

Lecture Slides for

INTRODUCTION TO

Machine Learning

ETHEM ALPAYDIN

© The MIT Press, 2004

alpaydin@boun.edu.tr

<http://www.cmpe.boun.edu.tr/~ethem/i2ml>



CHAPTER 1:

Introduction



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 “Da Vinci Code” also bought “The Five People You Meet in Heaven” (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:** Optimization, troubleshooting
- **Medicine:** Medical diagnosis
- **Telecommunications:** Quality of service optimization
- **Bioinformatics:** Motifs, alignment
- **Web mining:** Search engines
- ...



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

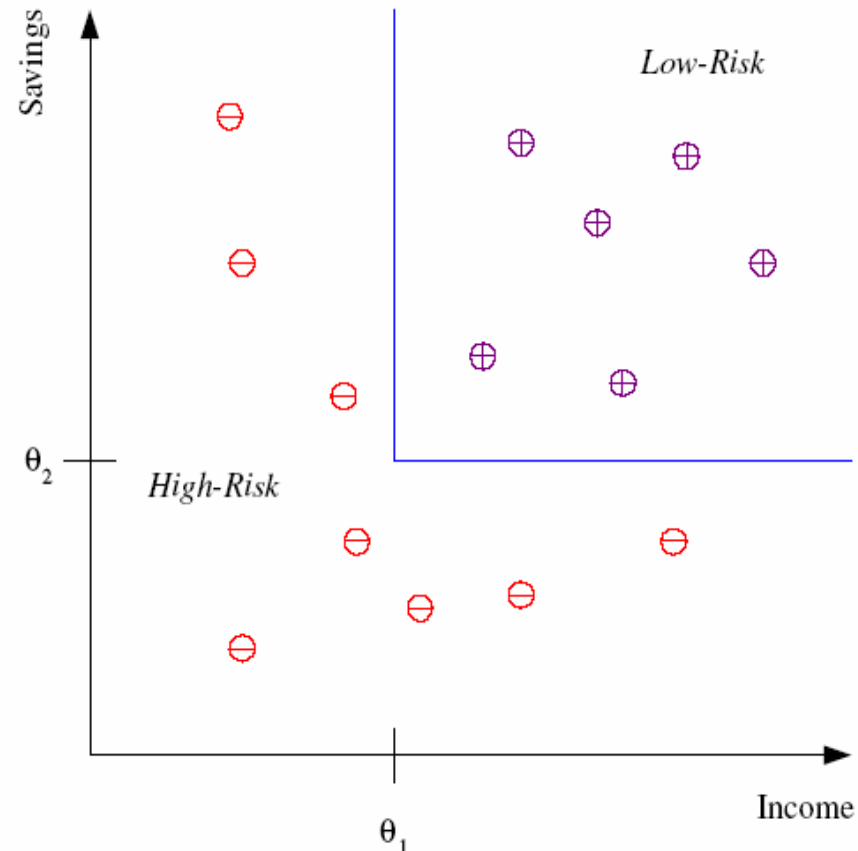
- Basket analysis:

$P(Y | X)$ probability that somebody who buys X also buys Y where X and Y are products/services.

Example: $P(\text{chips} | \text{beer}) = 0.7$

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.
 - Use of a dictionary or the syntax of the language.
 - Sensor fusion: Combine multiple modalities; eg, visual (lip image) and acoustic for speech
- **Medical diagnosis:** From symptoms to illnesses
- ...



Face Recognition

Training examples of a person



Test images



AT&T Laboratories, Cambridge UK
<http://www.uk.research.att.com/facedatabase.html>

Regression

- Example: Price of a used car

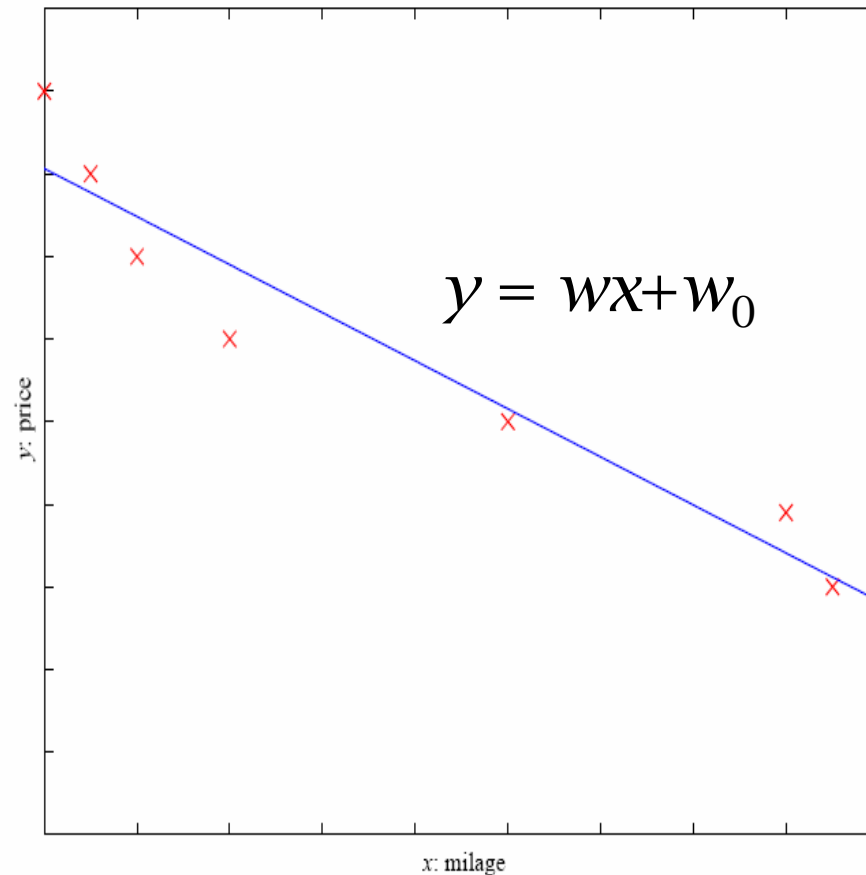
- x : car attributes

y : price

$$y = g(x | \theta)$$

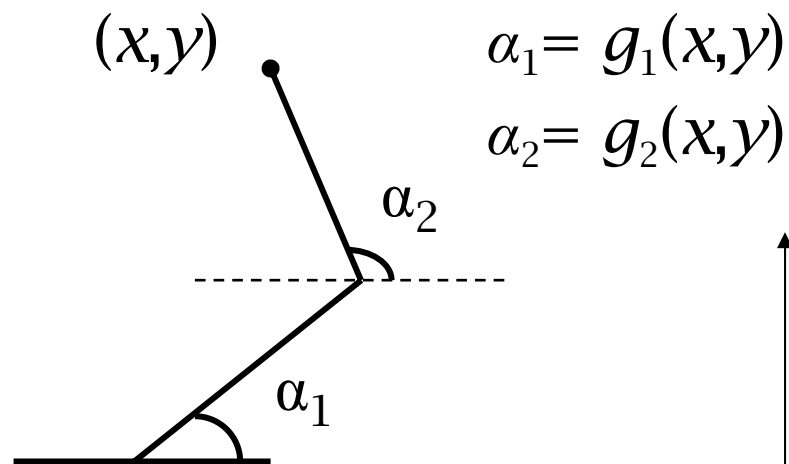
$g(\cdot)$ model,

θ parameters

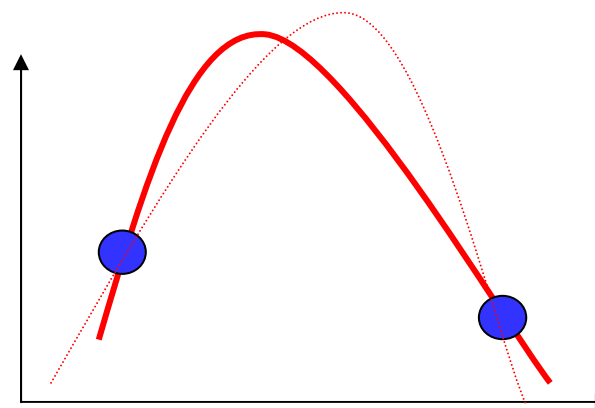


Regression Applications

- Navigating a car: Angle of the steering wheel (CMU NavLab)
- Kinematics of a robot arm



- Response surface design





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

- 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

- 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, ...



Resources: Datasets

- UCI Repository:
<http://www.ics.uci.edu/~mlearn/MLRepository.html>
- UCI KDD Archive:
<http://kdd.ics.uci.edu/summary.data.application.html>
- Statlib: <http://lib.stat.cmu.edu/>
- Delve: <http://www.cs.utoronto.ca/~delve/>



Resources: Journals

- Journal of Machine Learning Research www.jmlr.org
- Machine Learning
- Neural Computation
- Neural Networks
- IEEE Transactions on Neural Networks
- IEEE Transactions on Pattern Analysis and Machine Intelligence
- Annals of Statistics
- Journal of the American Statistical Association
- ...



Resources: Conferences

- International Conference on Machine Learning (ICML)
 - ICML05: <http://icml.ais.fraunhofer.de/>
- European Conference on Machine Learning (ECML)
 - ECML05: <http://ecmlpkdd05.liacc.up.pt/>
- Neural Information Processing Systems (NIPS)
 - NIPS05: <http://nips.cc/>
- Uncertainty in Artificial Intelligence (UAI)
 - UAI05: <http://www.cs.toronto.edu/uai2005/>
- Computational Learning Theory (COLT)
 - COLT05: <http://learningtheory.org/colt2005/>
- International Joint Conference on Artificial Intelligence (IJCAI)
 - IJCAI05: <http://ijcai05.csd.abdn.ac.uk/>
- International Conference on Neural Networks (Europe)
 - ICANN05: <http://www.ibspan.waw.pl/ICANN-2005/>
- ...