CSE 411: Machine Learning

Introduction

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Outline

“ Wisdom is not a product of schooling but of the lifelong attempt to acquire it.

– Albert Einstein *”*

Big Data

- Widespread use of personal computers and wireless communication leads to "big data"
- We are both producers and consumers of data
- Data is not random, it has structure, e.g., customer behavior
- We need "big theory" to extract that structure from data for
  1. Understanding the process
  2. Making predictions for the future

Why "Learn"?

- Machine learning is programming computers to optimize a performance criterion using example data or past experience.
- There is no need to "learn" to calculate payroll
- Learning is used when:
  - Human expertise does not exist (navigating on Mars),
  - Humans are unable to explain their expertise (speech recognition)
  - Solution changes in time (routing on a computer network)
  - Solution needs to be adapted to particular cases (user biometrics)

What We Talk About When We Talk About "Learning"

- Learning general models from a data of particular examples
- Data is cheap and abundant (data warehouses, data marts); knowledge is expensive and scarce.
- Example in retail: Customer transactions to consumer behavior:
  - People who bought "Blink" also bought "Outliers" (www.amazon.com)
- Build a model that is a good and useful approximation to the data.

Data Mining

- **Retail**: Market basket analysis, Customer relationship management (CRM)
- **Finance**: Credit scoring, fraud detection
- **Manufacturing**: Control, robotics, troubleshooting
- **Medicine**: Medical diagnosis
- **Telecommunications**: Spam filters, intrusion detection
- **Bioinformatics**: Motifs, alignment
- **Web mining**: Search engines
- ...

Machine Learning

What is Machine Learning?

- Optimize a performance criterion using example data or past experience.
- Role of Statistics: Inference from a sample
- Role of Computer science: Efficient algorithms to:
  - Solve the optimization problem
  - Representing and evaluating the model for inference

Applications

- Association
- Supervised Learning
  - Classification
  - Regression
- Unsupervised Learning
- Reinforcement Learning

Learning Associations

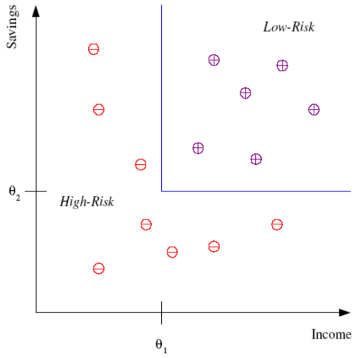
- Basket analysis: $P(Y|X)$ probability that somebody who buys X also buys Y where X and Y are products/services.
  - Example: $P(chips|beer) = 0.7$

Supervised Learning

Supervised Learning: Classification

Example: Credit scoring

- Differentiating between low-risk and high-risk customers from their income and savings



Discriminant: IF income $> \theta_1$ AND savings $> \theta_2$ THEN low-risk ELSE high-risk

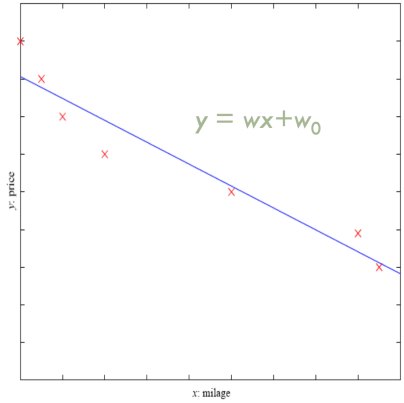
Classification: Applications

- AKA Pattern recognition
- **Face recognition**: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- **Character recognition**: Different handwriting styles.
- **Speech recognition**: Temporal dependency.
- **Medical diagnosis**: From symptoms to illnesses
- **Biometrics**: Recognition/authentication using physical and/or behavioral characteristics: Face, iris, signature, etc
- **Outlier/novelty detection**:

Supervised Learning: Regression

Example: Price of a used car

- x : car attributes
- y : price
- $y = g(x|q)$
  - $g()$ model
  - q parameters



Supervised Learning: Uses

- **Prediction of future cases**: Use the rule to predict the output for future inputs
- **Knowledge extraction**: The rule is easy to understand
- **Compression**: The rule is simpler than the data it explains
- **Outlier detection**: Exceptions that are not covered by the rule, e.g., fraud

Unsupervised Learning

Unsupervised Learning

- Learning "what normally happens"
- No output
- Clustering: Grouping similar instances
- Example applications
  - Customer segmentation in CRM
  - Image compression: Color quantization
  - Bioinformatics: Learning motifs

Reinforcement Learning

Reinforcement Learning

- Learning a policy: A sequence of outputs
- No supervised output but delayed reward
- Credit assignment problem
- Game playing
- Robot in a maze
- Multiple agents, partial observability, ...

Thank You!