ECS 271: Outline

- Introduction
- Concept Learning
- Decision Tree Learning
- Artificial Neural Nets
- Computational Learning Theory
- Bayesian Learning
- Genetic Algorithms + other topics
Grading

• 45% for a term paper
• 25% Mid term (in class, Closed book)
• 15% {Home Work Assignments}
• 15% Final (Take Home, 24 hr turn-around)
  – Each student reads and critiques two term papers from other students. These critiques have no influence on how I grade the term papers.
Outside Reading

• The text book is really at an upper division UG level. You are expected to read outside papers to boost the theoretical background.
Term Paper

- Choose the topic. Any problem with which you are **very familiar** would be a good topic
- Choose a ML Technique discussed in the book
- Search the WWW for a good data set
- Implement the method, get the results
- Write a report (see class web site for more details)
- This is a 4-credit course. I expect you to devote a minimum of 20 hours on this project alone and another 20 hours for the rest of the course.
What is Machine Learning?

- Learning is
  - making *useful* changes in our minds (Minsky)
  - constructing or modifying *representations* of what is being *experienced* (Michalski)
  - knowledge acquisition in the absence of explicit programming (Valiant)
  - An adaptive process that enables a system to do the same type of task more effectively the next time around (Simon)
    - “type” means “drawn from the same population”
Why ML? Why Now?

• Recent progress in algorithms and theory
• Growing flood of on-line data
• Growing computational power
• Easier to build than similar programmed systems
  – Search engines
  – Computer games (TD-gammon)
  – User interfaces/Personal assistants (paper clip asst.)
  – Robot exploring Mars/ Vacuum Cleaner
• Better understanding of human/animal learning
Opportunities for Tomorrow

• Learn across full mixed-media data
• Learn across multiple databases
  – Internal databases
  – Web and Newsfeeds
• Learn by active experimentation
• Learn to make decisions rather than predictions
Types of Learning

- Rote Learning (memorization)
- Learning from examples (generalize from specific instances)
- Learning by being told (compile abstract advise)
- Learning from scalar feedback (reinforcement learning)
What is the Learning Problem?

• Given
  – a task $T$
  – a performance measure $P$
  – some experience $E$

• Learn to do the task

• Example: Learn to play $T = \text{checkers}$ until $P = 90\%$ of the campus-wide tournaments are won, by using $E = \text{the opportunity to play against player A.}$
How Do You Learn Checkers?

• What exactly is the meaning of “learning to play checkers”?
  – Given a board, what is the next move?
  – Given a board, what is the best move from among \{legal moves\}?  

• The \{legal moves\} defines a large search space. From this space we choose a move. That is, we are learning a target function $V$, given the board.
  – Target function, $V$: Board $\rightarrow$ Real Number
  – ChooseMove: Board $\rightarrow$ Move
Target Functions

• Define a function that assigns a score to the board
• The better the board, the better the score assigned.
• Then our search is really to maximize the score.
V for Checkers

• If $b$ is the final board state
  – $V(b) = 100$, for a winning state
  – $V(b) = -100$, for a losing state
  – $V(b) = 0$, for a draw

• If $b$ is NOT the final board state
  – $V(b) = V(b')$, where $b'$ is the best final board state that can be reached from $b$ while playing optimally (This is non much of a help)
Operational Definition

• What we want is a function that we can compute.

• What exactly is the value $V$ of a board?
  – We do not know. The best we can do is approximate with something we can compute
  – The most friendly computable functions are polynomials

$$V'' = w_0 + w_1 x_1 + \ldots + w_n x_n$$
Representation of Learned Function, $V^*$

- $V^*$ is an approximation to the unknown $V$
- $X_i$’s are features of the board
  - $X_1 = \#$ of black pieces
  - $X_2 = \#$ of red pieces
  - $X_3 = \#$ of black kings
  - $X_4 = \#$ of red kings
  - $X_5 = \#$ of blacks threatened by reds
  - $X_6 = \#$ of reds threatened by blacks
A Concept Learning Problem

• Consider a task

• The task is to learn a concept described by Boolean attributes

• Both positive and negative examples are provided by a teacher
  – The concept to be learned is “dog”

\[
\text{is\_mammal} \land \text{has\_claws} \land \neg \text{can\_fly} \land \text{has\_tail} \land \text{can\_bark}
\]