Machine Learning
Announcements

- Second midterm is tomorrow evening from 7PM – 10PM.
- Same locations as last time – just go where you went before!
  - Abb - Jon: Go to **Hewlett 200**
  - Jun - Mari: Go to **Hewlett 201**
  - Marq - Mik: Go to **Hewlett 101**
  - Mil - Ogr: Go to **Hewlett 102**
  - Oke - Pat: Go to **Hewlett 103**
  - Pau - Tan: Go to **Braun Auditorium**
  - Tao - Zuc: Go to **320-105**
Let's have some fun!
Perceptron Learning
\[ w_0 + w_1 \sum_{i=1}^{n} x_i w_i \]

- If the output is greater than 0, the result is YES.
- If the output is less than or equal to 0, the result is NO.
How do we choose good values for $w_0 \ldots w_n$?
One Approach

- **Train** the perceptron on valid data.
- For each data point:
  - Ask the perceptron what it thinks.
  - If correct, do nothing.
  - Otherwise, nudge $w_0 \ldots w_n$ in the right direction.
- Repeat until number of errors is “small enough.”
- **Question:** What kind of mistakes can we make?
\( w_1 - \alpha x_1 \)
\( w_2 - \alpha x_2 \)
\( w_3 - \alpha x_3 \)
\( w_4 - \alpha x_4 \)
\( w_5 - \alpha x_5 \)
\( w_6 - \alpha x_6 \)
\( \ldots \)
\( w_n - \alpha x_n \)
\( w_0 - \alpha x_0 \)

\( \sum \) > 0  →  \text{YES}
\[ w_1 + \alpha x_1 \]
\[ w_2 + \alpha x_2 \]
\[ w_3 + \alpha x_3 \]
\[ w_4 + \alpha x_4 \]
\[ w_5 + \alpha x_5 \]
\[ w_6 + \alpha x_6 \]
\[ \ldots \]
\[ w_n + \alpha x_n \]
\[ w_0 + \alpha x_0 \]
A Cute Math Trick

- For false positives, set $w_k = w_k - \alpha x_k$.
- For false negatives, set $w_k = w_k + \alpha x_k$.
- For correct answers, set $w_k = w_k$.
- Let “YES” be 1 and “NO” be 0.

Consider the difference between the actual answer and perceptron guess:

- False positive: Actually NO, we say YES. Difference is -1.
- False negative: Actually YES, we say NO. Difference is +1.
- Correct answer: Both YES or both NO. Difference is 0.

General update rule: $w_k = w_k + \alpha (real - guess)x_k$. 
Perceptron Learning Algorithm

- Start with a random guess of each $w_k$.
- Repeat until perceptron is sufficiently accurate:
  - Choose a training example $(x_0, x_1, ..., x_n)$.
  - Let $real$ be the real answer, $guess$ be the perceptron's guess.
  - For each $k$, set $w_k = w_k + \alpha(\text{real} - \text{guess})x_k$
- Note: Use *batching* in practice.
  - Update everything all at once.
Application: Handwriting Analysis

- Train a computer to recognize handwritten numbers 0 – 9.
- Large training and test set available (MNIST Handwritten Digit Database)
Perceptron
MAX
Combining Perceptrons

This is called a neural network.
Machine Learning

• Interesting in machine learning? Take CS109 or CS229!

• Many beautiful algorithms:
  • Naive Bayes classifiers (used in spam filtering).
  • Decision trees (used in hospitals for diagnostics).
  • Bayesian networks (used in cancer research and traffic control systems).
  • Word embeddings (recent approach for text processing and understanding).
Good Luck on the Exam!