Machine Learning (in 20 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 \( x \)?

• Is document \( x \) about “baseball”? 
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 $x = (x_1, ..., x_d)$ to $f(x) \in \{0, 1\}$ given labeled examples $(x, f(x))$
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 $\mathbf{x} = (x_1, ..., x_d)$ 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 \( \mathbf{x} = (x_1, ..., x_d) \) to \( f(\mathbf{x}) \in \{0, 1\} \) given labeled examples \((\mathbf{x}, f(\mathbf{x}))\)
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)*
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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
  – ...

“Bag of words”