Basic Concepts in Machine Learning

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Machine Intelligence

- Adaptive
- Robust
- Model real world and be able to react.
  - Hand coded rules are bound to fail.
  - Ideally, we would like the computer to program itself by showing it how it should behave.

Machine Learning

- Enable computer to figure out how to mimic a desired behavior by example.
- A program is viewed as function with adjustable parameters. The computer tunes the parameters to achieve the desired behavior.

Where is machine learning applied

- Quote from Sam Roweis:

  “Machine learning is most useful when the structure of the task is not well understood, but can be characterized by a dataset with strong statistical regularities.”

- Broad range of application from controlling the expressions in animojis to controlling the fate of entire countries.

Canonical Tasks

- Supervised Learning:

  Data consist of input-output pairs.

- Unsupervised learning:

  Only inputs are given. The goal is to find structure and representations of the data

- Reinforcement Learning: (weak supervision)

  Here, inputs represent the state of the world. The machine can choose from a set of actions and receive rewards accordingly. The goal is to learn to select action sequences that maximize reward over time.

Supervised learning

Data are a set of input-output pairs $\left(x_i, y_i\right)_{i=1}^{N}$

Goal is to find a function that approximates the input output relation as $f\left(x_i\right) \approx y_i$

- **Classification:**

  Categorize inputs. Outputs are discrete (also finite)

- **Regression:**

  Outputs are continuous

Unsupervised Learning

Goal is to find structure and representations of the data $\left(x_i\right)_{i=1}^{N}$

- **Clustering:** Group data into subsets of similar objects
- **Compression:** Find an alternative economical representation of the data from which the data can be approximately reconstructed
- **Estimating the data distribution:** Ideal goal.

Classification

We are given $\left(x_i, y_i\right)_{i=1}^{N}$ pairs. Where y_i are class labels from a set $\left(c_1, c_2, \ldots, c_K\right)$

Clustering

We are given $\left(x_i\right)_{i=1}^{N}$ data points. We want to group these points in to K subsets.

Dimensionality Reduction

Find a compact representation of a set d-dimensional points $\left(x_i\right)_{i=1}^{N}$ by mapping them to a p-dimensional space where p<<d.