Artificial Intelligence

Goal:
- Understand how intelligent behavior is possible
  - i.e. Come up with a theory that explains intelligent behavior

Methodology:
- Design, build and experiment with computation systems that perform tasks commonly viewed as intelligent

Flying Analogy
- First approach:
  + Dissect known flying animals
  + Figure out what they have in common
    - Flapping of wings made of some structure covered with feathers
- Second approach:
  + Understand principles of flight
  + Don't restrict to just natural occurrences of flight
  + Construct objects that embody hypothesized principles
  - Underneath how machines behave is possible

Overview

- Background
- Exchange Problems
- Deductive Approach
- Inductive Approach
- Generic Approach

Textbook:
Computational Intelligence: A Logical Approach
David Poole, Alan Mackworth and Randy Goebel
Oxford University Press. 1998

Optional Resource:
Knowledge Representation and Reasoning
Ronald J. Brachman and Hector J. Levesque
Morgan Kaufmann. 2004
Overview

• Agent Approach
  ⇒ Symbolic Reasoning

• Declarative Approach

• Example Problems

• Bookkeeping

Mapping Inputs to Outputs

• For agents with simple goals in simple domains
  Could just map current sensor values to actions
  -Mapping could be done by a neural network
  -Could first map current sensor values to actions with simple goals

Agent Approach

• This course focuses on building agents
  -An intelligent agent is one that behaves intelligently
  -Agent is something that acts in its environment
  -Environment is where the agent (or intelligent system) lives

• Agent has some sort of plan for its environment
  -Plan in some sense is the agent's goal in its environment
  -This course focuses on building agents

Examples
Procedural Approach

- Programs can quickly become huge, difficult to maintain, and to
  debug and understand
- Intelligence of the agent is manifest by the code
- Emphasis is on making the code work

Representing and Updating Internal State

- How do we represent the current state?
- How do we represent the internal state?
- Need a theory (formal specification)
- and implementation of the theory

Internal State

- For more complex goals in more complicated domains
- Agent might need more than current sensor values
- Might want to commit to future actions in chess, might want to form a strategy and follow through with it
- Might want to make assumptions about other agents' beliefs and goals
- Want to avoid trying the same thing over and over again
- Want to avoid making the same mistakes

Problems:

- How to represent the current state?
- How to update the state and determine the next action?
Declarative Approach: Symbols

- Model the internal state with symbols
  - Symbols will have meaning to us (us = the designer)
  - Meaning of symbols should be unambiguous, unlike English
- Need to express complex relations with minimum of symbols
  - Need a language for representing the internal state
- Example
  - have(milk) ∧ have(cereal) ∧ want(sugar)
    - $A \land B$ means $A$ and $B$ are both true for the agent
    - have(X) means agent has $X$ in its procession
    - want(X) means agent wants $X$ in its procession
  - Don't need a symbol such as have(milk) have(cereal) want(sugar)

Another Solution

- Break problem down into some subproblems
  - Isn't this how computer science has evolved?
  - How many layers are there in Internet communication?
- Although might not be most efficient way of doing things,
  - Some redundancy can make complex problems tractable

Overview

- Agent Approach
- Symbolic Reasoning
- Declarative Approach
- Example Problems
- Bookkeeping
- Bookkeeping Example
- Problem
- Declarative Approach
- Symbolic Reasoning
- Agent Approach
Declarative Approach

Intelligence is in

- Having an appropriate language for representing internal state
- Being able to reason about symbols to form new symbols

Knowledge Engineer:

- Decides the set of facts and rules for a particular domain

Programmer:

- Constructs algorithms that can take arbitrary sets of facts and rules to make conclusions
- Can reuse algorithm over and over again for any domain

Declarative Approach: Reasoning Algorithm

- Rules encode how new symbols are created from existing ones
- From rules and facts, we should be able to make conclusions that follow from internal state

Facts that are not explicitly represented:

- Assumptions that seem reasonable
- Plans of action
- Action to perform right now

Reasoning Algorithm

- Makes conclusions from rules and facts

Declarative Approach: Rules

- Not only can facts be represented with symbols
- But also more general knowledge can be represented

Examples:

- Having cereal means having food
  
  \[ \text{have(cereal)} \rightarrow \text{have(food)} \]

- If X is connected to Y and there is a path from Y to Z, then there is a path from X to Z
  
  \[ \text{connected(X,Y)} \land \text{path(Y,Z)} \rightarrow \text{path(X,Z)} \]

- If X is connected to Y, then there is a path between them
  
  \[ \text{connected(X,Y)} \land \text{connected(Y,Z)} \rightarrow \text{connected(X,Z)} \]

Examples:

- If X is connected to Y and there is a path from Y to Z, then there is a path from X to Z
Delivery Robot

Delivery Robot

Overview

• Agent Approach
• Symbolic Reasoning

Fundamental Issues

• What are good languages for representing
  - the facts of an agent's internal state?
  - the rules that define the agent's reasoning?
• What are good algorithms that produce conclusions?
  - What do we mean by a 'good' algorithm?
  - What constraints are needed on the language that allow good algorithms?
Course Outline

Course Outline

- Building Answers
  - Direct and Knowledge-Based
- Problem-Solving and Search
  - Knowledge and Reasoning
  - Knowledge and Reasoning
  - Actions and Planning
    - Agents might have goals, have knowledge about actions
  - Non-monotonic Reasoning
    - Making assumptions and learning new information
  - Belief and Knowledge
    - Representing and reasoning about beliefs/knowledge of other agents
- Building Agents
  - Tie together concepts into a system

Overview

- Agent Approach
  - Symbolic Reasoning
  - Declarative Approach

Wiring

- Needs to know
  - What each device is
  - What is connected to what
  - Whether each switch is on
  - Whether each circuit breaker is on
  - Whether each light is on
- Needs to reason about
  - How to turn on a light
  - Whether there is a fault in the system
  - And where it is likely to be
- What is a good way of representing that knowledge?
- How do we specify what we want to reason about?
- How do we express what we mean to reason about?
- What is a good way of representing that knowledge?
Academic Integrity

You can do the homeworks with your colleagues.

- You cannot bring any part of your homework into the meeting.
- You cannot bring anything written out of your meeting.
- After the meeting, you rehash the solution from scratch.
- You cannot finish any part of your homework and then study
  before coming to the meeting.
- You can do the homeworks with your colleagues.

Tcl versus Python

- I've used Tcl in the past for homeworks. Tcl is not as commercially
  used as Python.
- Tcl has some weird idiosyncrasies:
  - Very picky about tokening
  - Hard to differentiate between a token and a list with one token.
- Most of you already know Python.

- Can do homeworks in Tcl or Python.
- If you don't have a lot of programming experience, use Python.
- If you want to minimize time spent on homeworks, use Python.
- If you know Python really well, and want to add another programming
  language to your Resume, use Tcl.

Two versions of each homework: Tcl and Python versions.

Assignments due at beginning of class, in hardcopy.
- Mixture of written answers and programming assignments.
- Programming in Tcl and a small amount in Prolog.

- First assignment has some Tcl/Prolog programming:
  - You can start this assignment already.
  - Information on the Web about downloading Tcl.

Grading Assignments and Projects 50% Midterm 25% Final 25%

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Reading Assignments

• We will be following the textbook closely.
• Reading assignments are posted on the course website.
• You are responsible for material in the textbook.
• We will be following the textbook closely.

Read chapter 1.2.3.5 for next class.