• Slack Channel - where you can ask questions
  + ohsu-cslu.slack.com #cs560
• Sakai
  + Used to submit homeworks to me
  + Private announcements I do not want to share with the world
  + Has link to WebEx
    + Will be recorded incase you miss a lecture
    + Recordings will be on Webex, might take 24 hours
    + Will be used for office hours as well
• Course website: cslu.ohsu.edu/~heeman/cs560
  + Lecture slides: 1-up and 2-up
  + Homework assignments
• Email: heemanp@ohsu.edu
  + Communicating with me
  + Can also use messaging in slack
Textbook

• 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
• Example Problems
• Bookkeeping
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
  - A better approach:
    + Understand principles of flight
    + Don’t restrict to just natural occurrences of flight
    + Construct objects that embody hypothesized principles

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Mapping Inputs to Outputs

• Many intelligent tasks involve mapping from current sensor values to output
  - Identifying tumor
  - Call routing
  - Image labeling

• Mapping can be done by neural network, SVM, decision tree, etc
  - Use lots of training data that maps inputs to outputs
  - Use probabilistic models to give best answer
Overview

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Limitation of Mapping Approach

• Not enough training data
  - Impossible to get training data: want to detect burglar in my house through my smart home sensors

• Might be interested in the internals of the model
  - Making the reasoning understandable to a person

• Might need to incorporate well-known knowledge rather than learn from scratch
  - e.g., Books are physical things, and physical things have a weight
  - e.g., If someone asks me a question, I should answer it
Declarative Approach: Symbols

• Model knowledge 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 language for representing the internal state

• Example
  \[ \text{have(milk)} \land \text{have(cereal)} \land \text{want(sugar)} \]
  - \( A \land B \) means \( A \) and \( B \) are both true for the agent
  - \( \text{have}(X) \) means agent has \( X \) in its procession
  - \( \text{want}(X) \) means agent wants \( X \) in its procession
  - Don’t need a symbol such as \( \text{havemilkhavecerealwantsugar} \)
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
    \[ \text{have(cereal)} \rightarrow \text{have(food)} \]
  + Use additional connector in representing rules
  - if X is connected to Y and there is a path from Y to Z,
    then there is a path from X to Z
    \[ \text{connected}(X,Y) \land \text{path}(Y,Z) \rightarrow \text{path}(X,Z) \]
  + Use tokens that start with an uppercase letter for variables
  - if X is connected to Y, then there is a path between them
    \[ \text{connected}(X,Y) \rightarrow \text{path}(X,Y) \]
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 actions
  - Action to perform right now
- Reasoning algorithm
  - Makes conclusions from rules and facts
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
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 can produce the conclusions that correspond to reasoning?
  - What do we mean by a ‘good’ algorithm?
  - What constraints are needed on the language that allow good algorithms?
Overview

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Delivery Robot

- Robut needs to know
  - layout of space
  - where things are
  - which doors are open
- Needs to reason about
  - How to get from one point to another
  - Delivering multiple package
    + Can only carry one package at a time?
- What is a good way of representing that knowledge?
  - How do we specify what we want to reason about?
  - How do we the reasoning?
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 do the reasoning?
Overview

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Course Outline

- Knowledge and Reasoning
  Datalog: Syntax, Semantics, Inference
  Search procedures
  Representing knowledge

- Richer formalisms
  Reasoning about Equality
  Integrity constraints
  Disjunctive knowledge
  Quantification
  First order predicate logic

- Actions & 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

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Grading

Assignments  50%
Midterm        25%
Final          25%

• Course website: cslu.ohsu.edu/~heeman/cs560

• Slack channel
**Tcl versus Python**

- In the past, I used Tcl 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

- Started using Python for homeworks a few years ago
  - Most of you already know Python
  - Can further brush up on your Python skills
  - Might be a few artifacts of Tcl left in the homework assignments
Homework

• Homework usually given out Monday by 11:55pm
  - Should have it done by Friday at 11:55pm
    + But not officially due till Saturday at 11:55pm
  - Can have an extension on one homework
  - Can always ask me for another extension

• Homework must be submitted through Sakei
  - If you have problems, email it to me heemanp@ohsu.edu
  - Single pdf with your answers on it
    + Sample homework on the website
    + Homework should be typeset
    + Can include pictures of hand-drawn solutions taken with cellphone
  - Pdf should include relevant code as well
    + You need to typeset it so that it fits horizontally and vertically
- If your solution does not work, you need to say so
  + Failure to disclose will result in an extra penalty
- Submit your code as a single python file and/or prolog file
Critique

• Answer key given out via Sakai when you submit your answers
  - On honor system not to share it, nor post questions about the answers

• Have until Sunday at 11:55pm to submit a critique
  - Explain what you did wrong, and why you made that mistake
  - Worth up to half the marks that you lost
    + Really good explanations might even get more
  - Should show that you reviewed and understood answer key and understood whether your answer was correct
  - See sample homework for how to format this
Academic Integrity

• You can do the homeworks with your colleagues
  - But, 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
  If you can do this, then you have learned,
  Which is the point of taking the course.

• Corollary
  - Unless both people have photographic memories,
    homework assignments should look different
Reading Assignments

• We will be following the textbook closely
• You are responsible for material in the textbook
• Reading assignments are posted on the course website
  - Read chapter 1, 2.1-2.5 for next class