Machine Learning (in 30 minutes or less)

Doug Downey
Machine Learning

• “The study of computer programs that improve automatically with experience”

• Used heavily in:
  – Bioinformatics, robotics, marketing/advertising, recommendations systems, information retrieval, fraud detection, handwriting/speech recognition, etc., etc...
Example Machine Learning Tasks

• How likely is person \( x \) to default on a loan?

• What is the location of robot \( x \)?

• Does patient \( x \) have Type II Diabetes?
Learning a function from examples

- **Given:** examples of a function $f$ for various inputs $x$:
  - $\{(x_1, f(x_1)), \ldots, (x_n, f(x_n))\}$

- **Goal:** Estimate $f$
  - Input $x = (x_1, \ldots, x_d)$; individual features $x_i$
  - Output $f(x)$

- Probably the most common machine learning task formulation (though there are others)
Learn function from \( \mathbf{x} = (x_1, \ldots, x_d) \) to \( f(\mathbf{x}) \in \{0, 1\} \) given labeled examples \((\mathbf{x}, f(\mathbf{x}))\)
Representation

- In general, inputs and outputs can be
  - Nominal (e.g. Gender)
  - Ordinal (e.g. small, medium, large)
  - Numeric (e.g. Years of Education, probability of credit default, etc.)

- Predicting a nominal output: classification
  - Thus, predicting whether a document is about politics or sports is an instance of **Text Classification**

- Predicting a numeric output: regression (typically continuous)
Which classifier is best?

Learn function from $\mathbf{x} = (x_1, \ldots, x_d)$ to $f(\mathbf{x}) \in \{0, 1\}$ given labeled examples $(\mathbf{x}, f(\mathbf{x}))$
Which classifier is best?

Answer: you don’t know

Solutions:

1) try many and compare
2) Use domain knowledge
What does it mean for an ML algorithm to perform well?

• Metrics
  – Lots of possibilities
  – Classification: **accuracy**, precision, recall, cost, etc.
    • Accuracy = fraction of examples $x$ where algorithm’s predicted $f(x)$ matches true classification
  – Regression: mean squared error, etc.
What does it mean for an ML algorithm to perform well?

Learn function from \( x = (x_1, ..., x_d) \) to \( f(x) \in \{0, 1\} \) given labeled examples \((x, f(x))\)
What does it mean for an ML algorithm to perform well?

- We want to know how our algorithm will perform on new inputs
  - So, test on a set of examples from disjoint from training (e.g. 80% train, 20% test)
How to do Machine Learning

1) Pick a feature representation for your task
2) Compile data
3) Choose a machine learning algorithm
4) Train the algorithm
5) Evaluate the results

6) *Probably: go to (1)*
How to do Machine Learning

1) Pick a feature representation for your task
2) Compile data
3) Choose a machine learning algorithm
4) Train the algorithm
5) Evaluate the results

6) Probably: go to (1)
Feature Engineering

- The art of machine learning
  - Features should be predictive and (relatively) independent

- How likely is person x to default on a loan?
  - FICO score
  - Income
  - Education Level
  - Assets
  - Social Security Number
  - ...

“Lightly-supervised” ML