Agent-Based Modelling

Welcome and Outline

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Computational Science Lab

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Course Objectives

Course objective

At the end of the course you should be able to:

- Define what Agent-Based models (ABMs) are.
- Compare different methods for developing ABMs
- Properly analyse the output of an ABM
- Summarize and Compare existing ABM
- Develop your own Agent-based Model
- Properly report on your ABM (Scientific paper)

Course objective

This is a 4-week course, so the pressure is on.

Teaching is done in 3-ways

1. Formal Lectures 8×2 hours
2. Practical Work in Groups - 2 hours guided, 4 hours open per week.
3. Reading of papers

4 weeks is not a long time to fully digest and recall material.

Given this and the subject matter itself, the focus is on practical/project work. There is a choice between open-ended and more prescribed project.

Course Contents

Course Contents

There a total of:

1. 16 hours of lectures - 1.5 - 2.5 hour modules
2. 6 hours of guided practical lectures
3. 16 hours of (mandatory) project work

You are expected to fill in the extra hours 112 hours working on the project (coding, reporting), reading, and preparing for quiz.

Lecture Contents

The first two weeks are lectures, 2 hours per day

Table 1: Lectures

#	Topic	Week	Date
1	Introduction & Classic Models	1	3 June
2	Game Theory for ABM	1	4 June
3	Decision Processes for ABM	1	5 June
4	Rational Agent Theory	1	6 June
5	Bounded Rationality	1	7 June
6	Sensitivity Analysis for ABM	2	10 June
7	Global Sensitivity Analysis for ABM	2	11 June
8	Q & A and Discussion	2	12 June

Practical Lectures & Assignments Contents

First three Tuesday's you will have a guided hands-on instruction to help you with the programming.

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Table 2: Practical Lectures and Assignments

#	Topic	Week	Date
1	Introduction to Mesa (Python ABM)	1	4 June
2	Game Theory (using axelrod Python library)	1	4 June
3	Decision Theory (using statsmodel Python library).	2	11 June
4	Sensitivity Analysis (using SAlib Python library)	3	18 June

Practical Lectures & Assignments Contents

There are four jupyter notebooks corresponding to the lecture material. These notebooks are intended to do two things:

1. Give you practical guidance/practice to help with project work
2. As an assessment component

First three notebooks contain exercises (3, 4, 3). These notebooks are automatically tested/graded and based on results you will receive a bonus or penalty to your final grade as follows:

Table 3: Penalty Bonus Scheme

Correct	Grade Change
0-30%	-0.5
40%-90%	0.0
100%	+0.5

Assessment

Assessment Component & Weighting

In a 4-week course the best way to learn is through practical work - and this will be the major part of your effort.

There are two ways in which you will be assessed

1. Group Project - 70%
2. Quiz - 30%
3. Bonus or Penalty - ± 0.5

The weighting reflects the amount of time we expect that you will spend on each. Since the Quiz and the Group Project address different topics within the course, partial grades do not compensate for each other. The grades in the Quiz and the Group Project should be at least 5.5 to pass the course.

Assessment method

Group Project

You will be asked to write a report and submit the code of your ABM. The report should take the form of a scientific paper (6-8 pages long with figures). A grading scheme will be provided (later).

Quiz

This will assess content in the lectures and the required reading. It will be an online multiple choice/answer quiz. This grade is given individually.

Deadline

A group project proposal should be submitted by each group and is due on **11 June 2024**. The group project proposal should contain:

1. The abstract of the group project highliting the key research question. See How to write an effective abstract. This should be around 300 - 350 words and should be submitted in the group page on canvas.
2. In addition to the abstract, the group should also explain why Agent-based modelling is the optimal modelling technique in the project (as opposed to ODE's, Markov Chains etc.) This should be around 300 words and should be submitted in the group page on canvas.

I will share some examples during the lectures. The project proposal will be graded as a part of the Group Project.

Deadline

The final Group Report (including code and any relevant data) is due a week after course ends: **10 July 2024**

Delays

The consequence of not meeting a report deadline is a 1 grade point penalty per day after the deadline. A maximum of 4 days of delay is allowed, due to the grading logistics and the need to provide timely feedback. For special circumstances, please contact the Study Advisor to request a deadline extension. Your study advisor will contact me.

Software

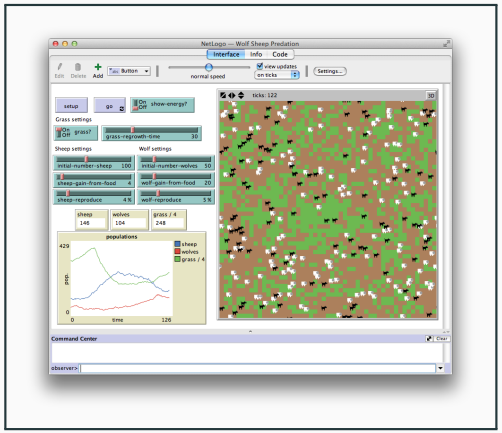
Software

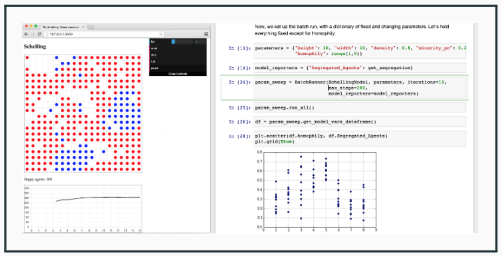
We do not require you to program in any specific language. But we will use two tools that you should install:

NetLogo - https://ccl.northwestern.edu/netlogo/

MESA -https://github.com/projectmesa/mesa

Netlogo is used in the lectures by me. You're welcome to use it, but it's idiosyncratic.
MESA is a Python library and will be used in the practical lectures. This is what we would recommend.
You also need to install Python 3.
Please install Netlogo Now.





Project

Project

In the project you will work in teams of 4-5 to design, implement, analyse and apply an agent-based model.

The project officially starts on 3 June - find team members.

Topic

You have a choice about topic and type.

option one

Identify a (novel) research question. Then take an existing model:

1. Civil Violence (Joshua M. Epstein 2002)
2. Evolutionary Iterated Prisoners Dilemma (Axelrod et al. 1987)
3. Sugarscape (Joshua M Epstein and Axtell 1996)
4. ...

Then you could/should:

1. build the model
2. recreate the experiments
3. extended the model (to answer you specific research question). This step is important - merely replicating an existing paper/model is not sufficient to pass the project.
4. conduct sensitivity analysis, validate or analyse the model

Topic

option two

Identify a (novel) research question. Develop your own model (based on data/system/dynamics) of a process

Then you could/should:

1. compare with existing models (if any)
2. build the model
3. conduct sensitivity analysis, validate the model or analyse the model

Report Structure

The good news is that we expect you to use a standard format for reporting.

This is a standard format called Overview, Design concepts, and Details (ODD) that is encouraged as a standard for reporting ABM.

You should follow that protocol in preparing your report (Grimm et al. 2010)

References

Axelrod, Robert et al. (1987). "The evolution of strategies in the iterated prisoner's dilemma". In: *The dynamics of norms*, pp. 1–16.

Epstein, Joshua M. (2002). "Modeling civil violence: An agent-based computational approach". In: *Proceedings of the National Academy of Sciences* 99.suppl 3, pp. 7243–7250. DOI: 10.1073/pnas.092080199. eprint: http://www.pnas.org/content/99/suppl_3/7243.full.pdf. URL: http://www.pnas.org/content/99/suppl_3/7243.abstract.

Epstein, Joshua M and Robert Axtell (1996). *Growing artificial societies: social science from the bottom up*. Brookings Institution Press.

Grimm, Volker et al. (2010). "The ODD protocol: A review and first update". In: *Ecological Modelling* 221.23, pp. 2760–2768. ISSN: 0304-3800. DOI: https://doi.org/10.1016/j.ecolmodel.2010.08.019. URL: http://www.sciencedirect.com/science/article/pii/S030438001000414X.