# Representational Dimensions

CPSC 322 Lecture 2

January 10, 2006

# Lecture Overview

Recap from Last Lecture

Representation

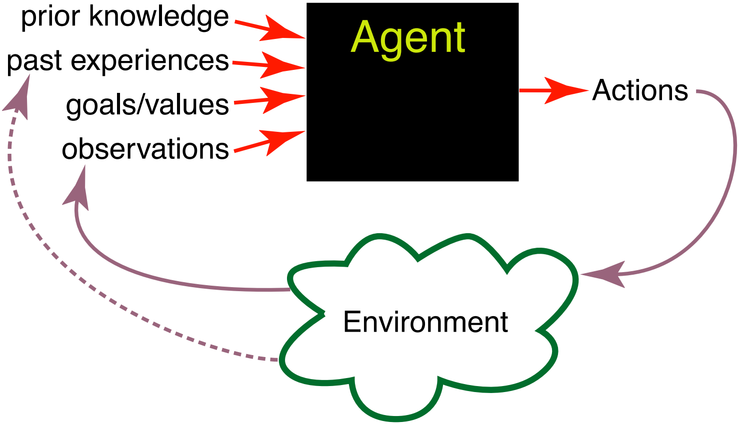
An Overview of This Course

Further Dimensions of Representational Complexity

# Essentials

- Course web site: http://www.ugrad.cs.ubc.ca/~cs322/
  - This is where most information about the course will be posted, most handouts (e.g., slides) will be distributed, etc.
- Textbook: *Computational Intelligence, 2nd Edition*, by Poole, Mackworth and Goebel. Still under development; electronic version only.
- WebCT: used for textbook, discussion board
  - Use the discussion board for questions about assignments, material covered in lecture, etc. That way others can learn from your questions and comments!
  - Use e-mail for private questions (e.g., grade inquiries or health problems).

# Agents acting in an environment



# Representation

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# Representation

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- What different configurations can the world be in, and how do we denote them in a computer?
- What sorts of beliefs can we have about what configuration the world is in, and are these beliefs certain?
- How would the world be changed if we were to take some given action: what are the system dynamics?

# What do we want from a representation?

**We want a representation to be:**

- rich enough to express the knowledge needed to solve the problem.
- as close to the problem as possible: compact, natural and maintainable.
- amenable to efficient computation; able to express features of the problem we can exploit for computational gain.
- learnable from data and past experiences.
- able to trade off accuracy and computation time.

# Representation and Reasoning System

Problem $\Longrightarrow$ representation $\Longrightarrow$ computation

A representation and reasoning system (RRS) consists of

- Language to communicate with the computer.
- A way to assign meaning to the symbols.
- Procedures to compute answers or solve problems.

Example RRSs:

- Programming languages: Fortran, C++,...
- Natural Language

We want something between these extremes.

# Overview of this course

**This course will emphasize two main themes:**

## Reasoning

How should an agent act given the current state of the world and its goals?

## Representation

How should the world be represented in order to help an agent to reason effectively?

# Representations considered this course

**Furthermore, the course will consider three main representational dimensions:**

1. Static vs. sequential domains (AKA one-off vs. responsive)
2. Deterministic vs. stochastic domains
3. Single-agent vs. multiagent domains

# 1. Static vs. Sequential Domains

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**How many decisions does the agent need to make?**

- The agent needs to take a single action
  - solve a Sudoku
  - diagnose a patient with a disease
- The agent needs to take a sequence of actions
  - navigate through an environment to reach a goal state
  - bid in online auctions to purchase a desired good

But... is this really a characteristic of the **domain** alone?

# 2. Deterministic vs. Stochastic Domains

Historically, AI has been divided into two camps: those who prefer representations based on logic and those who prefer probability.

- Is the environment deterministic or stochastic?
- Is the agent's knowledge certain or uncertain?

In past years, CPSC 322 has covered logic, while CPSC 422 has introduced probability

- this year I'll introduce both representational families in the same course
- this should give you a better idea of what's included in AI

Some of the most exciting current research in AI is actually building bridges between these camps.

# 3. Single-agent vs. Multiagent domains

One final representational question is whether the environment includes other agents

- Everything we've said so far presumes that there is only one agent in the environment.
- If there are other agents whose actions affect us, it can be useful to explicitly model their goals and beliefs rather than considering them to be part of the environment
- Agents can have their own goals: cooperative, competitive, or a bit of both

# Modules we'll cover in this course

1. Making single decisions in deterministic environments
   - Search, CSPs
2. Making sequential decisions in deterministic environments:
   - Planning
3. Richer representations in deterministic environments:
   - Logic
4. Making single decisions in stochastic environments:
   - Bayes Nets, Influence Diagrams
5. Making sequential decisions in stochastic environments:
   - MDPs
6. Multiagent systems
   - Zero-sum games; Nash equilibria

# Dimensions of Representational Complexity

**We've already discussed:**

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**Some other important dimensions of complexity:**

- Explicit state or propositions or relations
- Flat or hierarchical
- Knowledge given versus knowledge learned from experience
- Goals versus complex preferences
- Perfect rationality versus bounded rationality

# Explicit State or propositions or relations

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  - 30 binary features can represent $2^{30} = 1,073,741,824$ states.

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  - Often it is more natural to describe states in terms of features.
  - 30 binary features can represent $2^{30} = 1,073,741,824$ states.
- Features can be described in terms of objects and relationships.
  - There is a feature for each relationship on each tuple of individuals.
  - One binary relation and 10 individuals can represents $10^2 = 100$ propositions and $2^{100}$ states.

# Flat or hierarchical

**Is it useful to model the whole world at the same level of abstraction?**

- You can model the system at one level of abstraction: flat
- You can model the system at multiple levels of abstraction: hierarchical
- Example: Planning a trip from here to a resort in Cancun, Mexico

# Knowledge given versus knowledge learned from experience

**How much do we know about the world in advance?**

- The agent is provided with a model of the world before it starts to act
- The agent must learn how the world works based on experience
  - in this case, the agent often still does start out with some prior knowledge

# Goals versus complex preferences

**If an agent doesn't want to achieve anything, it has no reason to act. How do we represent an agent's desire(s)?**

- An agent may have a goal that it wants to achieve
  - e.g., there is some state or set of states of the world that the agent wants to be in
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  - e.g., there is some proposition or set of propositions that the agent wants to make true
- An agent may have complex preferences
  - e.g., there is some preference function that describes how happy the agent is in each state of the world; the agent's task is to put the world into a state which makes it as happy as possible

# Perfect rationality versus bounded rationality

**We've defined rationality as an abstract ideal. Is the agent able to live up to this ideal?**

- Perfect rationality: the agent can derive what the best course of action is.
- Bounded rationality: the agent must make good decisions based on its perceptual, computational and memory limitations.

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