Machine Learning

Machine Learning: algorithms that use “experience” to improve their performance.

We use machine learning situations where it is very challenging (or impossible) to define the rules by hand: e.g.
- face detection
- speech recognition
- stock prediction
- driving a car
- medical diagnosis

Machine Learning

Machine Learning: write programs with thousands/millions of undefined constants.

Learn through experience how to set those constants.

Machine learning algorithms are getting better and better and better......

Example 1: Hand-written digit recognition

Images are 28 x 28 pixels
Represent input image as a vector \( \mathbf{x} \in \mathbb{R}^{784} \)
Learn a classifier \( f(\mathbf{x}) \) such that,
\[
f: \mathbf{x} \rightarrow \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}
\]

Example 2: Face detection

- Again, a supervised classification problem
- Need to classify an image window into three classes:
  - non-face
  - frontal-face
  - profile-face

Example 3: Spam detection

This is a classification problem
Task is to classify email into spam/non-spam
Data \( x_i \) is word count, e.g. of viagra, outperform, “you may be surprised to be contacted”...
Requires a learning system as “enemy” keeps innovating

Example 4: Machine translation

What is the anticipated cost of collecting fees under the new proposal?
Use random variables to represent everything about the world

Space of possible random variables and classifiers indexed by parameters which are knobs we turn to create different classifiers.

**Learning:** the problem of estimating joint probability density functions, tuning the knobs, given samples from the function.

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- **Given “labeled data”**

- **Learn CLASSIFIER**, that can predict label of NEW instance

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This is huge!

- Growing flood of online data
- Recent progress in algorithms and theoretical foundations
- Computational power
- Never-ending industrial applications.