Artificial Intelligence

Fiona Yan Liu
Department of Computing
The Hong Kong Polytechnic University
Machine Learning

- Learning is essential for unknown environments
  - Learning modifies the agent's decision mechanisms to improve performance
- Design of a learning element is affected by
  - Which components of the performance element are to be learned
  - What feedback is available to learn these components
  - What representation is used for the components
- Type of feedback:
  - Supervised learning
    - Correct answers for each example
  - Unsupervised learning
    - Correct answers are not given
Inductive Learning

- Simplest form
  - learn a function $f$ from examples pair $(x, f(x))$
- Problem
  - Given a training set of examples
  - Find a hypothesis $h$ such that $h \approx f$
- This is a highly simplified model of real learning
  - Ignores prior knowledge
  - Assumes examples are given
Example of Inductive Learning

- Construct/adjust $h$ to agree with $f$ on training set
  - $h$ is consistent if it agrees with $f$ on all example
Example of Inductive Learning

- Construct/adjust $h$ to agree with $f$ on training set
  - $h$ is consistent if it agrees with $f$ on all example
Example of Inductive Learning

- Construct/adjust $h$ to agree with $f$ on training set
  - $h$ is consistent if it agrees with $f$ on all example
Example of Inductive Learning

- Construct/adjust $h$ to agree with $f$ on training set
  - $h$ is consistent if it agrees with $f$ on all examples
Univariate Linear Regression

- Regression with a univariate linear function is also known as “fitting a straight line”.
- A univariate linear function (a straight line) with input $x$ and output $y$ has the form $y = w_1x + w_0$
- Loss function: $Loss(h_w) = \sum_j (y_j - (w_1x_j + w_0))^2$
Solutions to Univariate Linear Regression

The partial derivatives of $Loss(h_w)$ with respect to $w_0$ and $w_1$ are zero:

- $\frac{\partial}{\partial w_0} \sum_j (y_j - (w_1 x_j + w_0))^2 = 0$
- $\frac{\partial}{\partial w_1} \sum_j (y_j - (w_1 x_j + w_0))^2 = 0$

These equations has unique solutions

- $w_1 = \frac{N(\sum x_j y_j) - (\sum x_j)(\sum y_j)}{N(\sum x_j^2) - (\sum x_j)^2}$
- $w_0 = \frac{\sum y_j - w_1 (\sum x_j)}{N}$
Linear Classification

- Linear classification can be viewed as the task of finding the linear separator that can separate different classes in the feature space:

\[ w^T x + b = 0 \]

\[ w^T x + b > 0 \]

\[ w^T x + b < 0 \]

\[ f(x) = \text{sign}(w^T x + b) \]
Linear Classification with Hard Threshold

- Linear functions can be used to do classification as well as regression:
  \[ h_w(x) = \text{Threshold}(w^T x) \]
  
  where \( \text{Threshold}(z) = 1 \) if \( z > 0 \) and 0 otherwise.

- Since the loss function is undifferentiable, we cannot obtain the solution as in the regression problem.

- \[ w_i \leftarrow w_i + \alpha(y - h_w(x))x_i \]