ROB 538: Multiagent Systems

Week 1, Lecture 1:

Agents
Autonomy
Environments

HW # 1: Due Oct 3
Reading Assignment: Chapter 1

Autonomy?

Merriam Webster:
Autonomy: the state of existing or acting separately from others
Levels of Autonomy

- Little to no autonomy: Remote controlled UAS
- Some autonomy: Lane following, emergency braking
- High autonomy: Airline autopilot, google self-driving car
- Shared autonomy: Search and rescue, amazon warehouse
- Full (or close to full) autonomy: High speed trading
Shared Autonomy Example

- Human and robot have different competitive advantages

- Search and rescue teams in response to fires/disasters:
  - Human to robot: *Go search behind that hill*
  - Robot does so, autonomously, without asking for a path. Reports.
  - Human looks at new data and instructs: *Compare notes with Robots 3, 5, 8*
  - Robot contacts other robots and exchanges information
  - Robot highlights spot on map: *This area has high likelihood of finding survivors*
  - Human consults with human partners
  - Human to robot: *Very well, explore area 9*
  - Robot calls robots 3 and 8 (not 5) and the three of them explore area 9
Autonomous Agent Definitions

- An agent is an algorithm that is capable of independent (autonomous) action.
  - Autonomous: figure out what needs to be done
  - How to select actions
  - How to evaluate actions

- An agent is a set of algorithms that senses, reasons about and acts in an environment
  - Sensing
  - Reasoning
  - Acting
  - Environment

Intelligence

- Complexity of tasks that we automate has grown

- A lot of what we take for granted today would have been viewed as AI ten years ago
  - Autopilot of a 747?
  - Deep Blue?
  - Internet searches?

- Seems Intelligence is something off in the distance but in reality it is in many everyday products
Intelligence

- My definition:

An agent that senses the world, reasons about the world, acts within that world, and learns from its interaction with the world is an intelligent agent.

Multiagent system

- Definition

- A multiagent is a system that consists of multiple agents that interact with one another and the environment.

  - Multiple
  - Agents
  - Interact
  - Environment
Why multiagent systems?

• Isn’t it just:
  – Distributed systems?
  – AI?
  – Game theory?
  – Economics/mechanism design?
  – Social science?
  – Biological/ecological modeling?

Environment

• Accessible vs. inaccessible
• Deterministic vs. non-deterministic
• Episodic vs. non-episodic
• Static vs. dynamic
• Discrete vs. continuous
Properties of the environment

• Accessible vs. inaccessible
  - Accessible: Agents can obtain complete, accurate, up to date information about the environment
  - Most environments of interest are inaccessible
    • For example, anything operating in the real world

Properties of the environment

• Deterministic vs. non-deterministic
  - Deterministic: an action taken by an agent has a predictable consequence. There is no uncertainty about the outcome of an action.
  - Most environments of interest are non-deterministic
    • For example, most things operating in the real world
Properties of the environment

- Episodic vs. non-episodic
  - Episodic: The agent acts for a fixed number of time steps and then the world is reset. There is no link between the “episodes”.
  - Non-episodic: The agents operates continuously in an environment.

- Some real world problems are episodic: games
- Other real world problems are non-episodic: exploring a terrain

- Some problems can be viewed as either:
  - Robot trying to find a target in a room.

Properties of the environment

- Static vs. dynamic
  - Static: The environment stays the same except for changes caused by the agents actions
    - A robot aims to detect fixed goals in an arena
  - Dynamic: The environment in which the agent operates changes
    - Goals that robot needs to detect appear/disappear/move
Properties of the environment

• Discrete vs. continuous
  - Discrete: There is fixed, finite number of actions
    • A game of chess is discrete (discrete does not mean “easy”)
  - Continuous: There is an infinite number of actions
    • Autonomous vehicle control is continuous (in the most general case)
      – Direction angle
      – Speed

Reactive Agents

• A reactive agent is one that interacts with a changing environment and responds to changes that occur in that environment
  - Fixed responses
  - Learning systems?
Goal Directed Agents

• We design agents to do something.
  – That something has to be expressed to the agent
  – Utility/Objective/Reward/Payoff function

• A goal directed agent is one that acts to achieve a specified goal
  – Fixed responses?
  – Learning systems?
Deductive/Inductive Reasoning

• Deductive Reasoning
  - Rover is a dog
  - All dogs are mammals
  - Rover is a mammal

• Inductive Reasoning
  - Ellen is a student
  - Most students study
  - Ellen must study

Brooks and the Subsumption Architecture

• Rodney Brooks
• Three key statements:
  - Intelligent behavior can be generated without explicit representations
  - Intelligent behavior can be generated without explicit abstract reasoning
  - Intelligent behavior is an emergent property of certain types of complex systems

• Two key ideas:
  - Situatedness and embodiment: Real intelligence is situated in the world, not in disembodied systems such as theorem provers or expert systems
  - Intelligence and emergence: Intelligent behavior arises as a result of an agent’s interaction with its environment

(from Wooldridge, “An Introduction to Multiagent Systems”, chap 5)
Properties of agents

• Input but no state (purely reactive)
  − No state information
  − Decision based solely on present input
    • Car example: do the same things as car in front

• State but no input (purely history based)
  − Build internal state based on past observation
  − Decision based on past successes, but no input
    • Car example: do the same thing as I did last time I was here

• State and input
  − Build internal state based on past observation
  − Use additional input to predict likely outcomes
    • Car example: do the thing that got me the most reward last time I saw the car in front of me turn right.

One take away