

DESIGNING AND CONSTRUCTING MODELS WITH MULTI-AGENT LANGUAGES

COMP_SCI 372/472 and LRN_SCI 372/451

Spring 2022

Tue & Thurs 3:30 – 4:50 PM

Annenberg 303

Contact Information

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Course Description

This is a hands-on projects course. All students will design and implement multi-agent models in the NetLogo language. There are no official pre-requirements for this course. However, undergraduates taking this course should understand that this course is challenging and demanding, and requires the drive for independent project work.

This course will begin with an introduction to the multi-agent language **NetLogo**. Students will design and implement several NetLogo models and analyze their behavioral regimes. Students will also learn to build models of interaction on social networks (or other types of networks). We will cover methodology for verifying, validating and replicating agent-based models and comparisons with systems dynamics and equation-based models. NetLogo comes with many extensions that support a variety of additional features. Students can use these extensions to create specialized models, such as complex networks, real-time data extraction, data mining, connections to physical devices, etc.. Students will also have an opportunity to explore existing and create their own *participatory simulations* using the **HubNet** architecture as well as exploring connecting real world sensors and motors to models. Students can also explore multi-level

agent-based modeling in which hundreds or thousands of models are connected with NetLogo's LevelSpace extension.

The course is designed for both undergraduates (300 level) and graduate students (400 level). (400 level students will be expected to do additional project work.) Three main types of students are anticipated:

- Computer Science students who would like to learn about multi-agent modeling and multi-agent languages, artificial life and/or bottom-up AI
- Natural Science, Engineering and Social Science students who have content expertise and would like to learn how to build multi-agent models of their content domain
- Learning Science students interested in the design of multi-agent learning environments

NetLogo is a programmable modeling environment for simulating natural and social phenomena. It is particularly well suited for modeling complex systems that develop over time. Modelers can give instructions to hundreds or thousands of independent "agents" all operating concurrently. This makes it possible to explore the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from the interaction of many individuals. NetLogo lets users run simulations and "play" with them, exploring their behavior under various conditions. It is also an "authoring tool" which enables users (both novices and experts) to create their own models. NetLogo is simple enough that novices can easily run, explore and build their own simulations. NetLogo has extensive documentation and tutorials for all of its features. It also comes with a Models Library, which is a large collection of pre-written simulations that can be used and modified. These simulations address many content areas in the natural and social sciences, including biology and medicine, physics and chemistry, mathematics and computer science, and economics, linguistics, sociology and social psychology. Several model-based inquiry curricula using NetLogo have been in widespread use.

HubNet is an extension of NetLogo that enables multiple users to collaborate and participate in a simulation. In a HubNet activity, each participant controls an agent or set of agents in a larger model. Several HubNet activities are also included in the models library.

The class meets Tuesdays/Thursdays from 3:30 – 4:50. On some Thursdays, the TAs will conduct homework review sections. The class will place significant emphasis on supporting student projects. It is expected that class members will support each other and will make regular use of the class discussion board. Questions about NetLogo syntax, semantics and modeling idioms and efficiency should go on the our Canvas page and students are expected to read each others' questions and reply.

Curricular requirements fulfilled by this course

- For Computer Science undergraduate majors, it counts towards:
 - one credit of the project course requirement
 - the A.I. or Interfaces area breadth and depth requirements
- For Computer Science graduate students, it counts towards either Graphics and Interactive Media, or AI/ML.
- For Cognitive Science undergraduate majors, it counts as:
 - an advanced elective credit for the Cognitive Science major.
- For Learning Sciences graduate students, it fulfills:
 - a computational methods requirement (and possibly a design course requirement with permission of instructor)

- For Learning Sciences undergraduate students, it fulfills:
 - a design of learning environments requirement
- For graduate students working on the Cognitive Science specialization, it counts as
 - one course credit toward specialization
- For graduate students working with the Northwestern Institute on Complex Systems (NICO), this is a core course
- For graduate students in the TSB program, it counts as either Graphics and Interactive Media, or AI/ML.

Grading

Assignments will generally be handed out on Tuesdays and will be due the following Monday at 9AM. We will make every effort to return commented assignments by class on Thursday. All assignments will be graded, and judged as either complete or incomplete (or, in occasional cases, outstanding). Some students may be asked to present their work in class. For assignments that are completed as a group, each group member must be responsible for a significant portion of the work involved. You will also be assessed on your class participation both in class and on the Canvas discussion boards. Email mam-fac@ccl.northwestern.edu if you need to request an extension for any assignment. Graduate students are required to do additional work. Assignments will be submitted on Canvas. There will be no exams for this course.

- Class Participation: 15%
- Homework Assignments: 35%
- Final Project: 50%

In addition to these metrics, you will also get extra credit for the course for finding errors in the textbook reading, or finding text that is unclear. Send message to the discussion list on canvas IABM: A collaborative treasure hunt for the 2nd edition.

Course Requirements

- Read the course textbook, and several other selected papers
- Master the NetLogo language
- Read, post, and reply to NetLogo questions on the discussion board
- Complete assigned homework exercises/explorations, including activities such as:
 - Revising an existing NetLogo model from the Models Library
 - Participating in a few HubNet collaborative simulations
 - Comparing systems dynamics models with multi-agent models
 - Incorporating social network primitives, measures and utilities into multi-agent models (generally, assignments will be handed out in class on Monday and due the following Monday)
- Complete the final project
 - Construct at least one polished NetLogo or HubNet model and do an analysis of the model
 - Submit weekly progress reports on the final project

About the Final Project

The final project is to design and implement a polished NetLogo (or HubNet) model. This includes interface window, commented procedures and a full and detailed info window. The model should be

embedded in a web page that describes it to a novice user. It should be possible from that web page to download the model or to run it. The final project also includes a paper describing and analyzing the model. For proficient Java or Scala coders there is another option for the final project, to write a NetLogo extension. See me if you are interested. All final projects must be preceded by a project proposal. You will get feedback on your proposal and once approved you can start working on your final project. Subsequent to approval, every week we expect a progress report emailed to mam-fac@ccl.northwestern.edu updating us on the progress you are making on your final project.

For 400 level students, there are additional requirements. 400 level students must both a) produce a more polished paper, embedded in the relevant literature, at a standard that could put it on a trajectory towards publication, and one of the following: 1) Create an additional HubNet activity that complements the NetLogo model, 2) design and implement an extension to NetLogo, or 3) incorporate some other advanced NetLogo feature (e.g., LevelSpace or interfacing with hardware such as Arduino) into a complementary model. In your final project proposal you will need to outline the option you are choosing and will receive feedback from us. The final project will culminate with a poster session during which you will have the opportunity to share your model with members of the Northwestern community.

As part of your final project, you will produce a number of products, one of which is a poster describing your project. *You are **required** to present your poster at our Poster Fair*, which is hosted during our NU registered Final Exam time – Thursday, **June 9, 3-5PM**. **Please let us know as soon as you can if this date presents a conflict for you.**

Textbook

Wilensky, U., & Rand, W. (2015). *An introduction to agent-based modeling: Modeling natural, social and engineered complex systems with NetLogo*. Cambridge, MA: MIT Press.

Please purchase before first class and, if possible, try to get the 5th printing – that is the latest version. It can be purchased at NU bookstore, directly from MIT Press or from Amazon. If you instead get an older printing, please visit <https://www.intro-to-abm.com/#updates> for details on specific changes.

Selected further readings to be determined. These readings will be posted on Canvas.