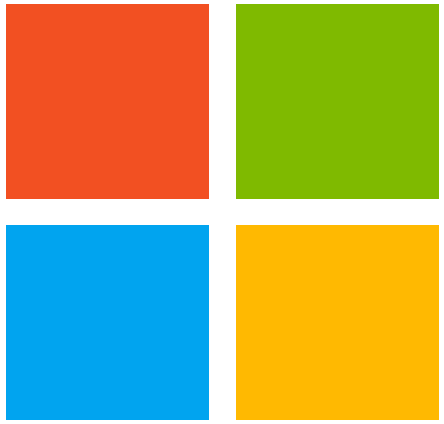
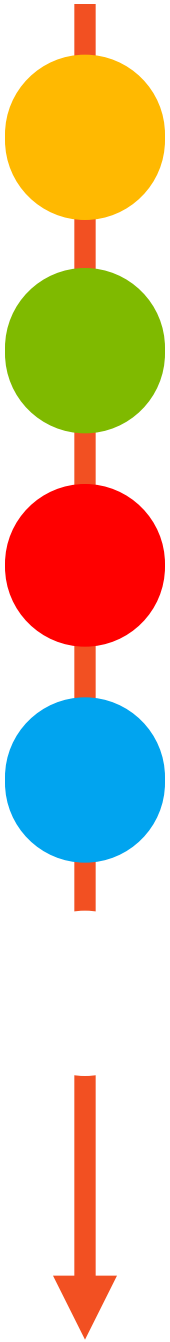


2018 TJMSC Tech. Courses

Introduction to Machine Learning

Dinghow Yang
Tongji Microsoft Student Club

Oct 28, 2018
Room 516, Ji Shi Building
SSE, Tongji Univ



同济微软俱乐部
Tongji Microsoft Student Club

What is Machine Learning?

Supervised Learning

Unsupervised Learning

Reinforcement Learning

Learning Resources

Most materials are referenced from CS451, David Kauchak

What is Machine Learning?

同济微软俱乐部
Tongji Microsoft Student Club

Machine learning is a field of artificial intelligence that uses statistical techniques to give computer systems the ability to "learn" (e.g., progressively improve performance on a specific task) from data, without being explicitly programmed

What is Machine Learning?

Machine learning is programming computers to optimize a performance criterion using example data or past experience.

-- Ethem Alpaydin

The goal of machine learning is to develop methods that can automatically detect patterns in data, and then to use the uncovered patterns to predict future data or other outcomes of interest.

-- Kevin P. Murphy

The field of pattern recognition is concerned with the automatic discovery of regularities in data through the use of computer algorithms and with the use of these regularities to take actions.

-- Christopher M. Bishop

What is Machine Learning?

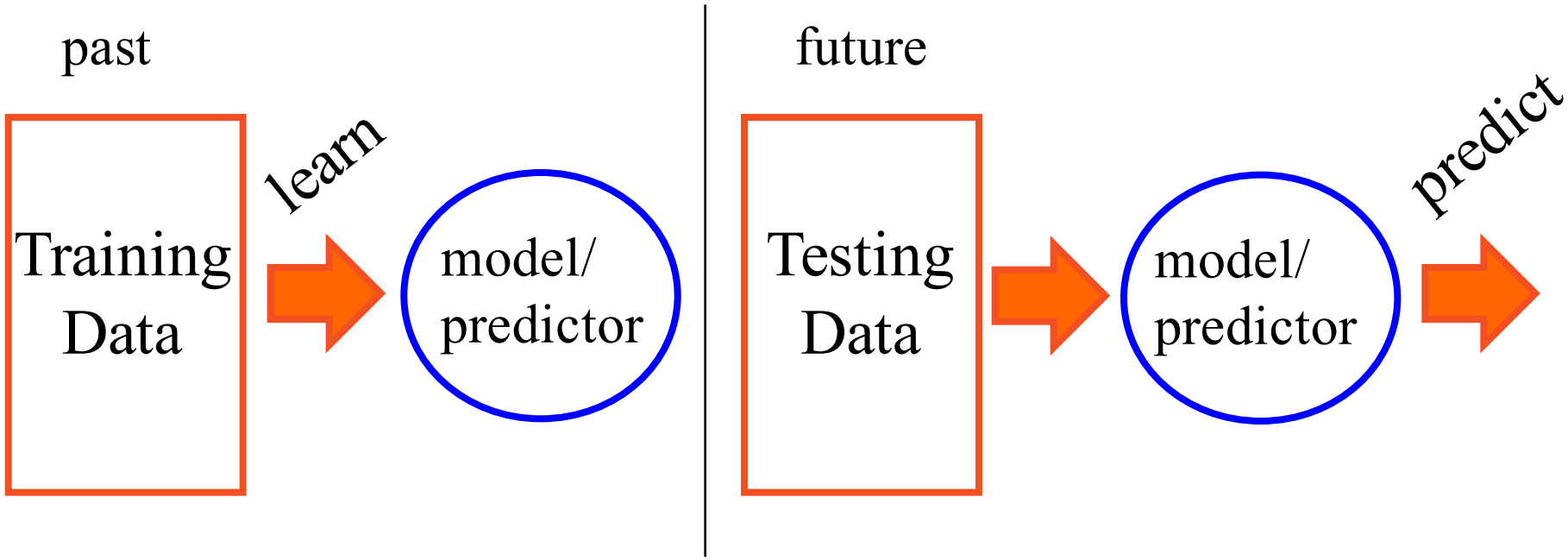
Machine learning is about predicting the future based on the past.

-- Hal Daume III

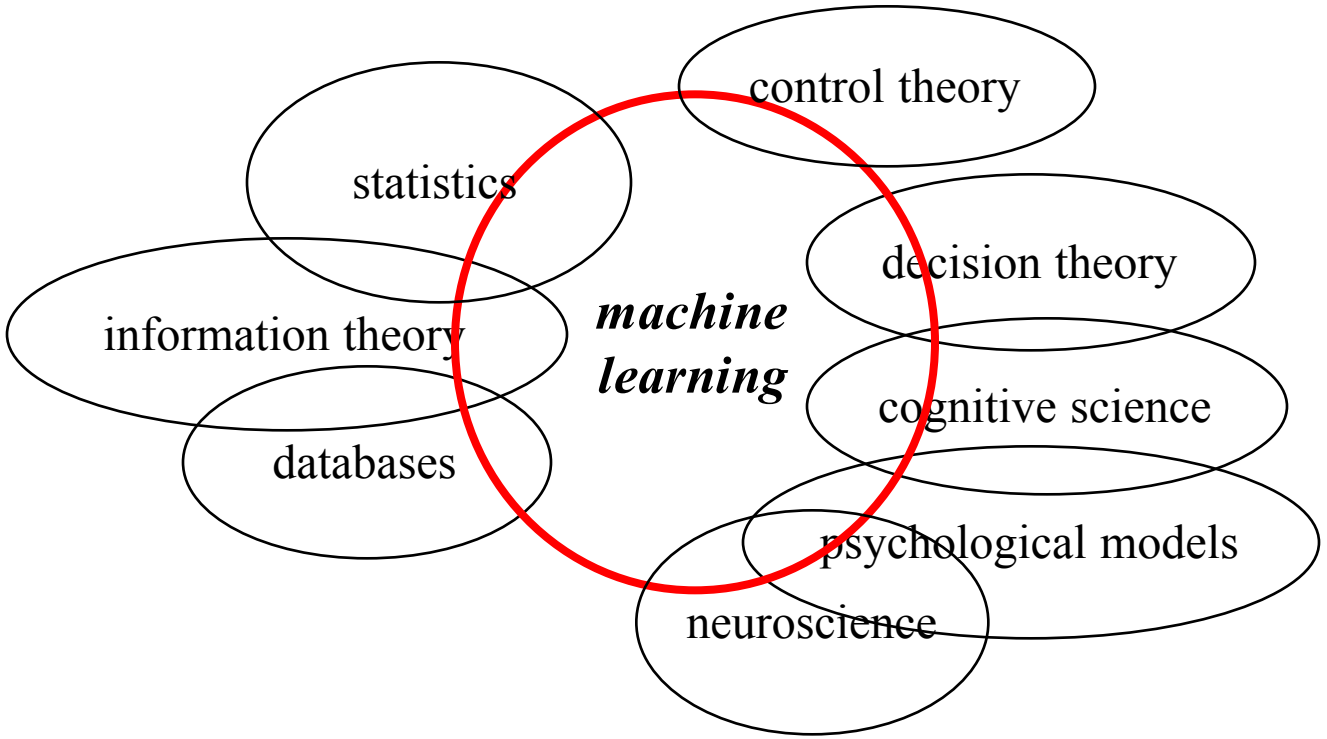
What is Machine Learning?

Machine learning is about predicting the future based on the past.

-- Hal Daume III



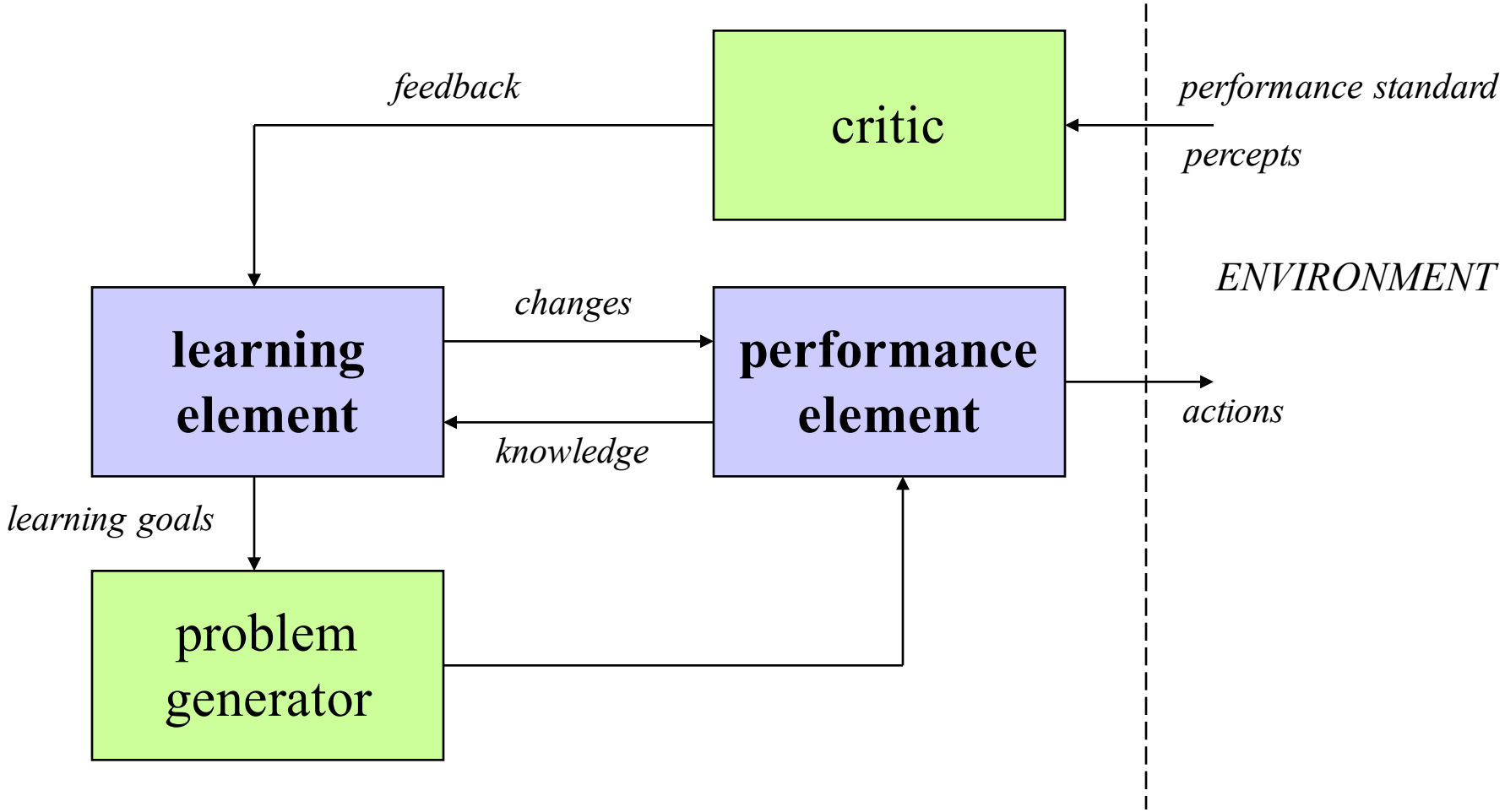
What is Machine Learning?



Machine Learning Related Fields

What is Machine Learning?

Architecture of a Learning System

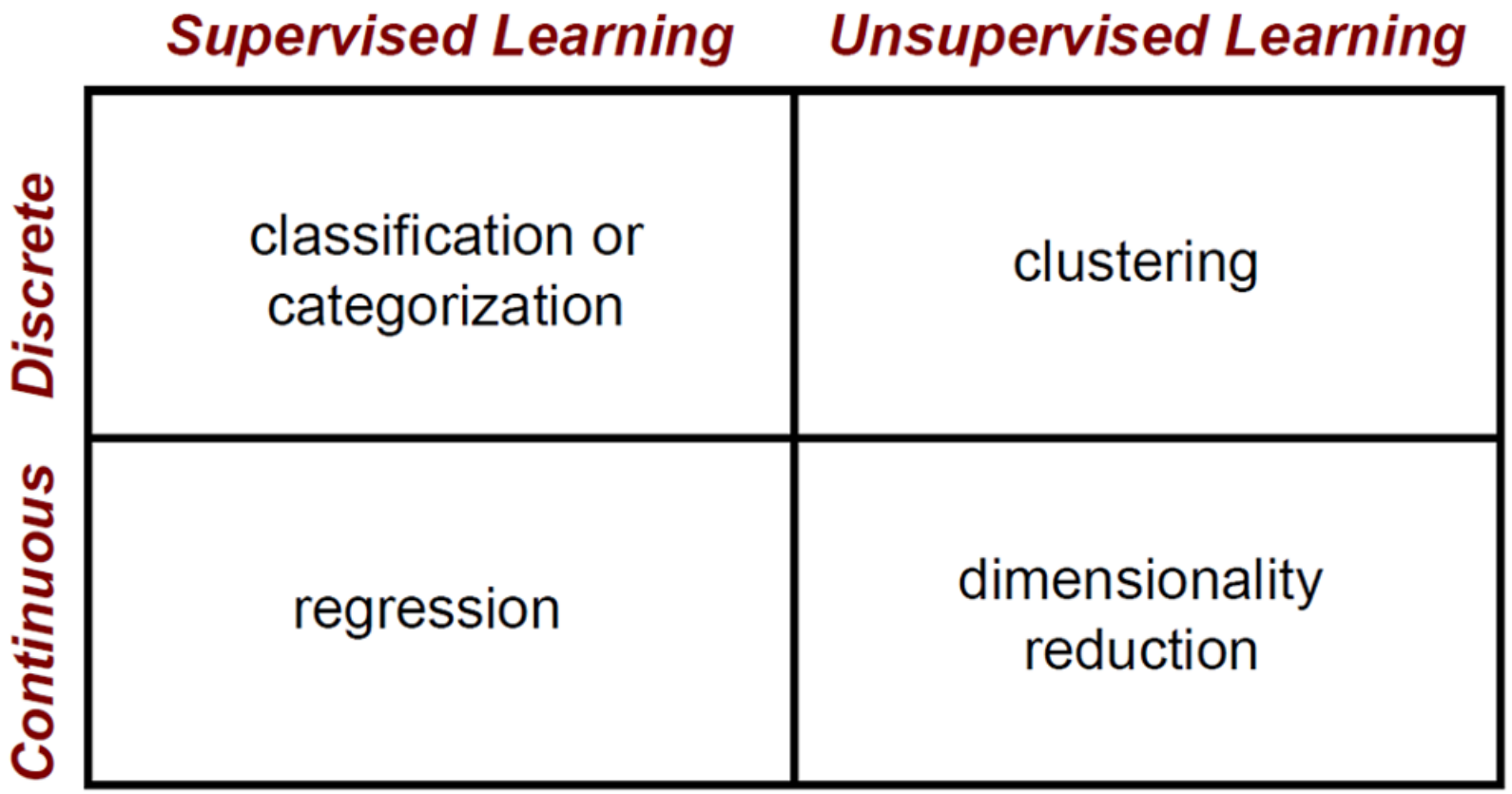


What is Machine Learning?

Dimensions of Learning Systems

- type of feedback
  - supervised (labeled examples)
  - unsupervised (unlabeled examples)
  - reinforcement (reward)
- representation
  - attribute-based (feature vector)
  - relational (first-order logic)
- use of knowledge
  - empirical (knowledge-free)
  - analytical (knowledge-guided)

What is Machine Learning?



Supervised Learning

Basic Problem: Induce a representation of a function (a systematic relationship between inputs and outputs) from examples.

- **target function** $f: X \rightarrow Y$
- **example** $(x, f(x))$
- **hypothesis** $g: X \rightarrow Y$ *such that* $g(x) = f(x)$

x = set of attribute values (***attribute-value representation***)
x = set of logical sentences (*first-order representation*)

Y = set of discrete labels (***classification***)
$Y = \Re$ (*regression*)

Supervised Learning

examples

label

$label_1$

$label_3$

$label_4$

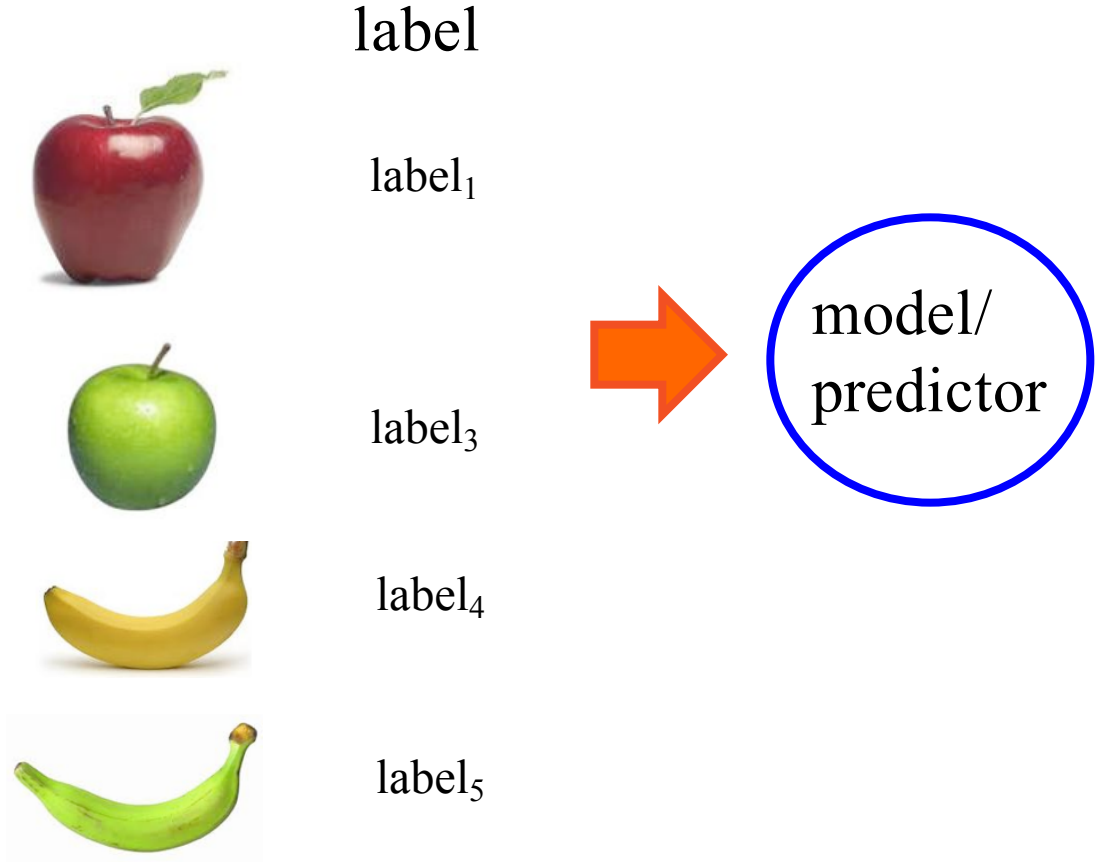
$label_5$

labeled examples

Supervised learning: given labeled examples

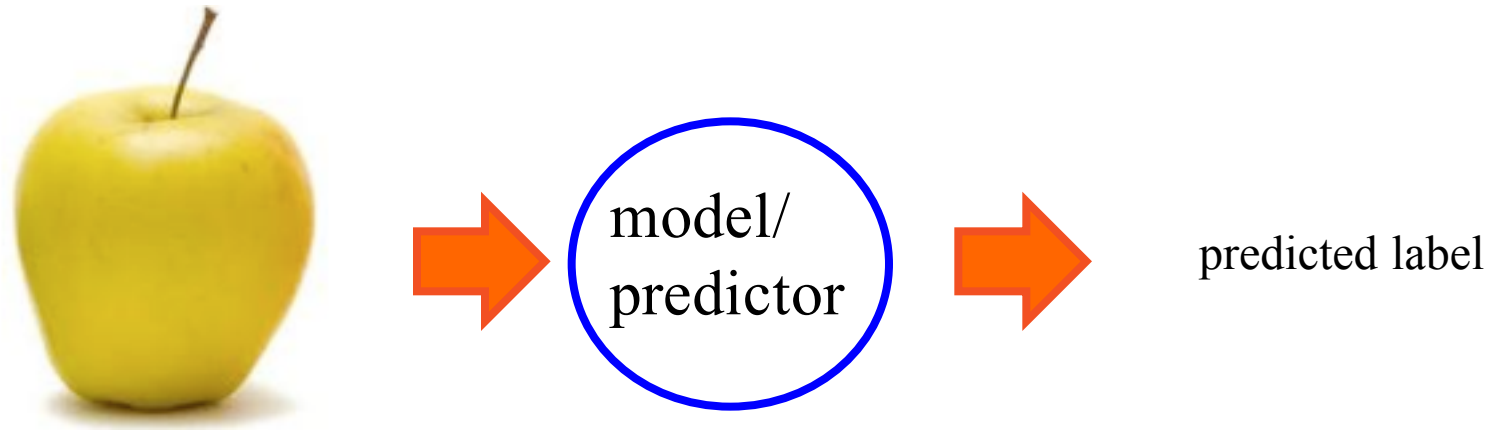
Supervised Learning

Supervised learning: given labeled examples



Supervised Learning

Supervised learning: learn to predict new example



Supervised Learning

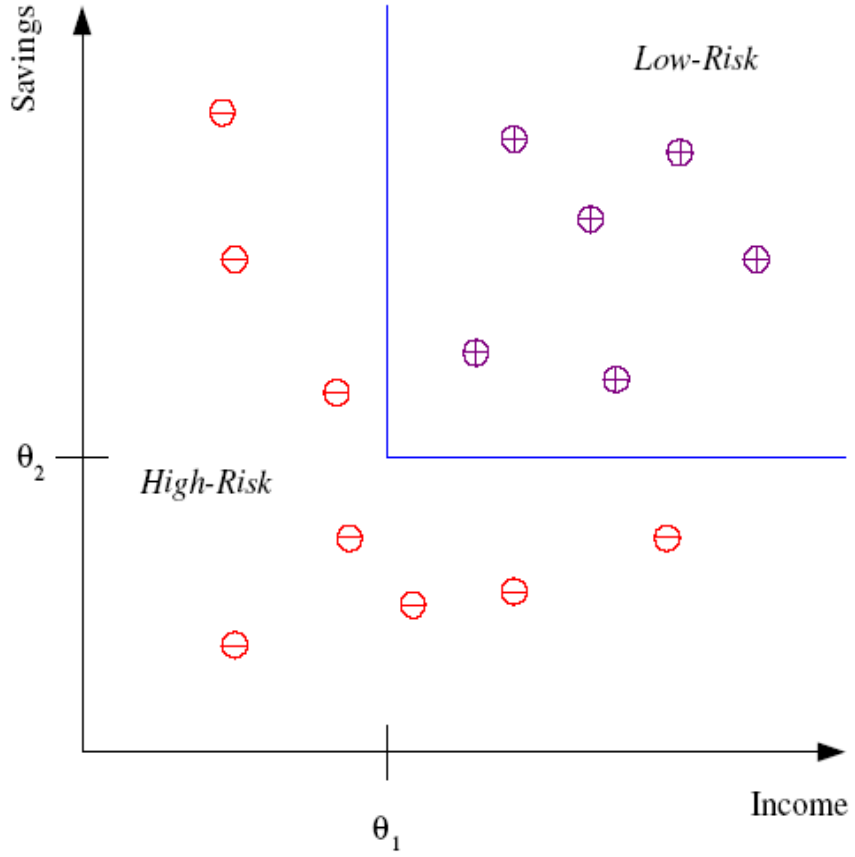
	label
	apple
	apple
	banana
	banana

Classification: a finite set of labels

Supervised Learning

Classification Example

Differentiate between low-risk and high-risk customers from their *income* and *savings*



Supervised Learning

Classification Applications

Face recognition

Character recognition

Spam detection

Medical diagnosis: From symptoms to illnesses

Biometrics: Recognition/authentication using physical and/or behavioral characteristics: Face, iris, signature, etc

…

Supervised Learning

	label
	-4.5
	10.1
	3.2
	4.3

Regression: label is real-valued

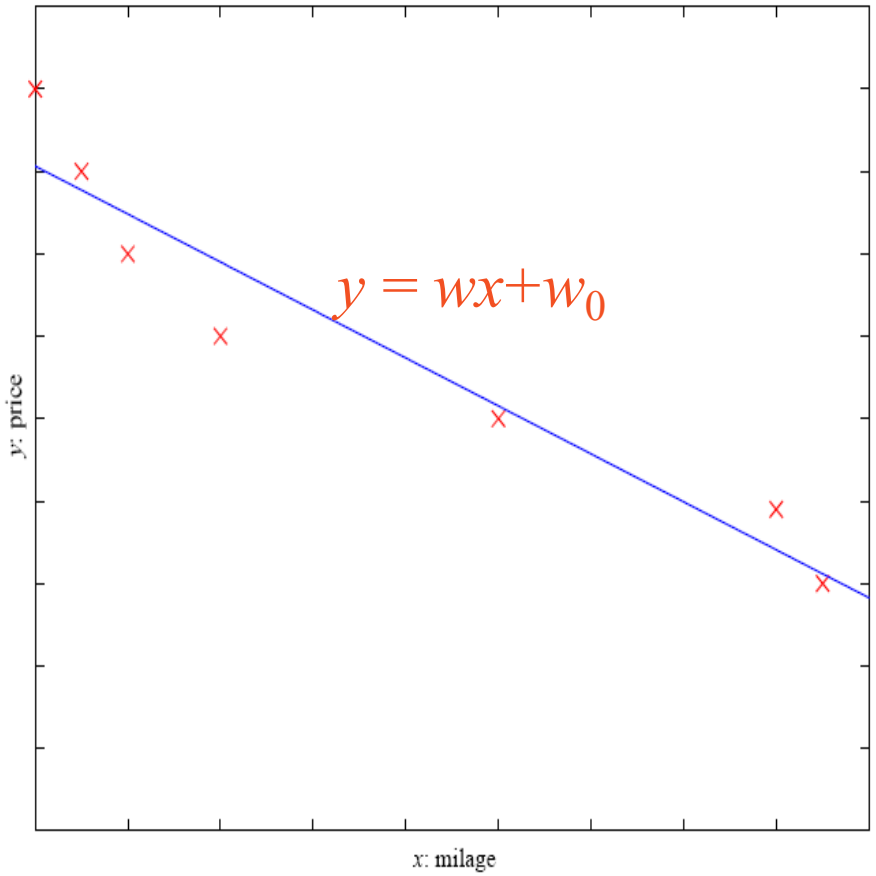
Supervised Learning

Regression Example

Price of a used car

x : car attributes
(e.g. mileage)

y : price



Supervised Learning

Regression Applications

Economics/Finance: predict the value of a stock

Epidemiology

Car/plane navigation: angle of the steering wheel, acceleration, …

Temporal trends: weather over time

…

Unsupervised Learning

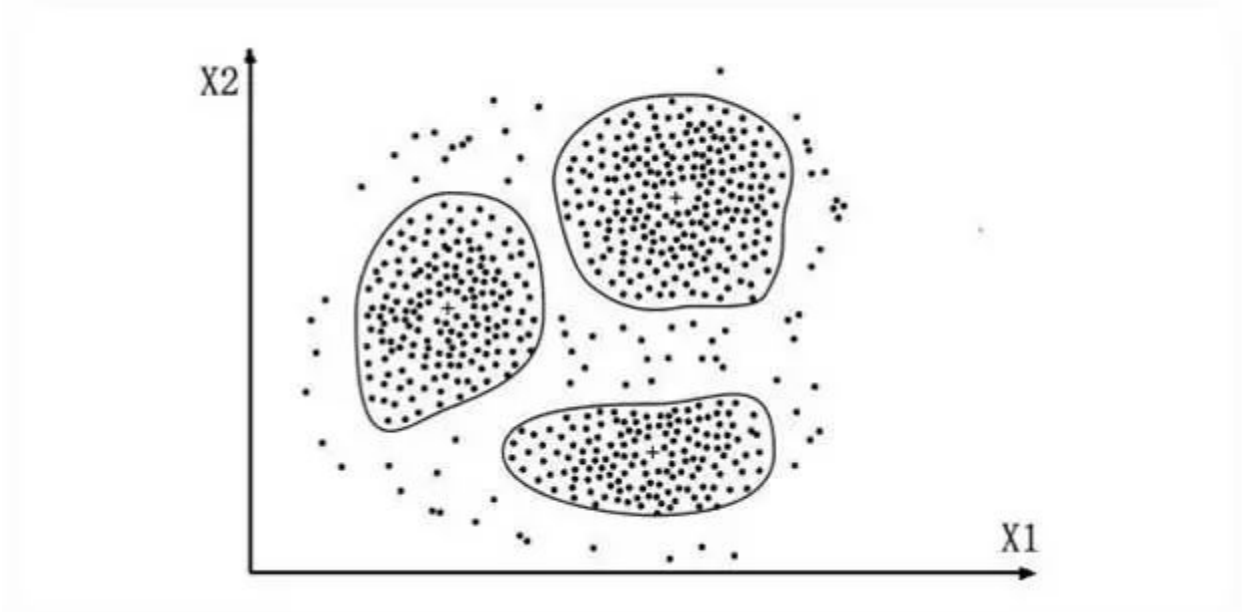
Unupervised learning: given data, i.e. examples, but **no labels**





Unsupervised Learning

Unupervised learning: given data, i.e. examples, but **no labels**
Cluster



Unsupervised Learning

Unsupervised learning applications

learn clusters/groups without any label

customer segmentation (i.e. grouping)

image compression

bioinformatics: learn motifs

…

Reinforcement Learning

left, right, straight, left, left, left, straight	**GOOD**
left, straight, straight, left, right, straight, straight	**BAD**

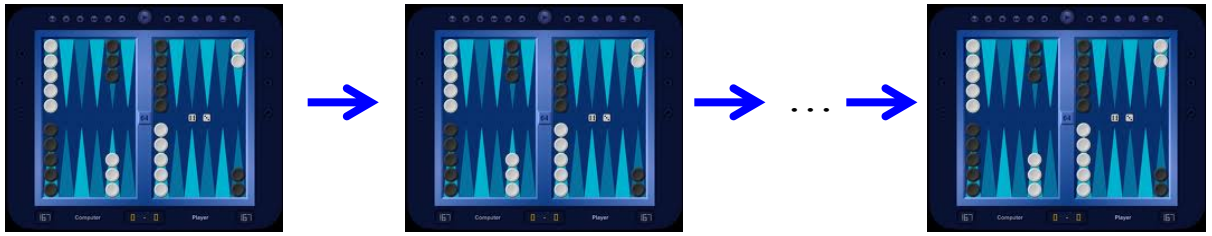
left, right, straight, left, left, left, straight	**18.5**
left, straight, straight, left, right, straight, straight	**-3**

Given a *sequence* of examples/states and a *reward* after completing that sequence, learn to predict the action to take in for an individual example/state

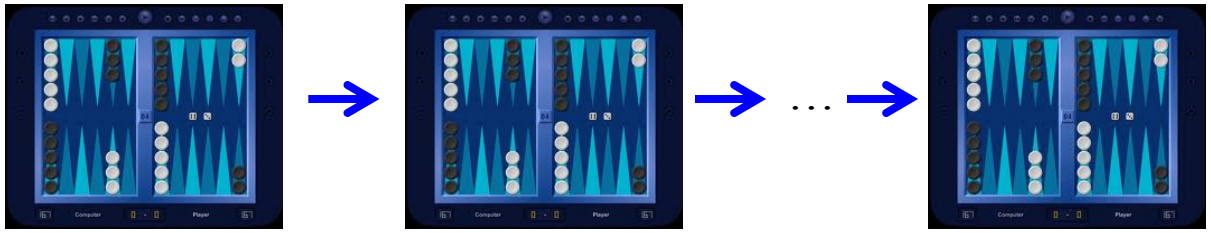
Reinforcement Learning

Example

Backgammon



WIN!



LOSE!

Given sequences of moves and whether or not the player won at the end, learn to make good moves

Other learning variations

同济微软俱乐部
Tongji Microsoft Student Club

What data is available:

- Supervised, unsupervised, reinforcement learning
- semi-supervised, active learning, …

How are we getting the data:

- online vs. offline learning

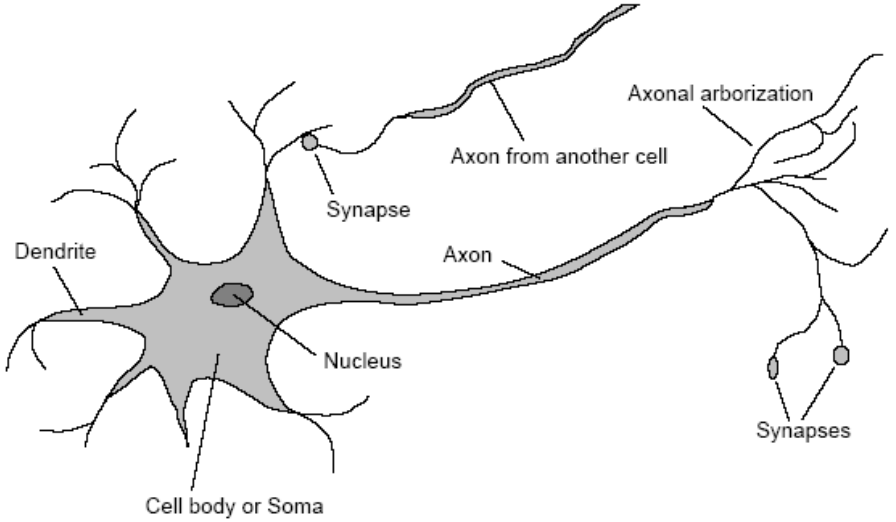
Type of model:

- generative vs. discriminative
- parametric vs. non-parametric

(Artificial) Neural Networks

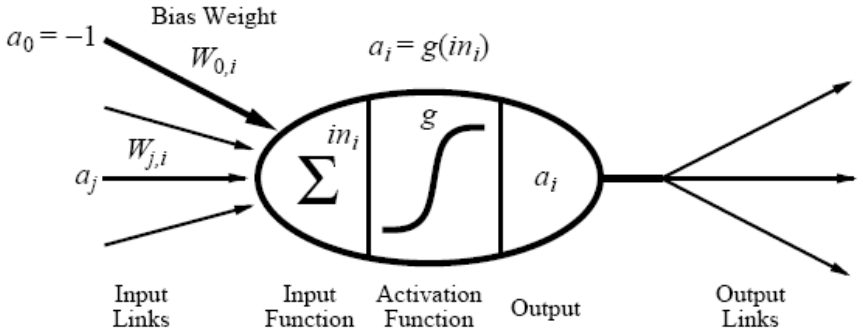
同济微软俱乐部
Tongji Microsoft Student Club

- Motivation: human brain
  - massively parallel (*10^{11} neurons, ~20 types*)
  - small computational units with simple low-bandwidth communication (*10^{14} synapses, 1-10ms cycle time*)

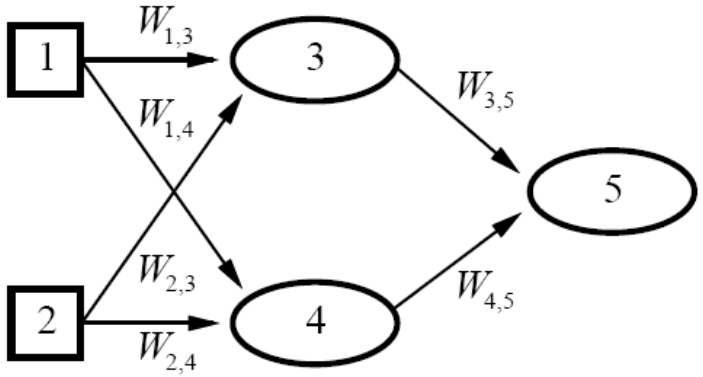


- Realization: neural network
  - *units* (≈ neurons) connected by *directed weighted links*
  - *activation function* from inputs to output

$$a_i \leftarrow g(in_i) = g\left(\Sigma_j W_{j,i} a_j\right)$$



(Artificial) Neural Networks



$$
\begin{aligned}
a_5 &= g(W_{3,5} \cdot a_3 + W_{4,5} \cdot a_4) \\
&= g(W_{3,5} \cdot g(W_{1,3} \cdot a_1 + W_{2,3} \cdot a_2) + W_{4,5} \cdot g(W_{1,4} \cdot a_1 + W_{2,4} \cdot a_2))
\end{aligned}
$$

- *neural network = parameterized family of nonlinear functions*
- *types*
  - *feed-forward* (acyclic): single-layer perceptrons, multi-layer networks
  - *recurrent* (cyclic): Hopfield networks, Boltzmann machines

[*connectionism, parallel distributed processing*]

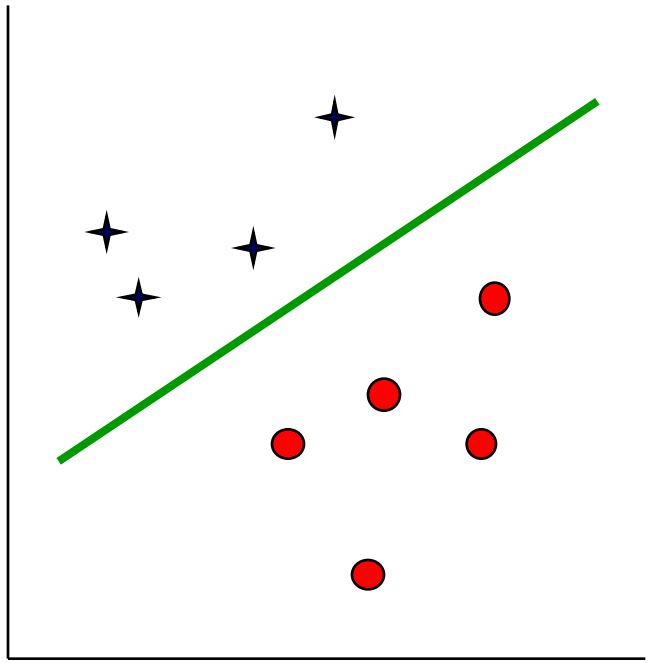
(Artificial) Neural Networks

Key Idea: Adjusting the weights changes the function represented by the neural network (*learning* = *optimization in weight space*).

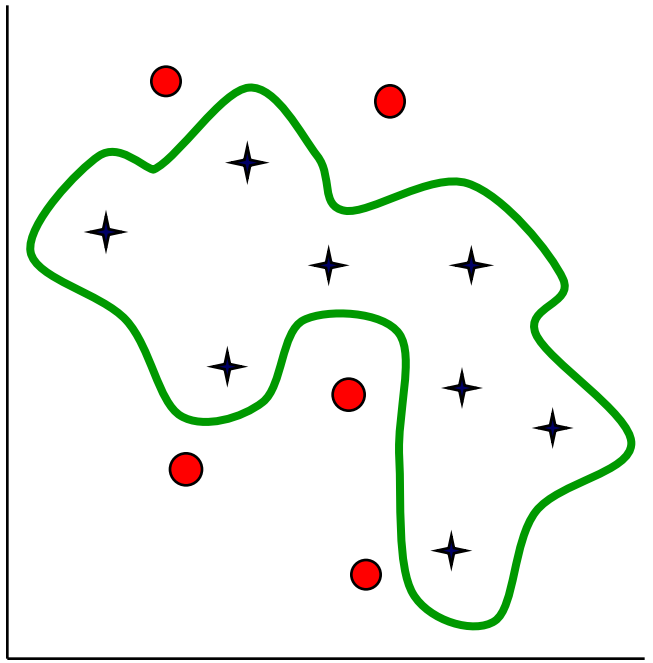
Iteratively *adjust weights* to reduce *error* (difference between network output and target output).

- Weight Update
  - *perceptron training rule*
  - *linear programming*
  - *delta rule*
  - *backpropagation*

(Artificial) Neural Networks



single-layer perceptron



multi-layer network

Learning Resources

同济微软俱乐部
Tongji Microsoft Student Club

Courses:

- **Stanford CS 229 Machine Learning, Andrew Ng**
- CMU 10-702 Statistical Machine Learning, Larry Wasserman
- CMU 10-715 Advanced Introduction to Machine Learning
- 国立台湾大学 林轩田：机器学习基石，机器学习技法
- Neural Networks for Machine Learning, Geoffery Hinton
- **Stanford CS231n, Convolutional Neural Networks for Visual Recognition,Feifei Li**

Learning Resources

同济微软俱乐部
Tongji Microsoft Student Club

Books:

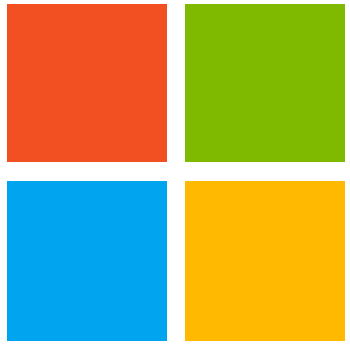
- The Elements of Statistical Learning(Second Edition)
- **周志华《机器学习》**
- **李航《统计学习方法》**
- Machine Learning:A Probabilistic Perspective(MLAPP)
- **Pattern Recognition And Machine Learning(PRML)**
- 机器学习实战

Learning Resources

同济微软俱乐部
Tongji Microsoft Student Club

Platforms & Tools:

- Python/Jupyter Notebook
- Tensorflow/Keras/Pytorch/Caffe/MXNet/**CNTK**
- Google Colaboratory
- Tensorflow playground
- **Azure ML Studio**
- Kaggle



Microsoft

同济微软俱乐部
Tongji Microsoft Student Club

微软学生俱乐部

扫一扫二维码，加入该群。

关注TJMSC微信公众号