduction to Java programming for beginners is:

- Schildt, Herbert. 2001. *Java2: A Beginner’s Guide*. Osborne McGraw Hill.
- The RePast web page contains free software and documentation: <http://repast.sourceforge.net>
- See also Sun’s “New to Java Programming Center”: <http://developer.java.sun.com/developer/onlineTraining/new2java/> and their Java Tutorial: <http://java.sun.com/docs/books/tutorial/index.html>

Schedule

19.10.2004: Introduction

Course logistics including tools and readings. Overview of contents.

26.10.2004: Examples of agent-based models in the social sciences

A survey of agent-based modeling in political science, economics, and sociology.

- Schelling, Thomas C. 1978. *Micromotives and Macrobehavior*. New York: W. W. Norton. Chaps. 1, 5.

02.11.2004: Principles of agent-based modeling

Conceptual introduction to agent-based modeling. Installation of Java, RePast, and development environment.

- Axelrod, Robert. 1997. "Advancing the Art of Simulation in the Social Sciences." In *Simulating Social Phenomena*, ed. Rosaria Conte, Rainer Hegselmann, and Pietro Terna. Berlin: Springer Verlag.
- *The Political Methodologist*. 2001. Special issue on computational modeling (Number 1, Fall), pp. 12-27.

Also recommended:

- Cederman, Lars-Erik. "Computational Models of Social Forms: Advancing Generative Macro Theory." Ms. Harvard University.
- Rosser, J. Barkley Jr. 1999. "On the Complexities of Complex Economic Dynamics." *Journal of Economic Perspectives* 13: 169-192.

09.11.2004: Java Primer I

Overview of the language. Primitive data types. Control structures.

- Eckel Chaps. 1-3; or Schildt Modules 1-3

16.11.2004: Java Primer II

Object-orientation. Inheritance.

- Eckel Chaps. 1-2; or Schildt Modules 4-7

23.11.2004: Java Primer III

Interfaces. Packages. Collections and arrays.

- Eckel Chaps. 5,8,11; or Schildt Module 8.
- See also Sun's [Tutorial on collections](#)

30.11.2004: A hand-crafted agent-based model

Comprehensive project incorporating all Java topics covered so far.

- Schelling, Thomas C. 1978. *Micromotives and Macrobehavior*. New York: W. W. Norton. Chap. 5.

07.12.2004: Introduction to the Iterated Prisoner's Dilemma

- Cohen, Riolo, and Axelrod. 1999. "The Emergence of Social Organization in the Prisoner's Dilemma." (SFI Working Paper).

14.12.2004 RePast Introduction and Tutorial I

History of RePast. How to create and run a simple RePast model. The control panel. RePast collections and random numbers.

- Nick Collier. 2002. "RePast: An Extensible Framework for Agent Simulation."
- Collier, Nicholson, and Howe, Thomas R. 2003. "RePast 2.0: Major Changes and New Features".
- RePast web page: "[How to build a model](#)", "[How to use the GUI](#)", "[How to work with random numbers](#)"

21.12.2004: RePast Tutorial II

Graphical displays. Charts. Grids. Probes.

- RePast web page: "[How to create charts](#)", "[How to create displays](#)", "[How to use spaces](#)"

11.01.2005: RePast Tutorial III

Batch runs. Parameter files. Output files. Advanced topics: schedules; customization.

- RePast web page: "[How to use parameters and parameter files](#)", "[How to collect data](#)", "[How to use a schedule](#)", "[How to create custom actions](#)", "[How to create property descriptors](#)"

18.01.2005: Emergent Structure Models

- Axelrod, Robert. 1997. *The Complexity of Cooperation*, Chap. 7. First published in the *Journal of Conflict Resolution* 41 (1997): 203-226.

25.01.2005: Emergent Network Models

- Albert, Réka and Albert-László Barabási. 2001. "Statistical Mechanics of Complex Networks."
- Strogatz, S.H. 2001. "Exploring complex networks." *Nature* 410: 268-276.

01.02.2005: Emergent Actor Models

- Cederman, Lars-Erik. 2002. "Endogenizing Geopolitical Boundaries with Agent-Based Modeling." *Proceedings of the National Academy* 99: 7796-7303. PDF Hollis e-resources.
- Cederman, Lars-Erik. 2003. "Modeling the Size of Wars: From Billiard Balls to Sandpiles." *American Political Science Review*.

08.02.2005: TBA