Games and Agents

Session I - Introduction to Agent Based Modeling

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A flock of birds

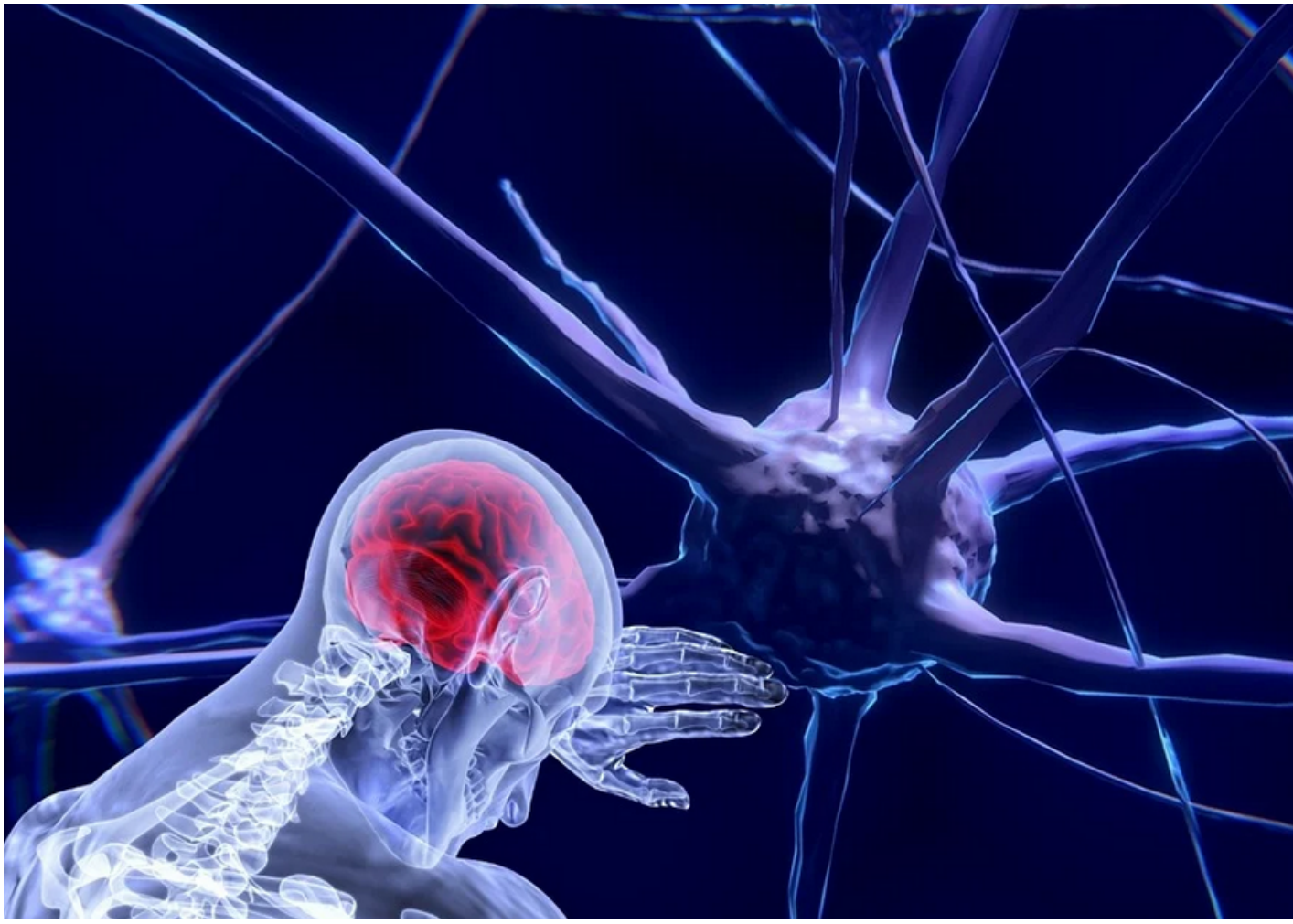
A flock of birds

Simple rules lead to seemingly sophisticated behavior (Reynolds 1987)

- **Align** yourself with the neighbors in terms of velocity and direction.
- **Separating** yourself enough from the others to avoid collusion.
- Try to **center** yourself to your neighbors.

Simple rules -> Complex Behavior


NYSE
NYSE
NYSE
CNBC
NYSE
NEW YORK STOCK EXCHANGE
imc
BARCLAYS
AstraZeneca



What is a scientific model?

- A simplified representation of some part of the reality that is useful for a scientific purpose.
  - Help us to **understand** the reality it represents.
  - **Manipulate** it to improve causal understanding.
  - Make **predictions** out of it.

Modelling complex systems

- The complexity of scientific models was limited by its mathematical tractability.
- Computer simlations relaxed relaxed this limitation.
- ABM's are less simplified in a specific way:
  - They describe individual components of a system
  - Individuals and components are autonomous entities

Agent-based models

- Computational model for simulation the interactions of autonomous objects (agents).
- Agents: people, animals, institutions, particles, etc.
- Bottom-up approach
- Define the behavior of agents and their interactions.

What problems are addressed by ABM?

- Housing market collapse (Gilbert, Hawksworth, and Swinney 2009; Geanakoplos et al. 2012)
- Stock Market fluctuations (LeBaron (2001))
- Managing tropical forests (Huth, Drechsler, and Köhler (2004))
- COVID- Contact Tracing (Hinch et al. 2021)

. . .

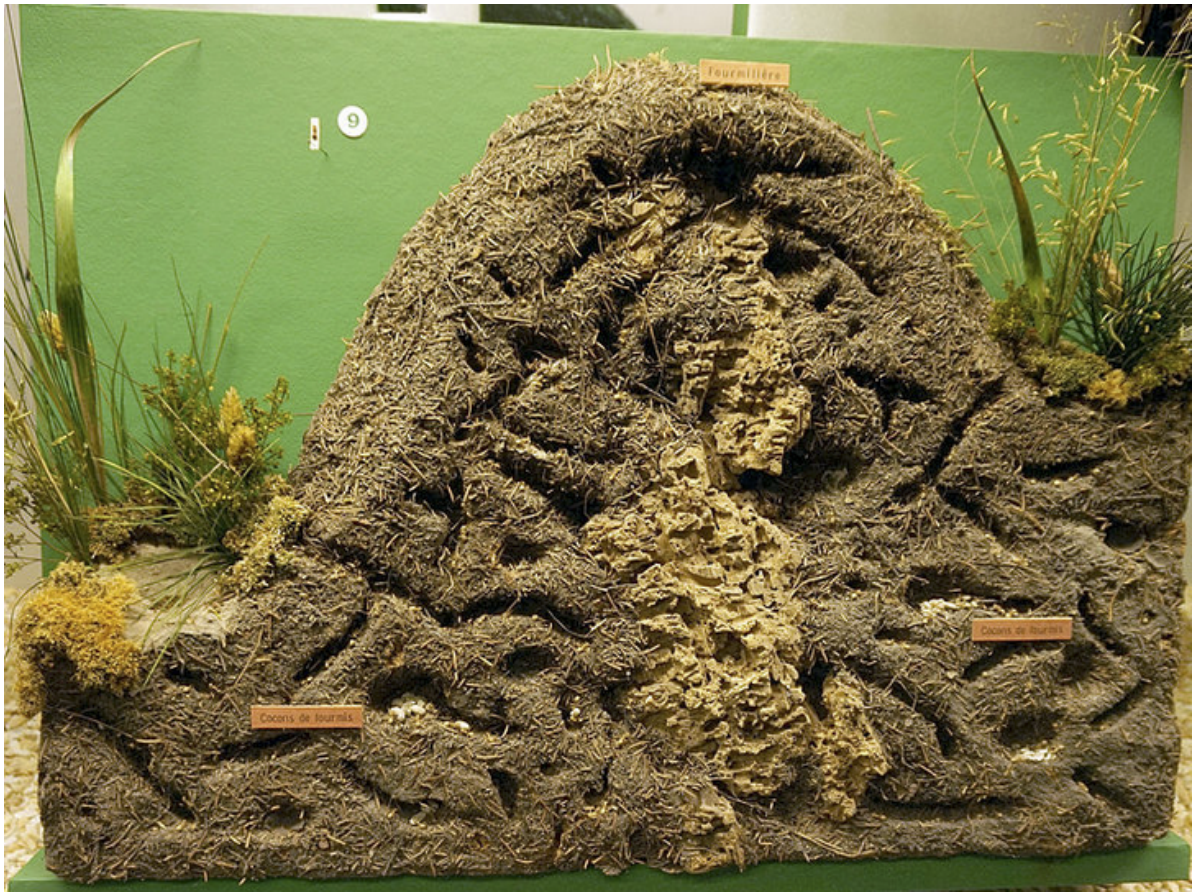
(See Railsback and Grimm 2019. For more, p.11)

Why ABM?

- Solve problems that traditional models and methods are too simple for.
- Support/refute theory based on additional features.
- Explore potential distribution of outcomes.
- Adresses problems related to *emergence*.

Emergence

- Describes a relationship between a low-level system (micro) and a high-level (macro) system.
- Macro-level phenomena can only be derived by studying micro-level phenomena.
- Simple interactions between a system's elements lead to unexpected global behavior (Epstein 1999)



Examples:

- The human body
- The human brain
- Pandemics
- Ecosystems
- Global Production chain
- Mexican waves

Features of ABM

(Romanowska, Wren, and Crabtree 2021)

- There are no strict rules on how ABM should be built.

Some features:

- Emergent
- Heterogeneity
- Temporal
- Spatial
- Learning/adaptation

Complex Adaptive Systems and ABM

- When we use agent-based models, we useally study a compleyx adaptive system.
- Dynamic of systems composed if interacting elements in different levels.

Two historical inspiration

- Evolution
- Emergence

Evolution: Universal Constructor

- One robot buiding another
  - Without a computer
  - Design a machine which's complexity increase under natural selection.
  - The concept of **celular automata**


John von Neumann (1903-1957)

Game of Life (1970)

- A cellular automaton
- Square cells with two states: alive and dead.
- 8 neigbors:
  - if <2 alive neighbors: dies
  - if 2-3 alive neighbors: lives
  - if > 3 alive neighbors: dies
  - if 3 alive neighbors: lives

Game of Life (1970)

Full Video: Youtube

Axelrod Tournaments (1980)

- Iterated Prisoners Dilemma Game: "**Cooperate**" "**Defect**"

- Colleagues were invited to submit their strategies
- Strategies played against each other repeatedly
- 15 strategies initially.
- The winner was the TIT FOR TAT strategy.

Building Agent-Based Models

- Modeling (Design, description etc.)
- Programming

What software to use

https://en.wikipedia.org/wiki/Comparison_of_agent-based_modeling_software

- Netlogo
- Python
- Mesa (Python)
- AgentPy (Python)
- R

Why Python?

- The skills are transferable
- The language is easy to learn
- You get to understand underlying concepts of ABM
- Potential to use in other fields with packages
- Easier to connect wit data
- Potential to combine other technologies
  - Reinfocement learning
  - Regression analysis

This workshop

- Hands-on introduction to agent based models
- We will use Python
- We will build models from scratch
- We will use other packages like Axelrod, AgentPy
- Focus more on Game Theory

Workshop Program

13 June 2022, Monday

- Python Basics

14 June 2022, Tuesday

- Python: Introduction to Object-Oriented Programming in Python
- Creating an Agent
- Interacting agents
- Implementing the Game
- Axelrod Tournaments

Workshop Program- cont

15 June 2022, Wednesday

- Creating a Population
- Evolution of strategies
- Python: Numpy, Pandas, Matplotlib
- Sensitivity Analysis

16 June 2022, Thursday

- Grid Games
- Seggregation Model
- Networks
- Advanced Topics Discussion

Preperation

- Jupyter Notebook

References

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