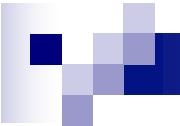


Introduction

Rui Kuang

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University of Minnesota

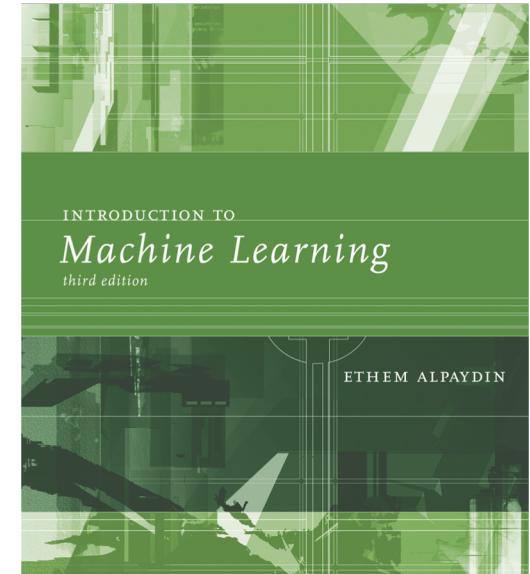


Teaching Staff

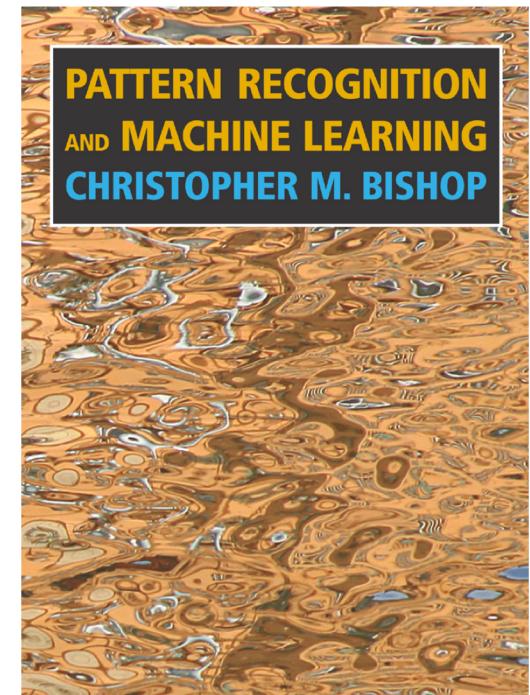
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Textbooks

- Primary: *Introduction to Machine Learning (Third Edition)*, Ethem Alpaydin, MIT Press, ISBN: 9780262028189

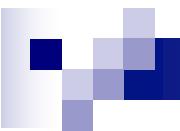


- Reference: *Pattern Recognition and Machine Learning*, Christopher Bishop, Springer, ISBN: 978-0-387-31073-2



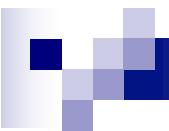
What is Machine Learning?

- Machine Learning: Design and development of algorithms for **training computers** with **example data** or **past experience** based on a **performance criteria**.
- Key concepts:
 - Example Data: Observed instances possibly with known outcome
 - Training/Learning: Process of generalization from the example data as probability distributions, rules, discriminative functions...
 - Performance criteria: Optimization of an objective function that evaluates the performance of solving a machine learning task



What is Machine Learning?

- Machine learning is data-driven artificial intelligence
- Machine learning is interdisciplinary
 - Role of statistics: Inference from a sample
 - Role of computer science: Efficient algorithms to
 - solve the optimization problem
 - represent and evaluate the model for inference
 - Share a lot of fundamental models and theories; MLers rediscovered some of them and invented new names?
 - ML is a new field with its own unique development with the revived and fast evolving AI.

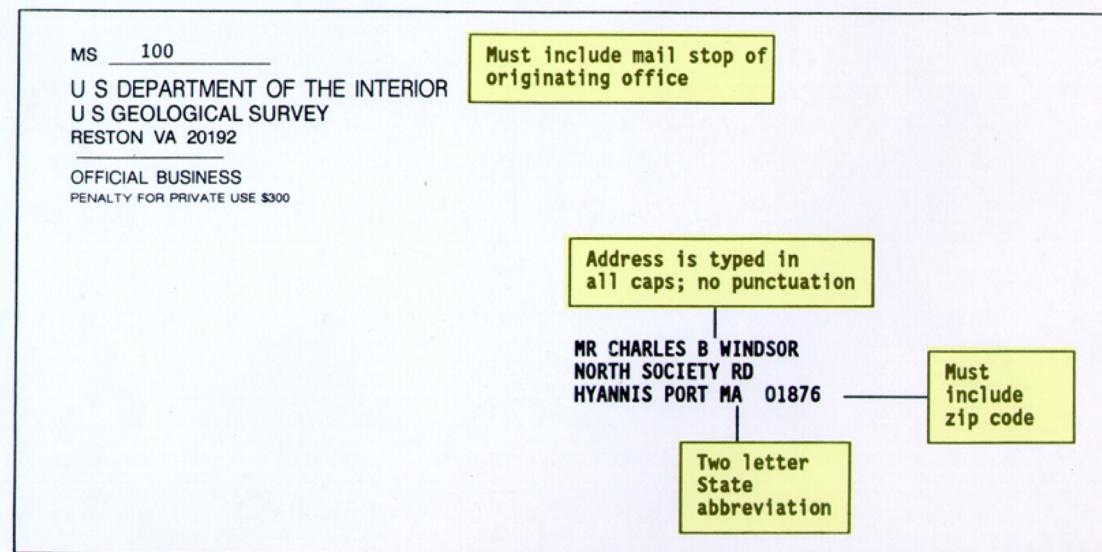


Why Machine Learning

- “Smart computers” can recognize complex patterns and make intelligent decisions based on data.
- Automatically process and analyze large volume of data such as face images, hand-writings, webpages.
- Machine learning/Artificial Intelligence solves difficult problems that human cannot solve.

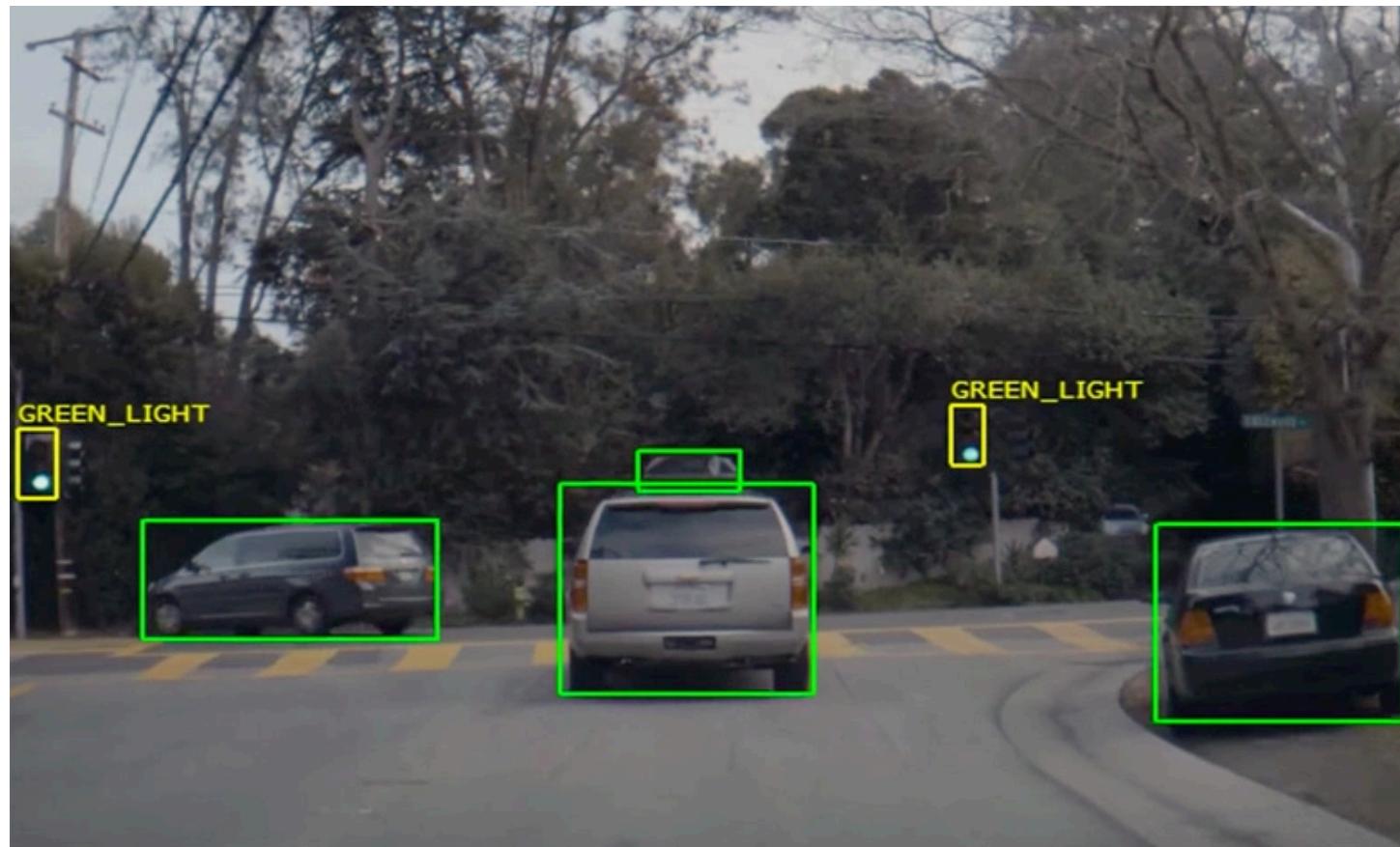
Machine Learning Example

- Handwriting recognition such as ZIP code reading

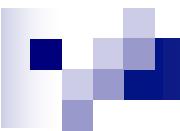


Machine Learning Example

- Object detection in “self-driving” cars



<https://bgr.com/2017/01/05/nvidia-autonomous-car-demo-video-bb8/>

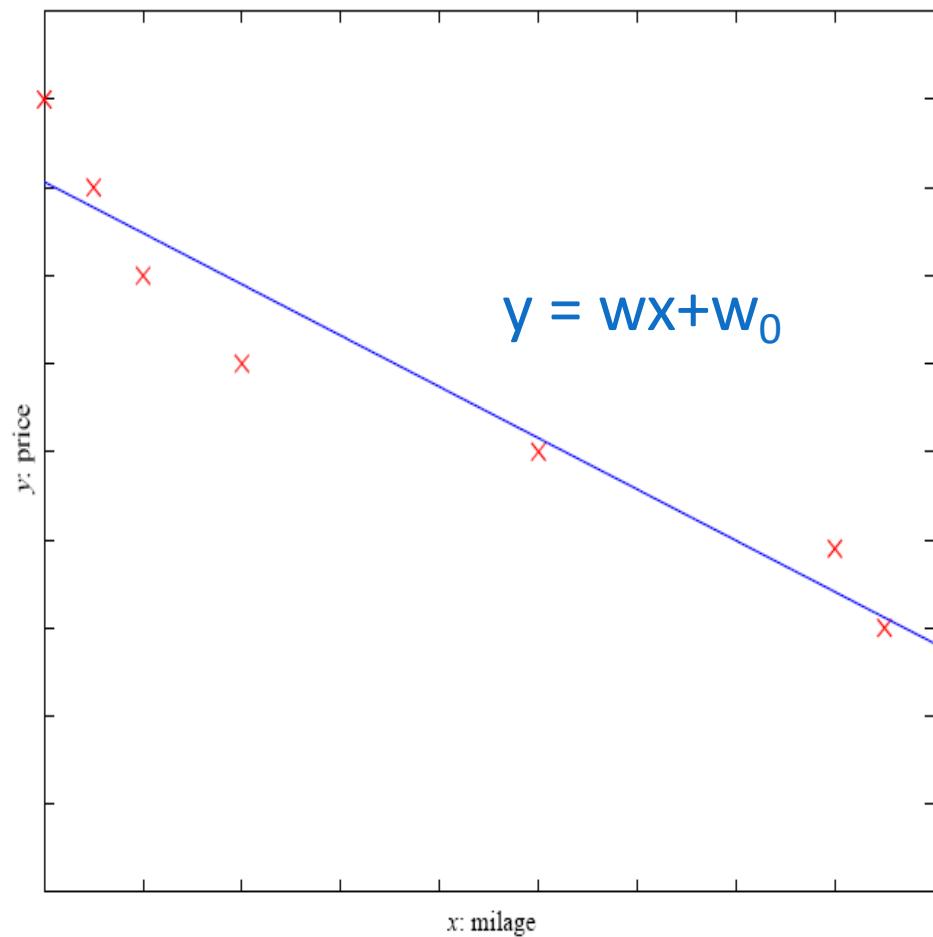


What We Talk About When We Talk About “Learning”

- Learning general models from a data of particular examples
- Data are cheap and abundant in the big data era; knowledge is expensive and scarce.
- Build a model that is a *good and useful approximation* to the data.

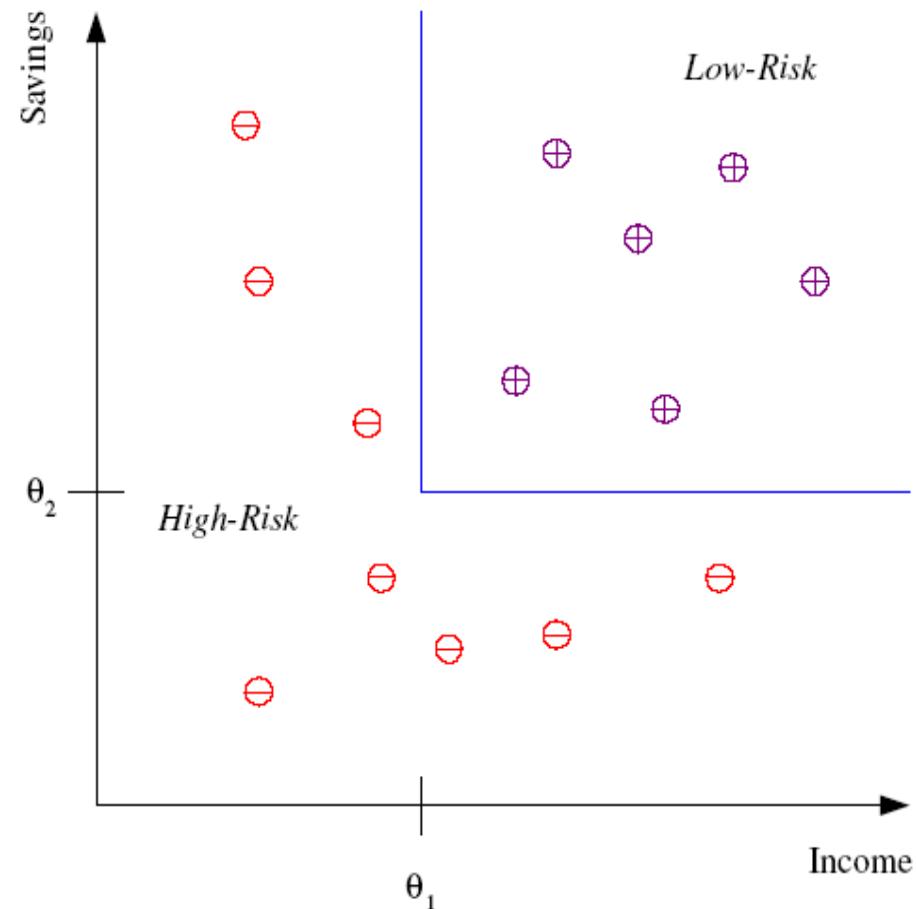
Regression

- Example: Price of a used car
- x : car attributes
- y : price
- $y = g(x | \theta)$
- $g(\cdot)$ model,
- θ parameters

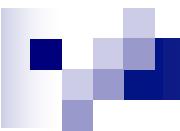


Classification

- Example: Credit scoring
- Differentiating between **low-risk** and **high-risk** customers from their *income* and *savings*



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



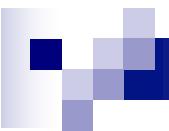
Classification: Applications

- 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
- ...



Supervised Learning

- 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

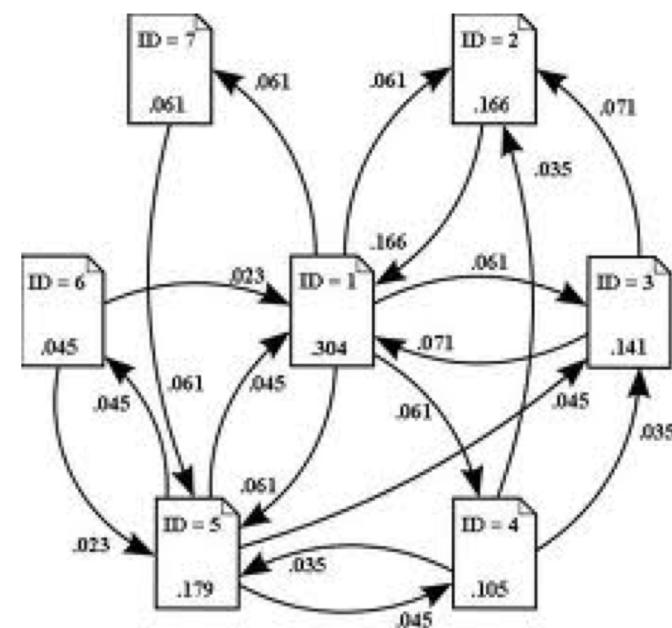


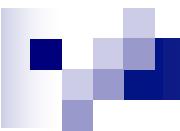
Unsupervised Learning

- Learning “what normally happens”
- No output
- Clustering: Grouping similar instances
- Example applications
 - Customer segmentation in CRM (Consumer relation management)
 - Image compression: Color quantization
 - Bioinformatics: Learning motifs

Other Examples

■ Link analysis





Prerequisites

■ Python programming

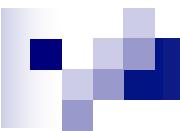
- PyCharm: <https://www.jetbrains.com/pycharm/>
- <https://docs.python.org/3.6/tutorial/>

■ Statistics and probabilities

- Appendix A in Alpaydin book; Chpt 2 in Bishop book.

■ Linear algebra/Matrix calculus/multi-variable calculus

- <https://www.math.uwaterloo.ca/~hwolkowi/mathrixcookbook.pdf>



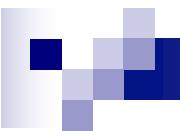
Grading Scheme

■ Homework assignments (50%):

- Five hands-on homework assignments and homework 0 (required by no grade)
- Programming and data analysis with matlab
- Written questions

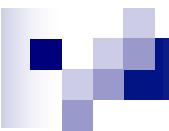
■ Midterm exam (25%) and final exam (25%)

- In-class, closed-book, 1-hour exam
- No alternative time allowed for time-conflict



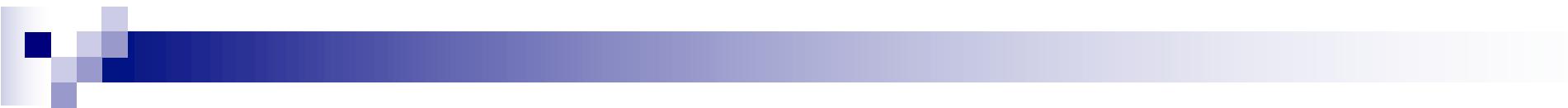
Late Submission Policy

- Submission of the homework can be late in at most 2 out of the 6 assignments.
- No homework will be accepted after 3 days past the due date



Course Objectives

- You are expected to
 - learn fundamental concepts and theories in machine learning.
 - acquire hands-on experiences with implementation of machine learning algorithms.
 - To understand how to derive the mathematical formulation of the fundamental machine learning models
 - learn how to formulate and solve application questions with appropriate machine learning methods.



Course Content

- Supervised learning
 - Regression
 - Classification
- Clustering
- Dimension reduction
- Bayesian methods
- Parametric methods
- Non-parametric methods
- Linear models
- Perceptrons
- Kernel machines
- Graphical models (if time allows)