Computer Science 6100/4100: Machine Learning

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What is Machine Learning?

- "Enabling computers to learn from data"
- Supervised learning: generalizing from seen data to unseen
- Unsupervised learning: Finding patterns in input data
- Reinforcement learning: learning how to act

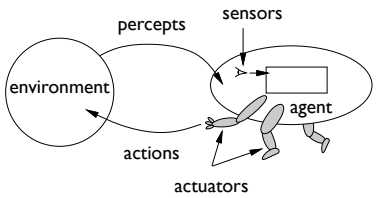
Where Does This Fit in AI?

- What is the goal of AI?
  - Two dichotomies: thinking/acting and humans/rationality (Russell & Norvig [RN])
- Turing test: acting like humans (restricted domain)
- Alternative goal: acting rationally?

Rational Behavior

- [RN]: Maximize goal attainment
- Easier when we specify utility functions
- Perfect rationality is problematic:
  - Computational limitations
  - Definition of optimality

Intelligent Agents [RN]



- Agents include humans and artificial agents
- Agent function maps percept histories to actions $f : P* \rightarrow A$
- Agent program runs on the physical architecture to produce *f*

Human Beings and Humanoid Robots

- Environment: ?
- Sensors/Percepts: ?
- Actuators/Actions: ?
- Performance measure: ?

A Trading Agent

- Environment: ?
- Sensors: ?
- Percepts: ?
- Actuators: ?
- Actions: ?
- Performance measure: ?

Supervised Learning

- Induction
- Simplest form: true function

  $f : X \rightarrow Y$
- You are given pairs generated from *f*

  $(x_1, y_1), (x_2, y_2), \ldots (x_n, y_n)$
- Learn *h* close to *f*

Learning a Hypothesis

- How do we learn *h*? Algorithms from machine learning and statistics
- What can we prove about *h*? Statistical/ computational learning theory
- Different learning algorithms have different *inductive biases*
- Example...

Hypothesis Spaces

- Examples: decision trees, linear classifiers
- Finding a hypothesis can be thought of as search in the hypothesis space
- Hypothesis space is part of the inductive bias

Unsupervised Learning

- No explicit outputs
- Build a model of the inputs in some way
  - Probabilistic model of feature distribution
  - Clustering

Reinforcement Learning

- Agent interacts with the world
- Receives feedback in the form of rewards (or costs)
- Must choose which actions to take
- Major issues:
  - Delayed reward/credit assignment
  - Exploration/Exploitation

Elements of RL

- Sutton & Barto [SB]:
  - Policy
  - Reward function
  - Value function
  - Model?

Markov Decision Processes (Problems)

- State space: S
- Initial state: S_0
- Action space: A
- Transition model: $T : S \times A \to S \times [0, 1]$
- Reward function: $R : S \to \mathbb{R}$

Utility Theory

- Going from the real-world to sensible reward functions
- Parallelism: in economics, utility theory is useful in abstracting over preferences
- Thought question: which of these two options would you prefer?

Learning in Economics

- Agents that participate in markets are assumed to be rational
- This means they solve interesting learning and decision-making problems
- Change the focus to understanding how the interaction of rational players leads to system-wide dynamics...
  - Two restaurants
  - Kyle's model

Syllabus and Course Policies

- Refer to handout...

A Note on Math

- Calculus
- Ability to play with matrices
- Probability!
  - Uniform, Gaussian distributions, Bayes rule
    - Let's do a quick problem...

Problem 1

- MBC Instruments has designed a new test for Horrible Disease. This test is correct with 99% accuracy. 1 in 10000 people in the general population has the disease. SBC took the test and it came out positive. Is it more likely that SBC has the disease or doesn't?

Statistics

- Difference between standard deviation and standard error?