Introduction to Intelligent Agents and Multiagent Systems

Artificial Intelligence: Multiagent Systems – I

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Outline

Objective

- Explain a major topic in AI
- Introduce you to open problems in the topic
- Motivate you to take up further research in the topic

Multiagent or MultiAgent or Multi-Agent?

I prefer "multiagent"; fine with people using other variants

The International Foundation for Autonomous Agents and **Multiagent Systems** (IFAAMAS)
`https://www.ifaamas.org/`

What Will We Discuss?

- What is an intelligent agent?
- What makes agents intelligent?
- What is a multiagent system (MAS)?
- How could agents communicate and cooperate in an MAS?
  - Social norms; accountability
- How could we design intelligent agents and MAS?
  - Agent-based software engineering

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Our focus will be on a software agent

What Will We NOT Discuss?

- Machine Learning (COMS30035)
  - Learning is a key component of AI (and MAS)
  - Vast topic in itself!
- Robotics (EMATM0053)
  - Shares a lot of commonalities
  - Physical world brings different challenges

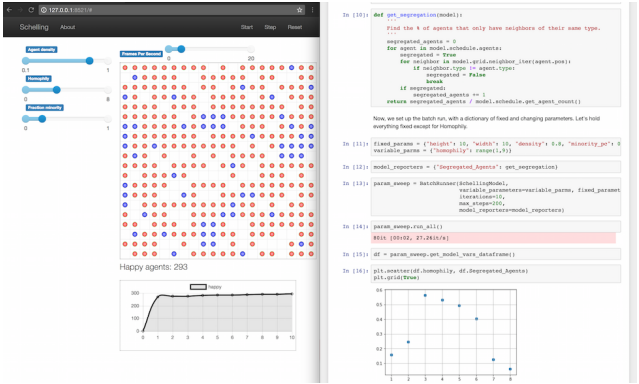
Reading

- Michael Wooldridge. 2009. An Introduction to MultiAgent Systems (2nd edition). Wiley Publishing.
- Gerhard Weiß. 2013. Multiagent Systems (2nd edition). MIT Press.

Labs: Modeling and Simulation of Agent Societies

Mesa: A Python framework for agent-based modeling (For Lab)

- Overview: `https://mesa.readthedocs.io/en/latest/`
- Tutorial: `https://mesa.readthedocs.io/en/latest/tutorials/intro_tutorial.html`
- Examples: `https://github.com/projectmesa/mesa`
- Install: `pip install mesa`

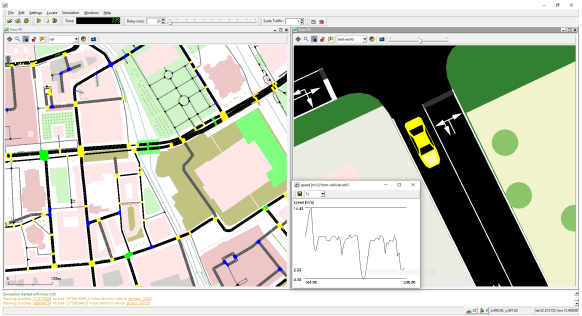


Source: `https://mesa.readthedocs.io/en/latest/`

Other Agent Simulation Frameworks

For your tea-time projects. . .

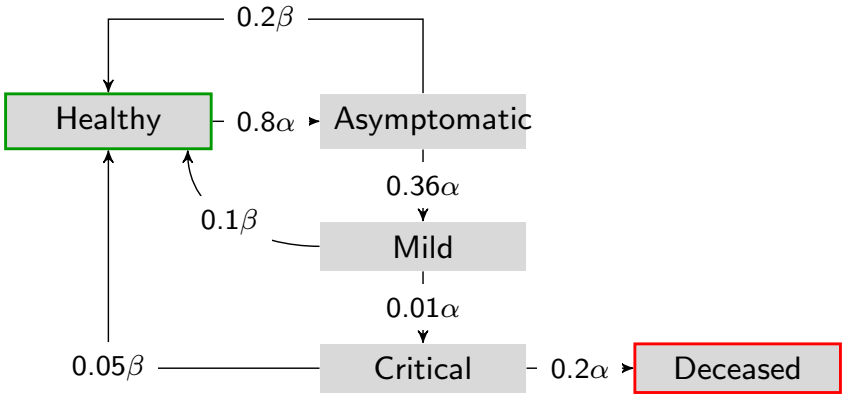
- Mason (Java-based)
  `https://cs.gmu.edu/~eclab/projects/mason/`
- Repast (Java-based)
  `https://repast.github.io/`
- SUMO (Traffic)
  `https://www.eclipse.org/sumo/`
- CARLA (Traffic)
  `https://carla.org/`



Source: `https://www.eclipse.org/sumo/`

Covid-19 as an Example Scenario for Labs

SEIRV Model; Adapted from Yang and Wang 2020, Annas et al. 2020



Q&A

Outline

Agent: A First Definition

An agent is a computer system that is capable of performing independent (autonomous) action on behalf of its users or owners (Wooldridge 2009)

- An agent figures out what needs to be done to satisfy its users' goals, rather than constantly being told

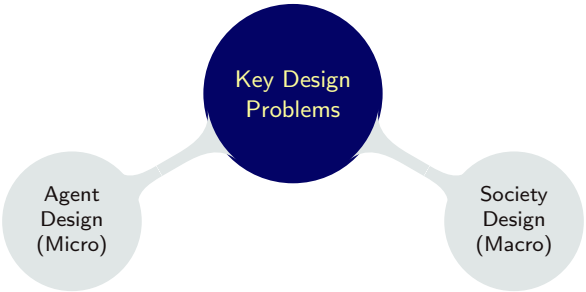
Multiagent System: A First Definition

A multiagent system is one that consists of a number of agents, who interact with one another (Wooldridge 2009)

- Agents act on behalf of their users
- Users have different goals and motivations
- For successful interaction, agents need to
  - coordinate,
  - negotiate, and
  - cooperate with each other

Key Design Problems

Micro and Macro



Agent Design: Micro Perspective

- How do we build agents that are capable of performing independent, autonomous actions in order to successfully bring out goals of their users?

Society Design: Macro Perspective

- How do we build agents that are capable of interacting (cooperating, coordinating, negotiating) with other agents in order to successfully bring about goals of their users, particularly when the other agents cannot be assumed to share the same goals?

Examples of Intelligent Agents and Multiagent Systems

Exercise

- Think of some examples
  - talk to your neighbours

Q&A

Outline

Revisiting: What is an Agent?

Important: An agent is autonomous

- capable of deciding for itself and performing independent actions

Definition

An agent is a computer system capable of performing autonomous action in some environment, in order to achieve delegated goals

Sense-Decide-Act Loop

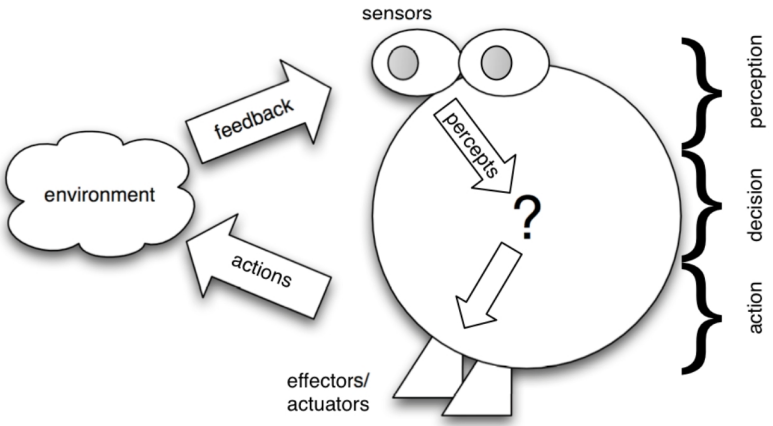
We think of agents as situated in an environment

- Engage in a close-coupled loop
- Continually interact with the environment
- sense – decide – act – sense – decide ...

Source: https://i.gifer.com/fetch/w300-preview/ea/eabe9e7d66941f7c63da30d11e3832a9.gif

Agent and Environment

Borrowed from Wooldridge 2009



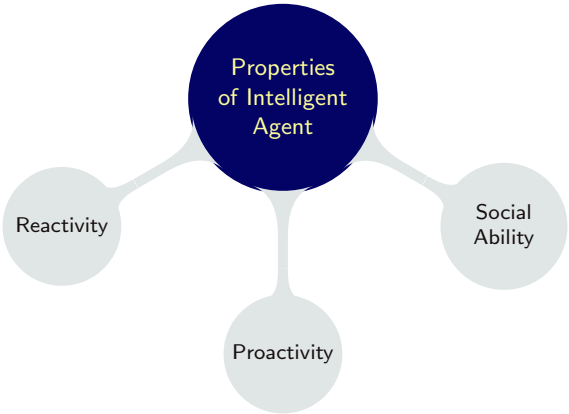
Simple (Not Interesting?) Agents

Analogous to a Control System

- Thermostat
  - delegated goal is to maintain room temperature
  - actions are to switch heating ON and OFF
- Email notification on your phone
  - delegated goal is to monitor for incoming message and flag it
  - actions are GUI actions

These examples satisfy the definition of an agent, but the decision making they are involved in is trivial

Properties of an Intelligent Agent



Reactivity

- Ideal scenario: Environment is fixed
  - A program can just execute blindly
- Reality: Environment is dynamic

- A reactive system is one that maintains an ongoing interaction with its environment and responds to changes that occur in the environment
- Response needs to be in-time for it to be useful

Example of Reactivity

Reactivity: Stimulus follows a response

Exercise: Think of some examples

Example of Reactivity

Reactivity: Stimulus follows a response

Exercise: Think of some examples

- Smart Home
  - Turn on the yard lights when motion is detected
    What if your neighbour's cat is in your yard!
  - Turn on the bedroom lights when someone enters
    What if your pet is moving around at night?
- Thermostat

Challenges with Reactivity

- Reacting to environment may be easy
- Lookup table: Stimulus $\rightarrow$ Response
- Not the most effective behaviour
- Can't think of all possible scenarios!

Proactivity

Proactivity is about exhibiting a goal directed behaviour

- Systematically working to achieve goal
- Anticipate and take initiative

Example of Proactivity

Exercise: Think of some examples

Social Ability in Agents

Real world is a multiagent environment

- We cannot go around attempting to achieve goals without taking others in the account
- Social ability in agents is the ability to interact with other agents (and humans) via a communication language
  - Coordinate
  - Negotiate
  - Cooperate

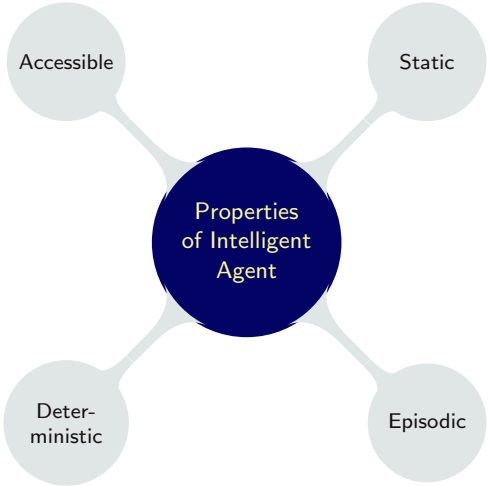
Example of Social Ability

Exercise: Think of some examples

Q&A

Outline

Properties of Environment



Accessible vs Inaccessible

Accessible

Agent has or can obtain complete, accurate, and up-to-date information about the state of the environment

- More accessible an environment, simpler to build agents to act in that environment

- Inaccessible
  - Internet
  - Physical world

Deterministic vs Non-Deterministic

Deterministic

- Environment in which each action has a single guaranteed effect
- No uncertainty about the resulting state

- Physical world is non-deterministic

Episodic vs Non-Episodic

Episodic

- Performance of an agent is dependent on number of discrete episodes
- No link between the performance of an agent in different scenarios

Static vs Dynamic

Static

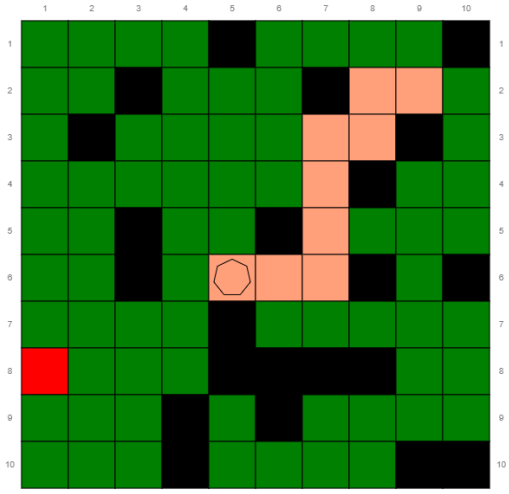
- Environment can be assumed to remain unchanged except by the performance of actions by the agent
- Predictable

Dynamic

- Other processes or agents also operate in the environment
- Physical world is dynamic

Environment in the Grid World

Exercise: Think about the properties of the Grid World environment



Q&A