



# 机器学习基本概念

Preliminaries of Machine Learning



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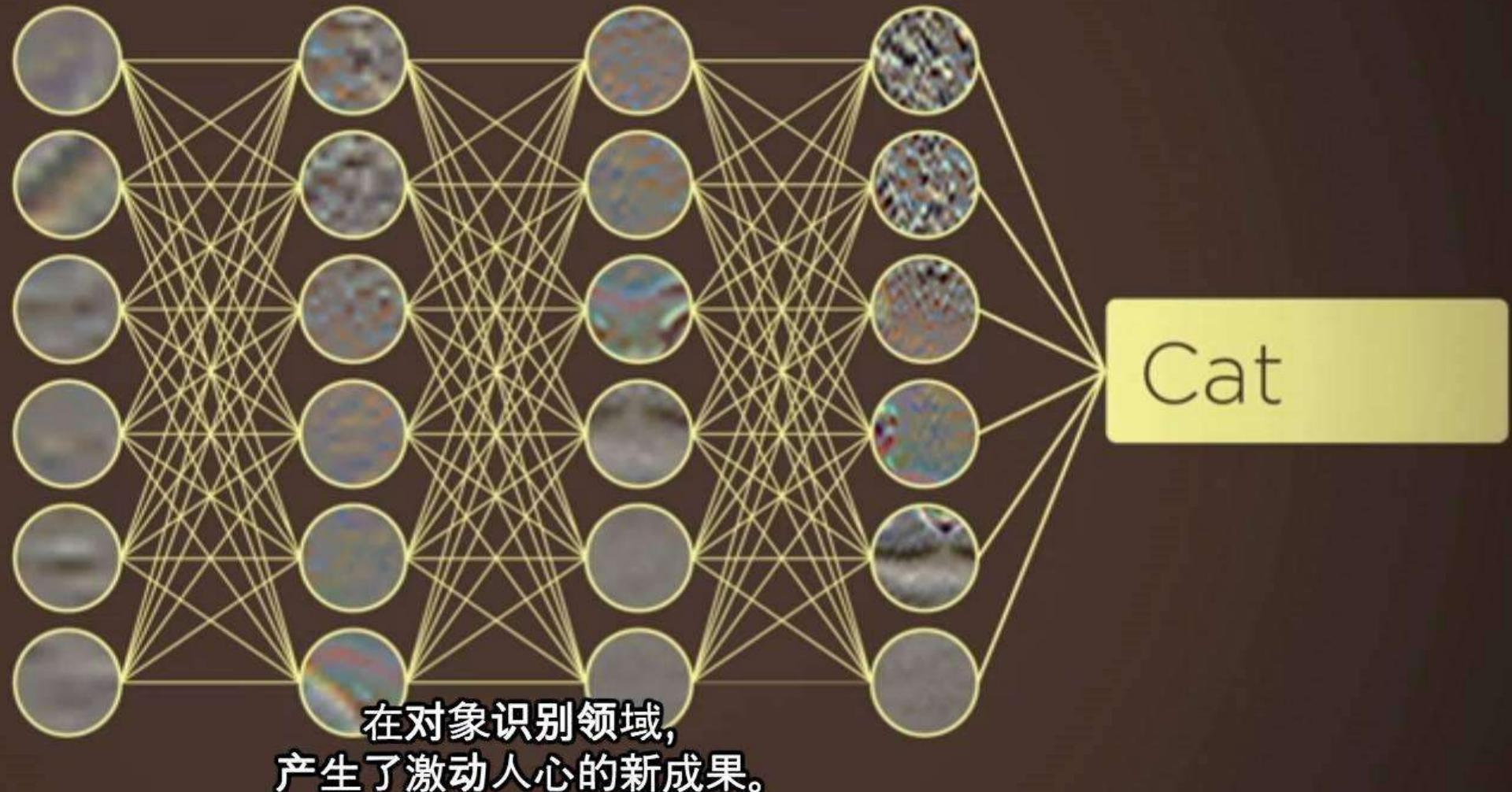
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机器学习定义

学习方法

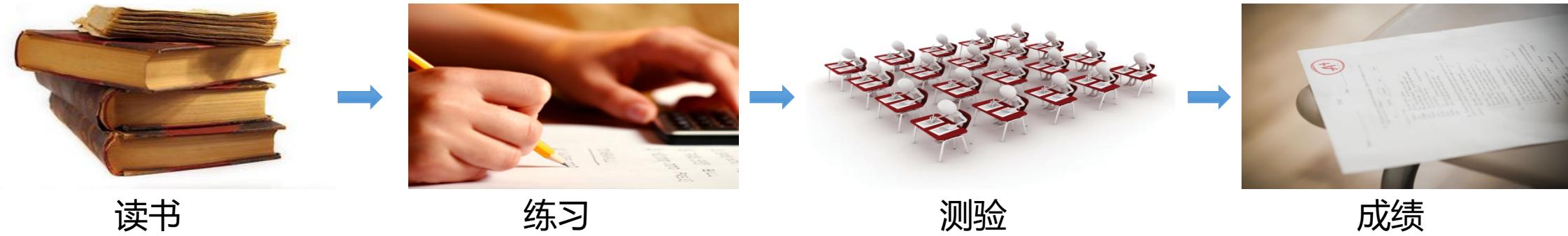
数学描述



在对象识别领域，  
产生了激动人心的新成果。

# 基本概念

- 机器学习 = 机器（计算机）+ 学习



- 如何判断是否属于学习

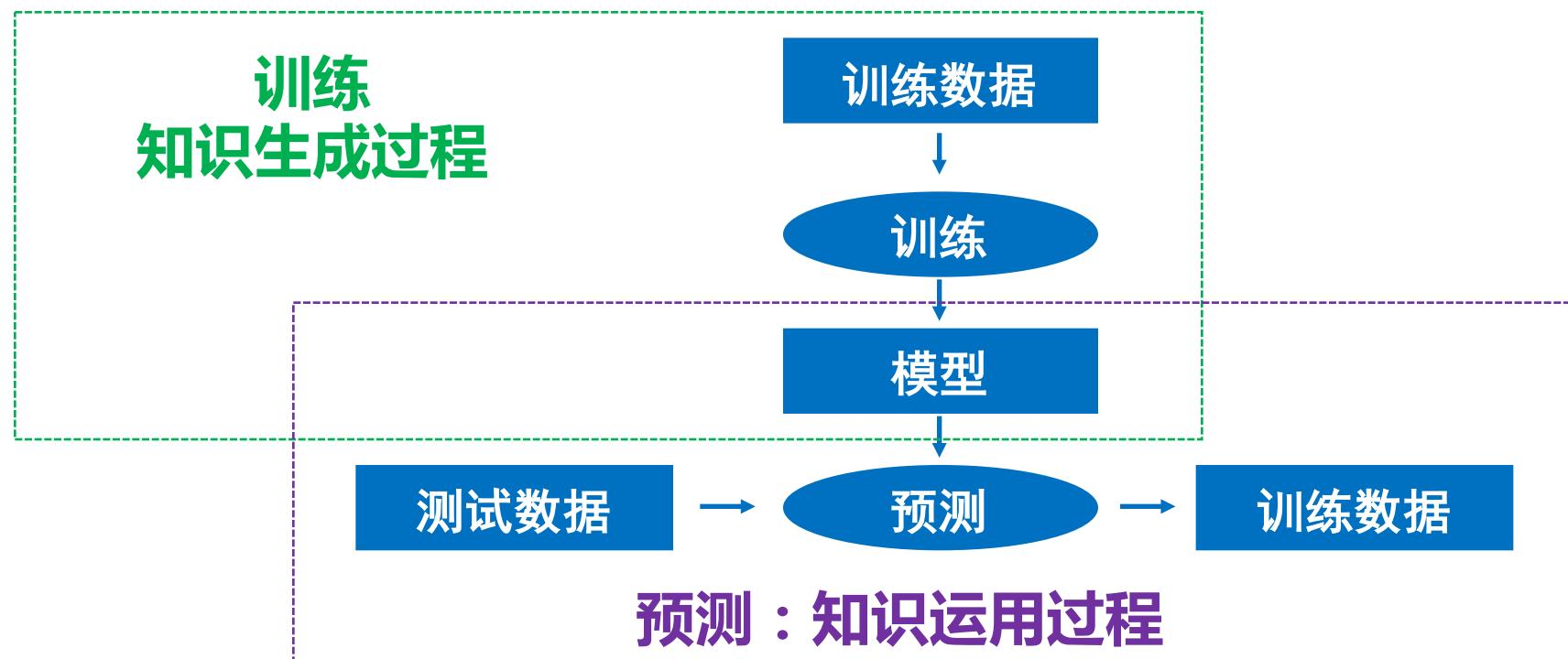
- 需要读书和练习
- 需要测验
- 测验题目和练习题目不能相同
- 需要有检测标准



# 机器学习定义

- Tom Mitchell (1998) Well-posed Learning Problem:

- A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.
- 机器学习是一种通过利用数据，训练出模型，然后使用模型预测的方法。



“A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.”

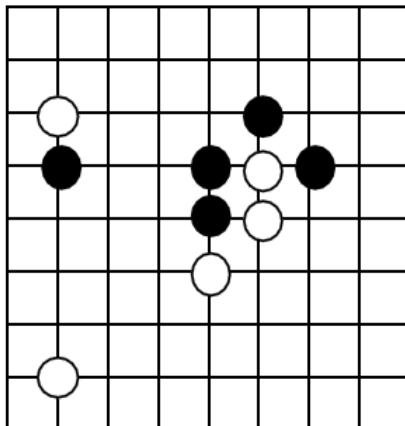
Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

- Classifying emails as spam or not spam.
- Watching you label emails as spam or not spam.
- The number (or fraction) of emails correctly classified as spam/not spam.
- None of the above—this is not a machine learning problem.

# 机器学习定义

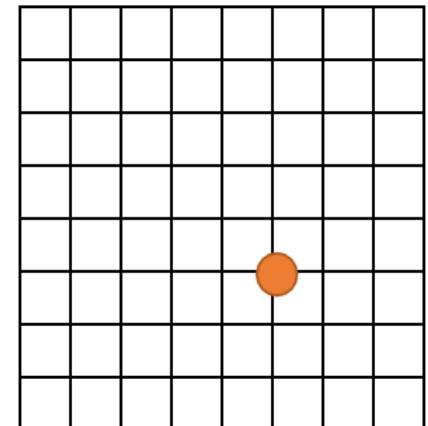
- Arthur Samuel (1959). Machine Learning:
  - Field of study that gives computers the ability to learn without being explicitly programmed.
  - 一种能够赋予机器学习的能力以此让它完成直接编程无法完成的功能的方法。

Current Board



**Prediction Model**

Next Action



# 基本概念

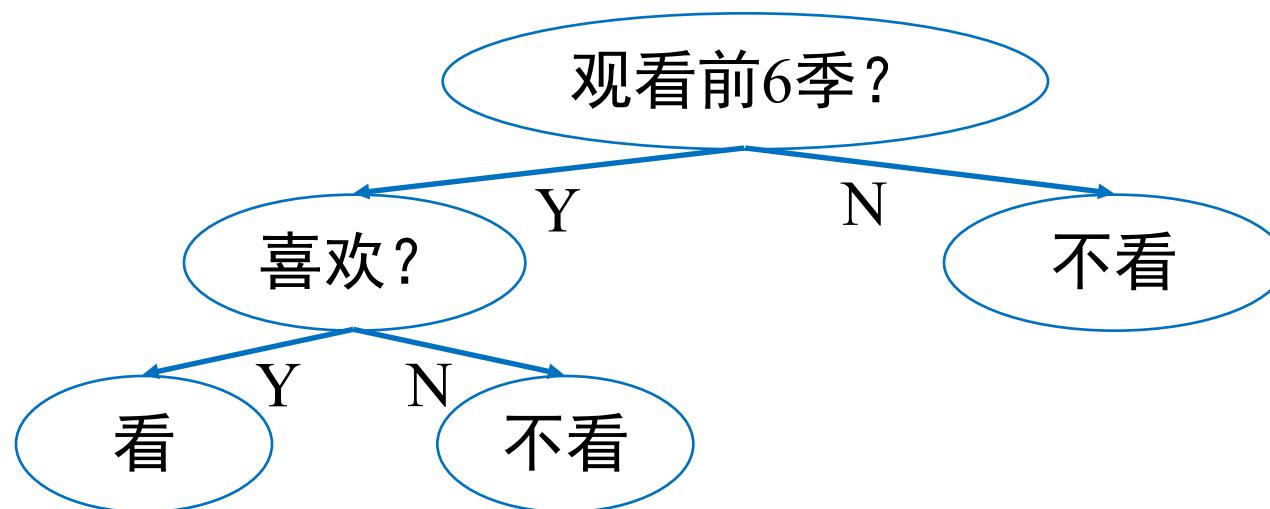
- 例1：同学A是否会观看《冰与火之歌》第7季？



# 基本概念

- **例1：**

- 同学A是否会观看《冰与火之歌》第7季？
- 判断依据：
  - 1 ) 是否观看前6季 ?
  - 2 ) 是否喜欢前6季 ?



# 基本概念

## • 例1：

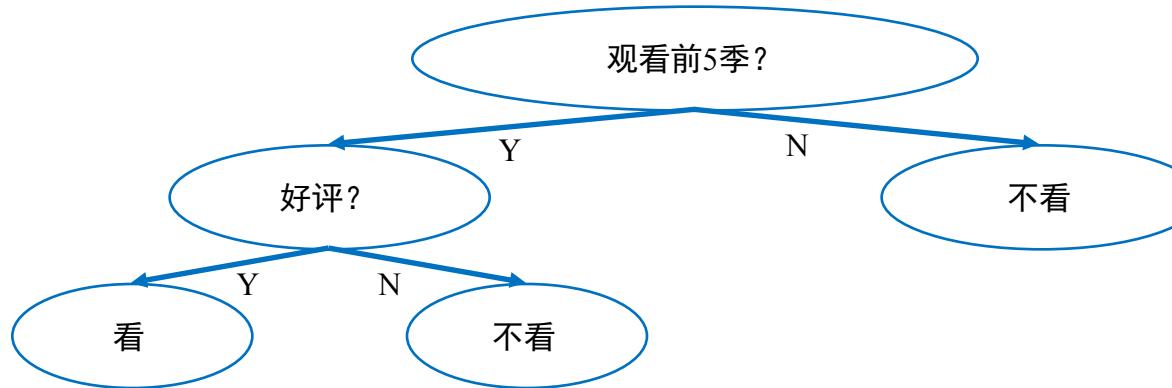
- 同学A是否会观看《冰与火之歌》第七季？
- 判断依据：
  - 1) 是否观看前6季？
  - 2) 是否对前6季好评？
- 训练数据集（通过调查得到）



人	观看前6季	好评	是否看第7季
同学1	是 (1)	是 (1)	是 (1)
同学2	否 (0)	否 (0)	否 (0)
.....	.....	.....	.....

# 基本概念

## • 机器学习的基本术语 II



术语	举例
特征 (Feature)	观看, 好评
特征值 (Value)	是 (1), 否 (0)
标记 (Label)	看 (1), 不看 (0)
决策树 (Decision Tree)	树形决策过程

# CONTENTS

- 1 什么是机器学习
- 2 机器学习的类型

# 常见的学习问题

- **分类 ( Classification )**

- 输出为离散值，二分类，多分类
- 例：预测某人是否观看《冰与火之歌》

- **回归 ( Regression )**

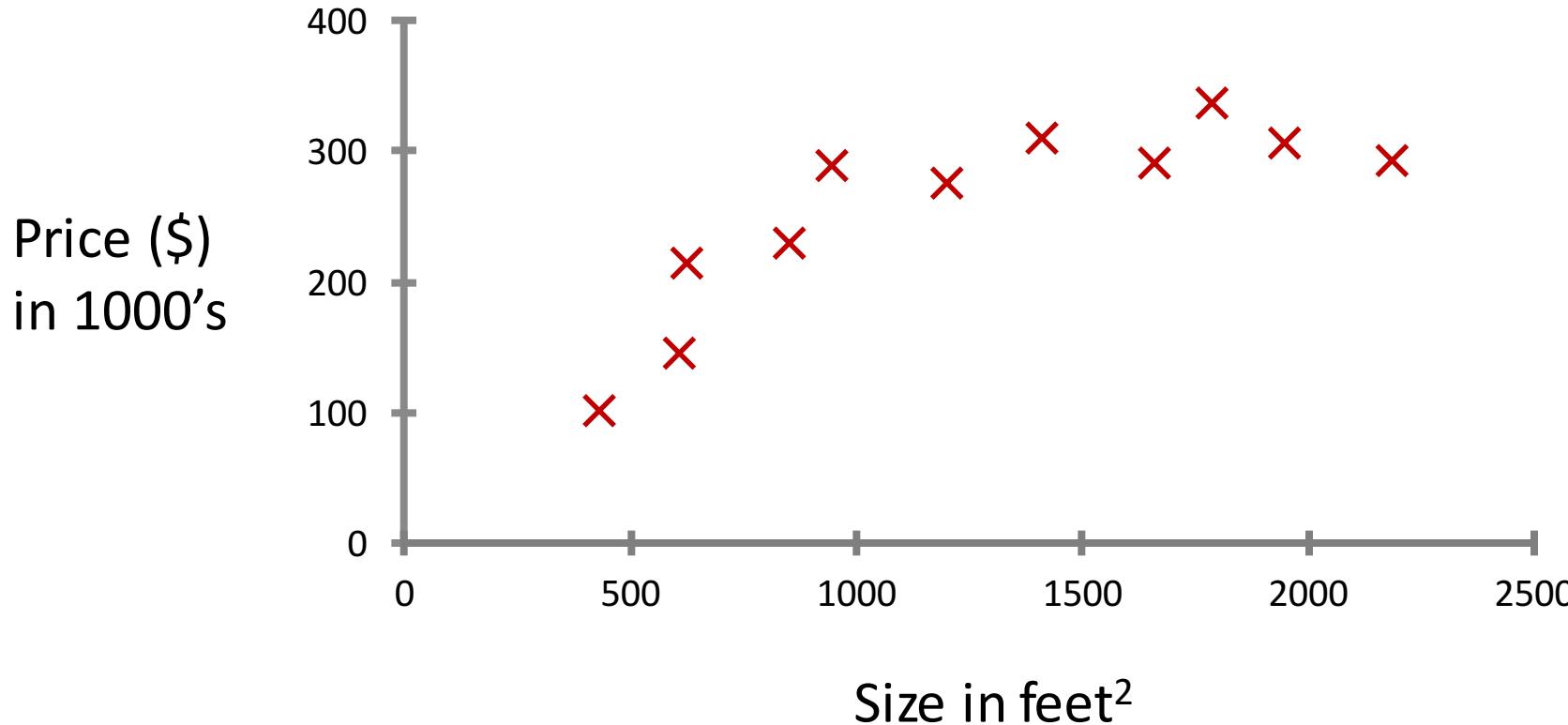
- 输出为连续值
- 例：预测《冰与火之歌》收视率

- **排序 ( Ranking )**

- 预测排列顺序
- 例：预测《冰与火之歌》中所有角色的受欢迎度排名

# 常见的学习问题

Housing price prediction.

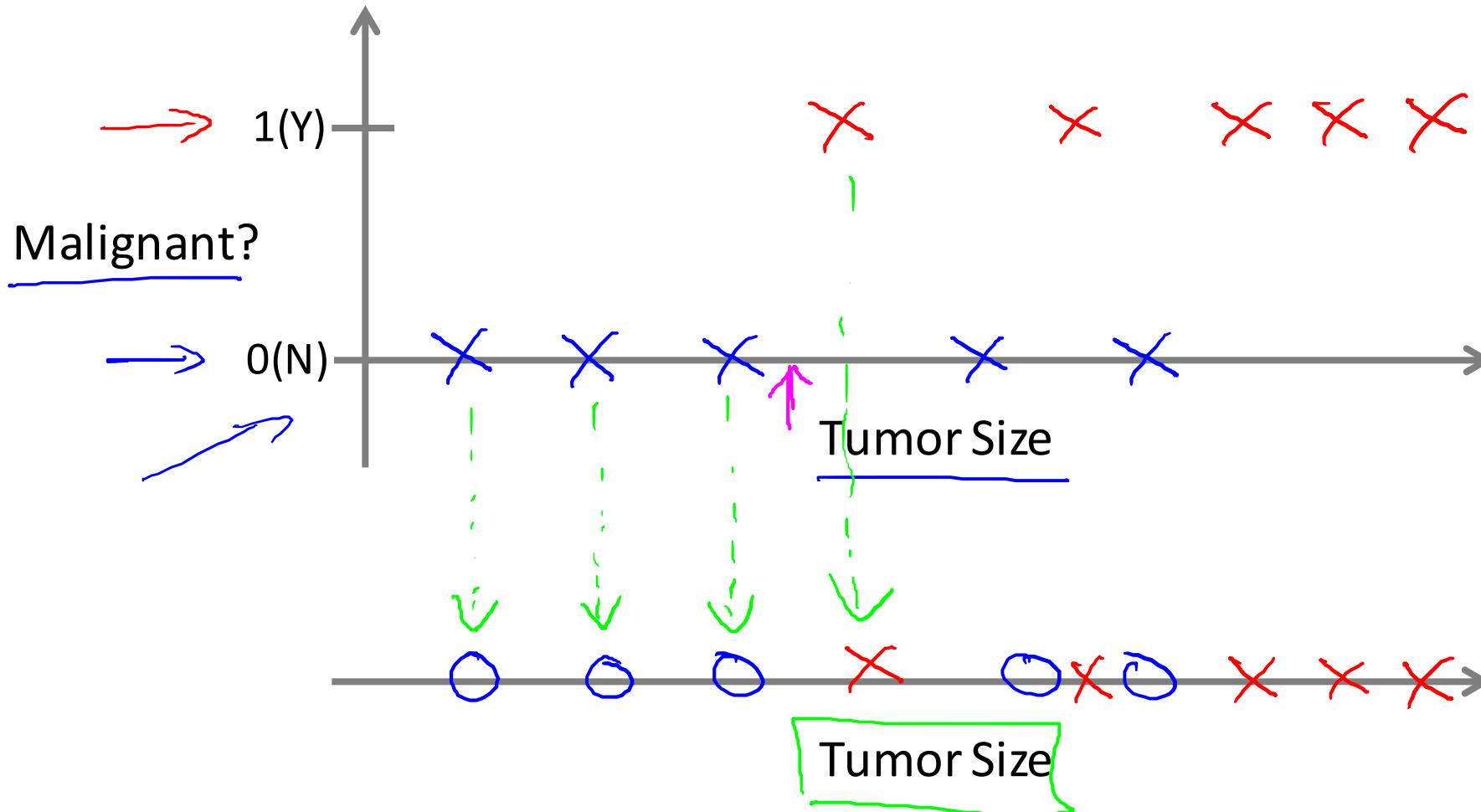


Supervised Learning  
“right answers” given

Regression: Predict continuous  
valued output (price)

# 常见的学习问题

## Breast cancer (malignant, benign)



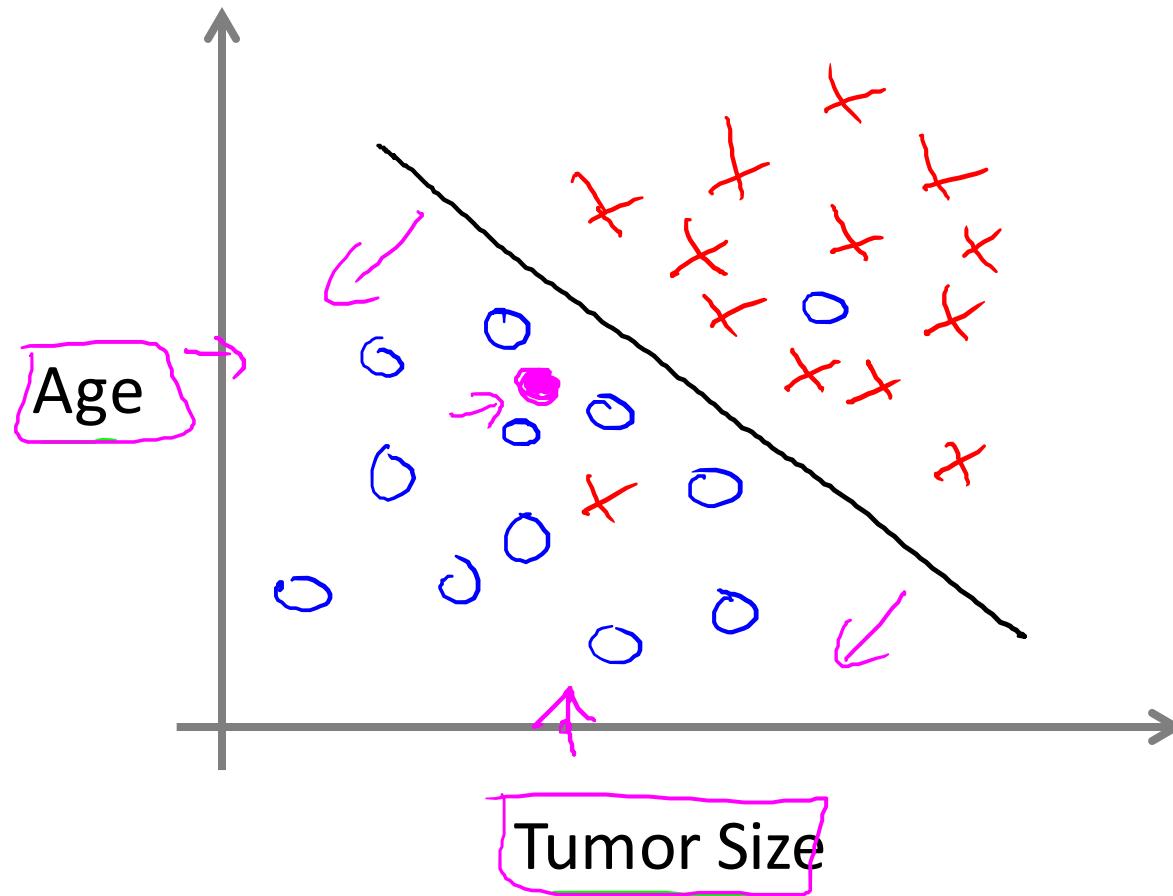
### Classification

Discrete valued output (0 or 1)



Figure 2: A slice displaying a cross section of a patient chest cavity from the LUNA16 dataset, with a nodule annotated.

# 常见的学习问题



- Clump Thickness
- Uniformity of Cell Size
- Uniformity of Cell Shape
- ...

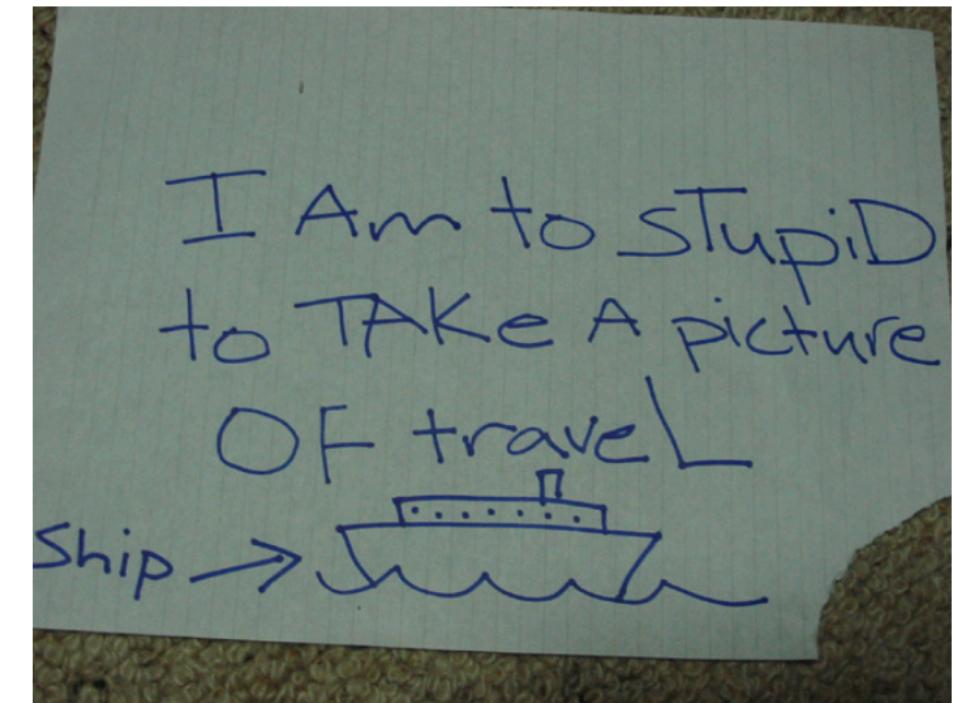
# 常见的学习问题

## • 练习2

- 图像质量评价是\_\_\_\_\_问题？  
A. 二分类 B. 多分类 C. 回归 D. 排序



(b) 7.84 ( $\pm 2.08$ )



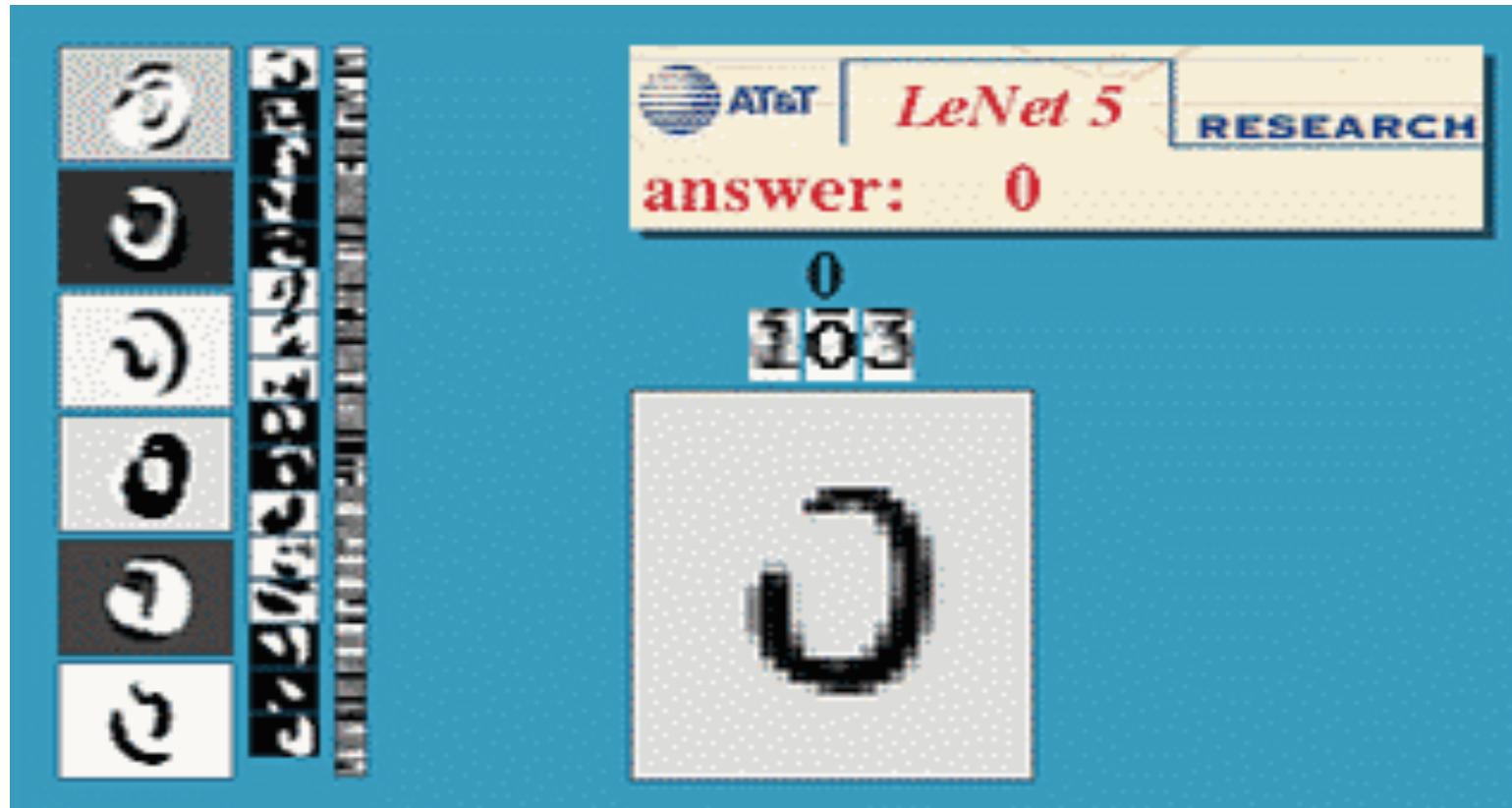
(c) 2.62 ( $\pm 2.15$ )

# 常见的学习问题

- **练习2**

- 数字识别是\_\_\_\_\_问题？

- A. 二分类 B. 多分类 C. 回归 D. 排序

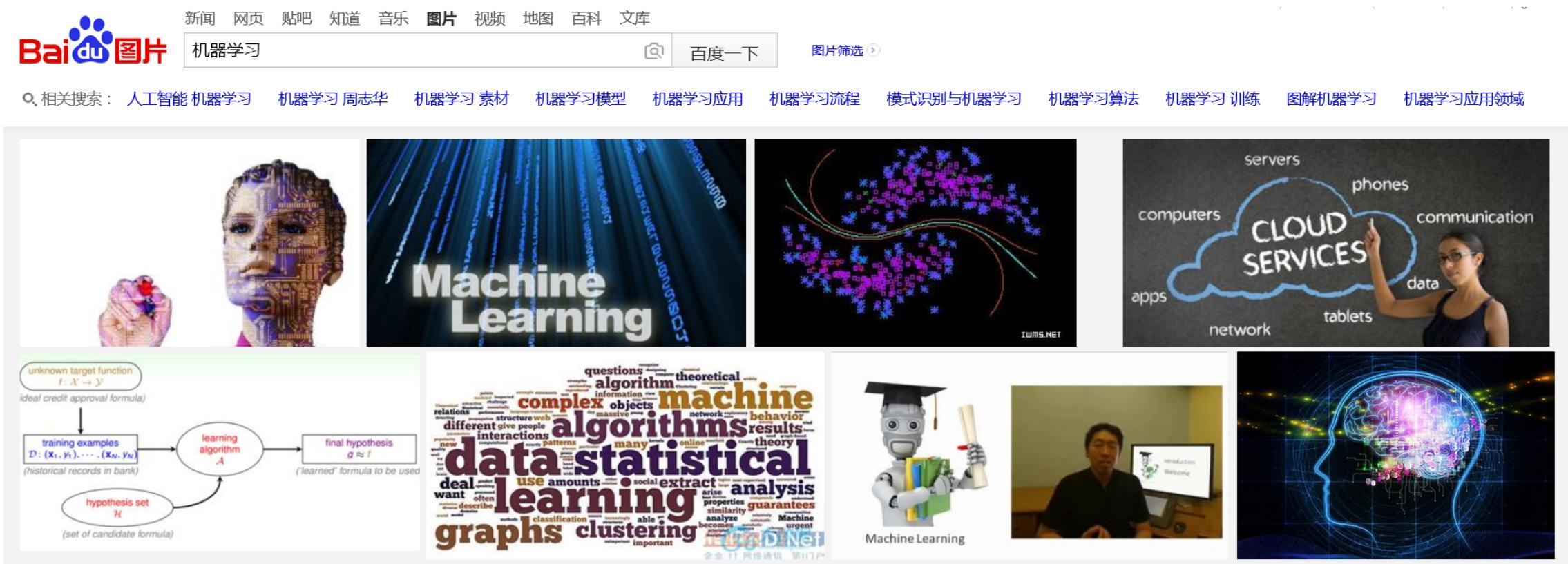


# 常见的学习问题

## • 练习3

• 网络搜索是\_\_\_\_\_问题？

- A. 二分类 B. 多分类 C. 回归 D. 排序



# 常见的学习问题

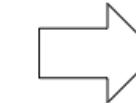
• 思考题：图像生成与翻译是\_\_\_\_\_问题？

- A. 二分类 B. 多分类 C. 回归 D. 排序

**Style Photo**



**Content Photo**

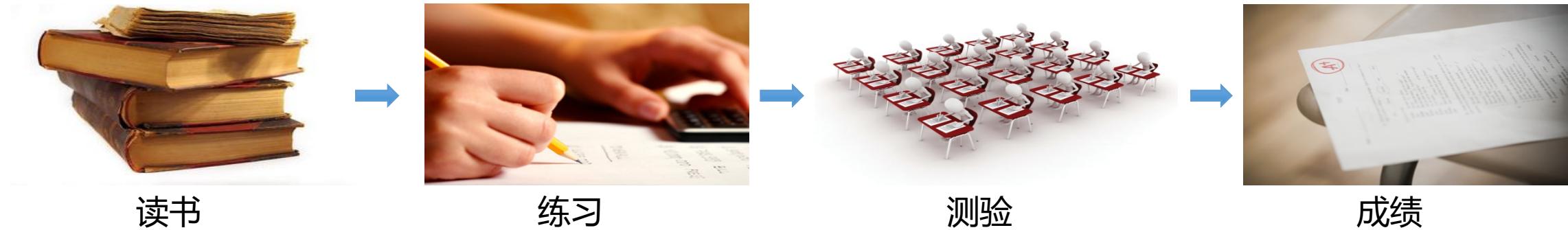


**Stylized Content**



# 学习方法

## • 人类的学习方法



- 无指导的学习：
  - 习题无答案，基于教材（先验知识）解答
- 有指导的学习：
  - 习题有参考答案，向参考答案靠近
- 强化学习：
  - 习题只有“对”或“错”的反馈

# 学习方法

## • 机器学习方法

- 有监督学习 ( Supervised Learning )

- 训练集 :  $\mathcal{D}: (\mathbf{x}_1, y_1), \dots, (\mathbf{x}_N, y_N)$

- 典型方法 : 分类、回归、排序

- 无监督学习 ( Unsupervised Learning )

- 训练集 :  $\mathcal{D}: (\mathbf{x}_1), \dots, (\mathbf{x}_N)$

- 典型方法 : 聚类

- 半监督学习 ( Semi-supervised Learning )

- 训练集 :  $\mathcal{D}: (\mathbf{x}_1, y_1), \dots, (\mathbf{x}_N, y_N), (\mathbf{x}_{N+1}), \dots, (\mathbf{x}_{N+M})$

- 典型方法 : 分类、回归、排序

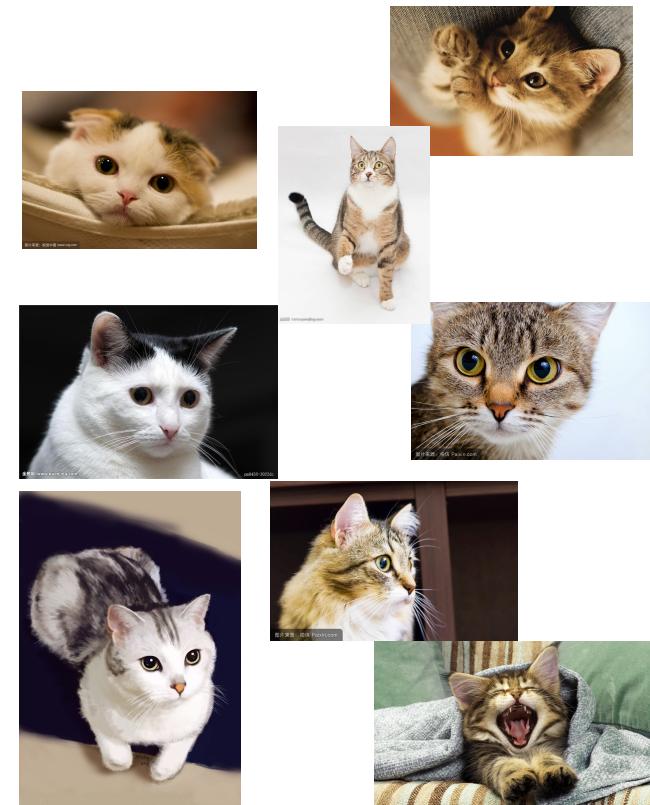
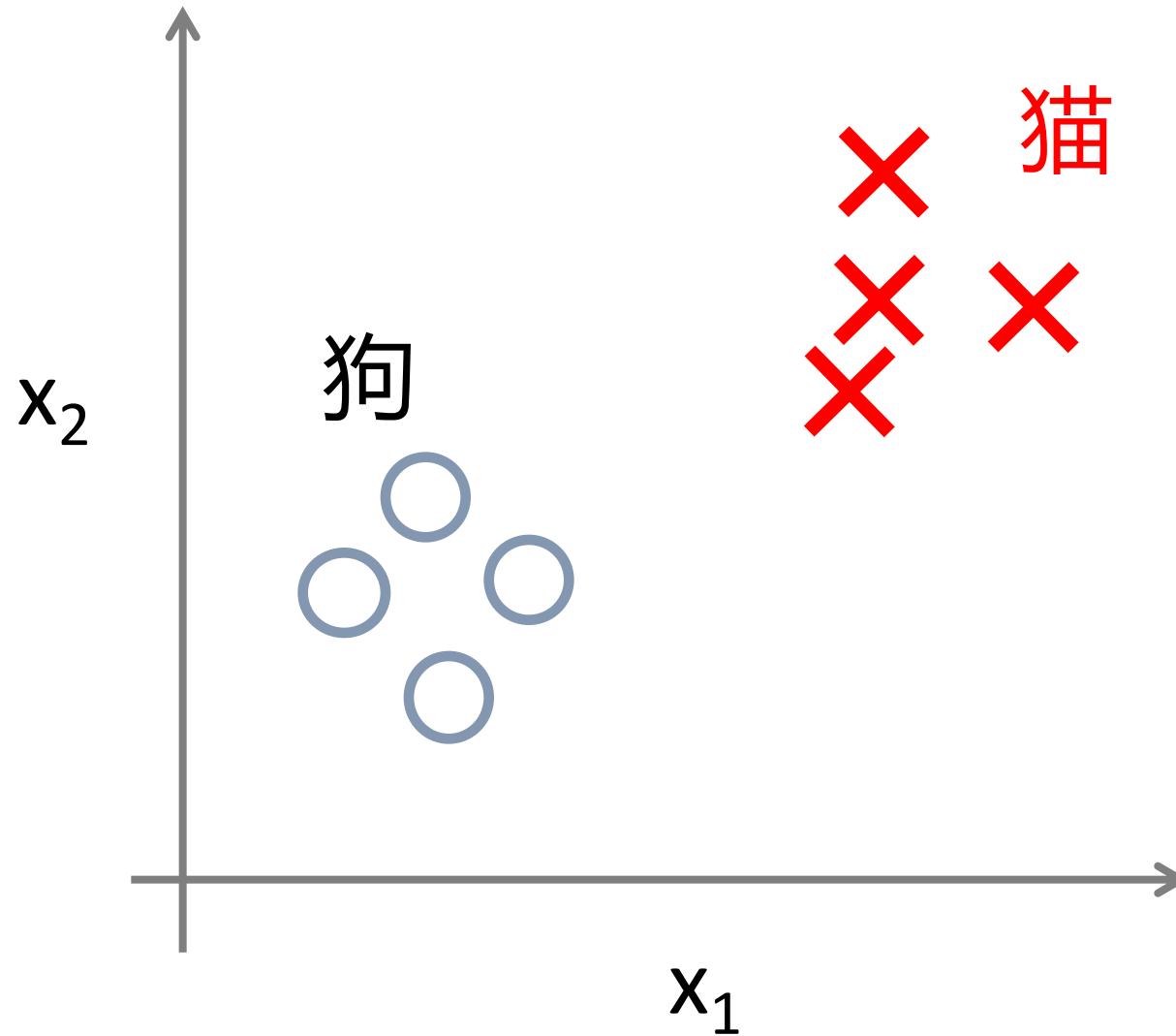
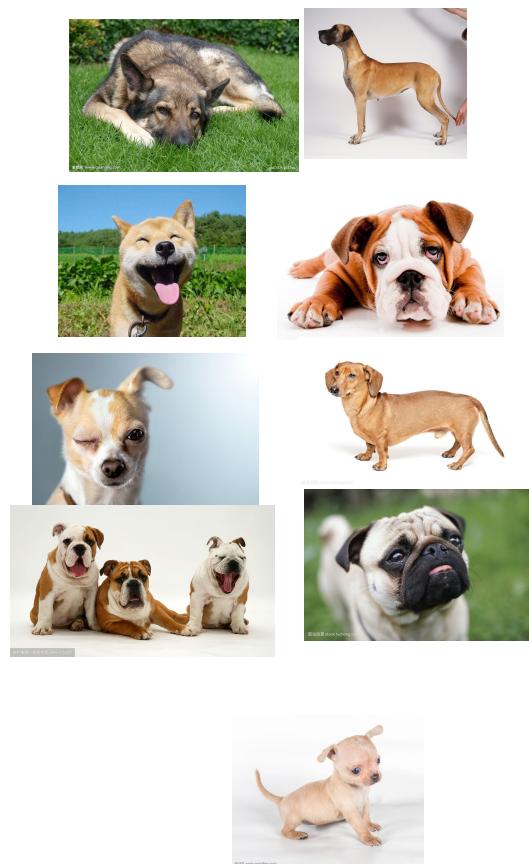
- 强化学习 ( Reinforcement Learning )

- 典型应用 : 游戏AI开发 ( AlphaGo )

# 学习方法

- 有监督学习

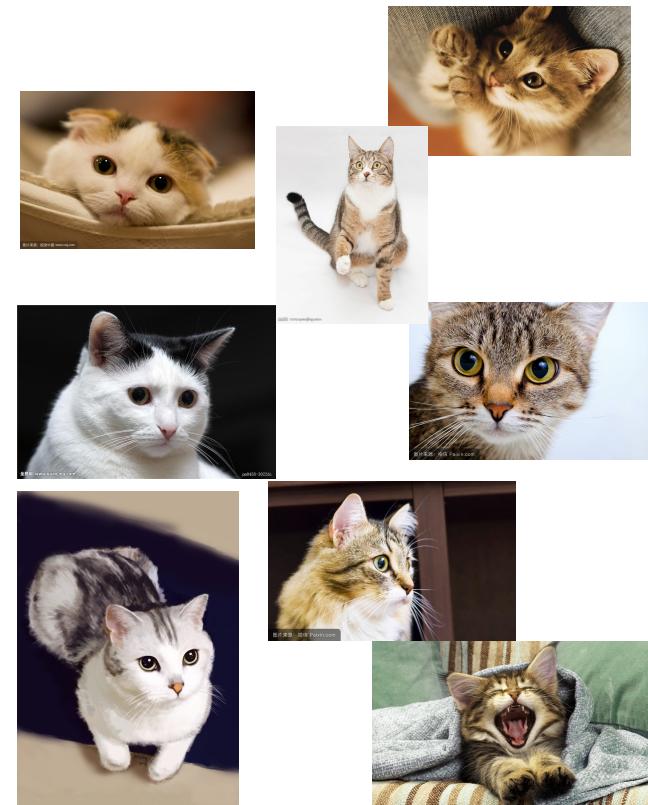
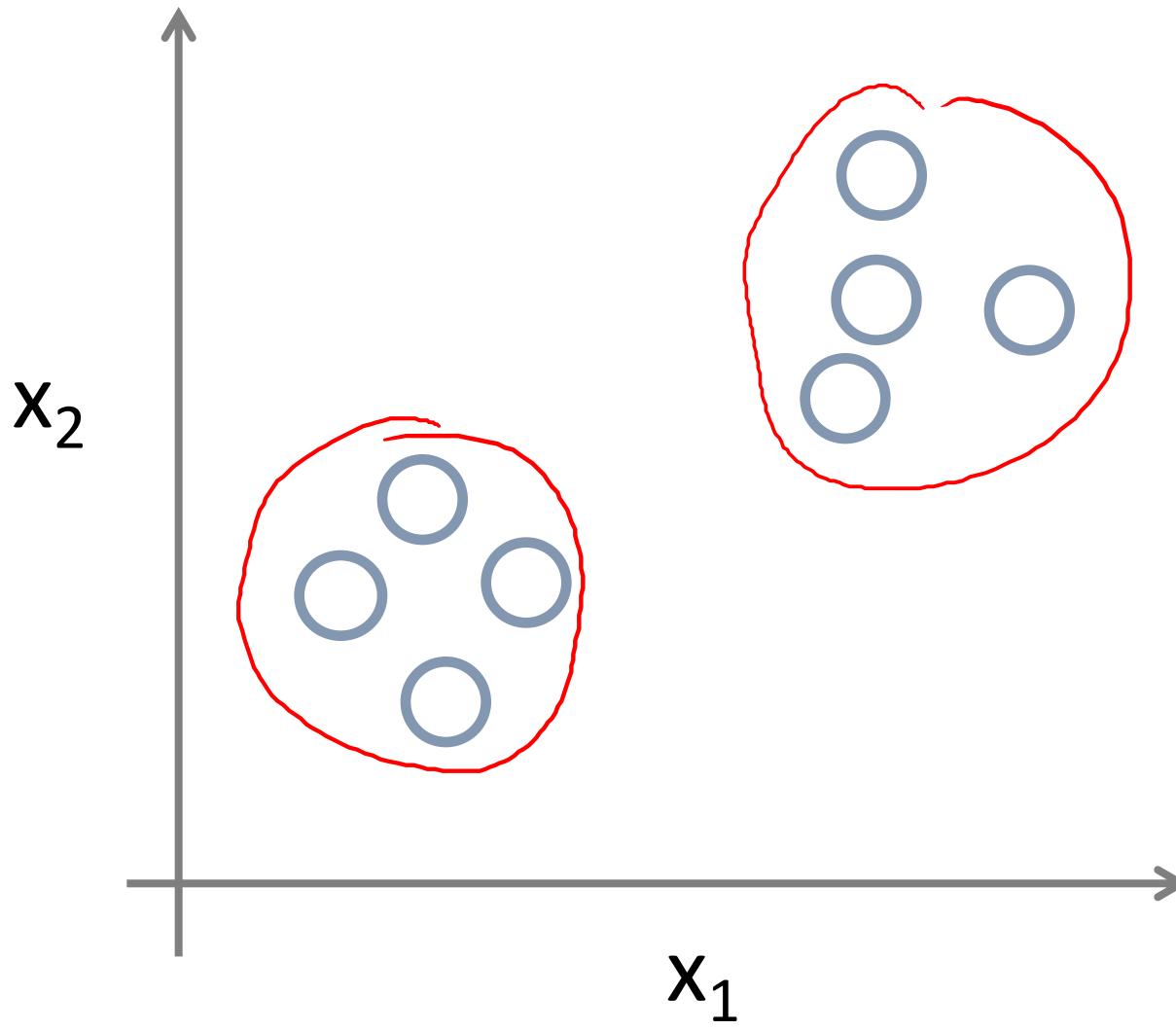
## Supervised Learning



# 学习方法

- 无监督学习

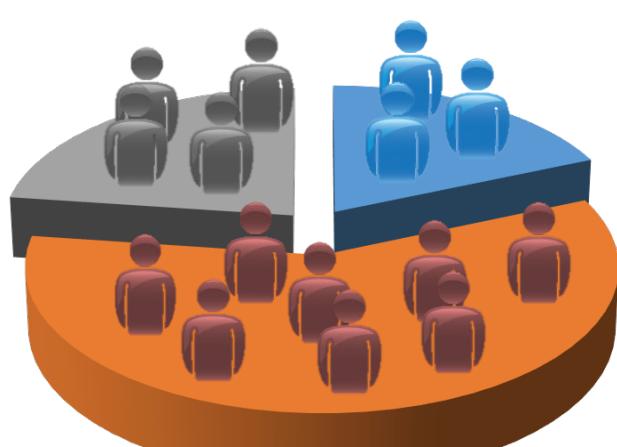
## Unsupervised Learning



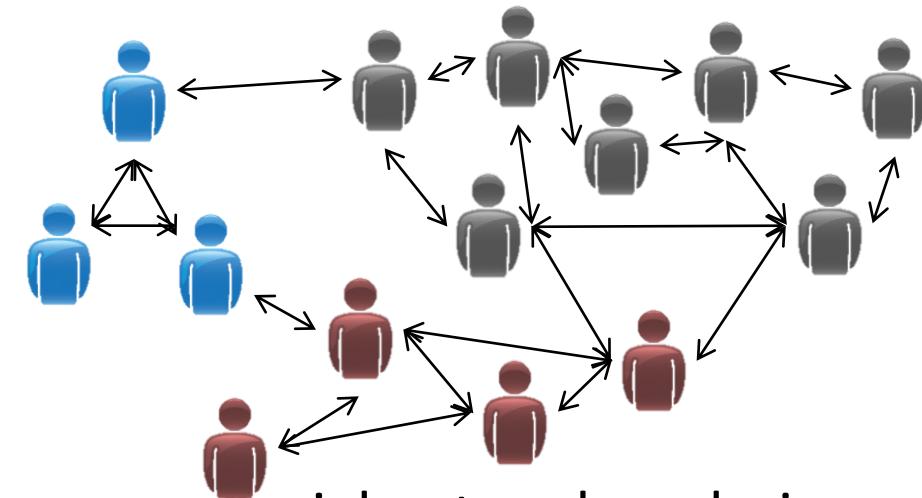
# 学习方法



Organize computing clusters



Market segmentation



Social network analysis

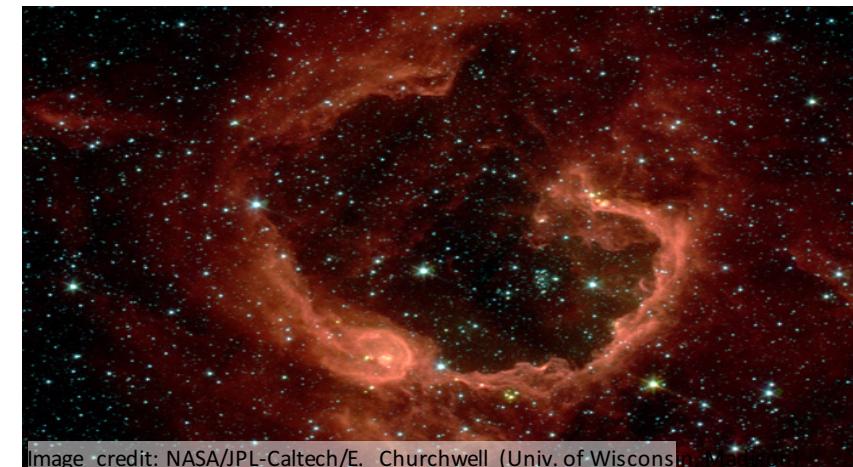


Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin-Madison)

Astronomical data analysis

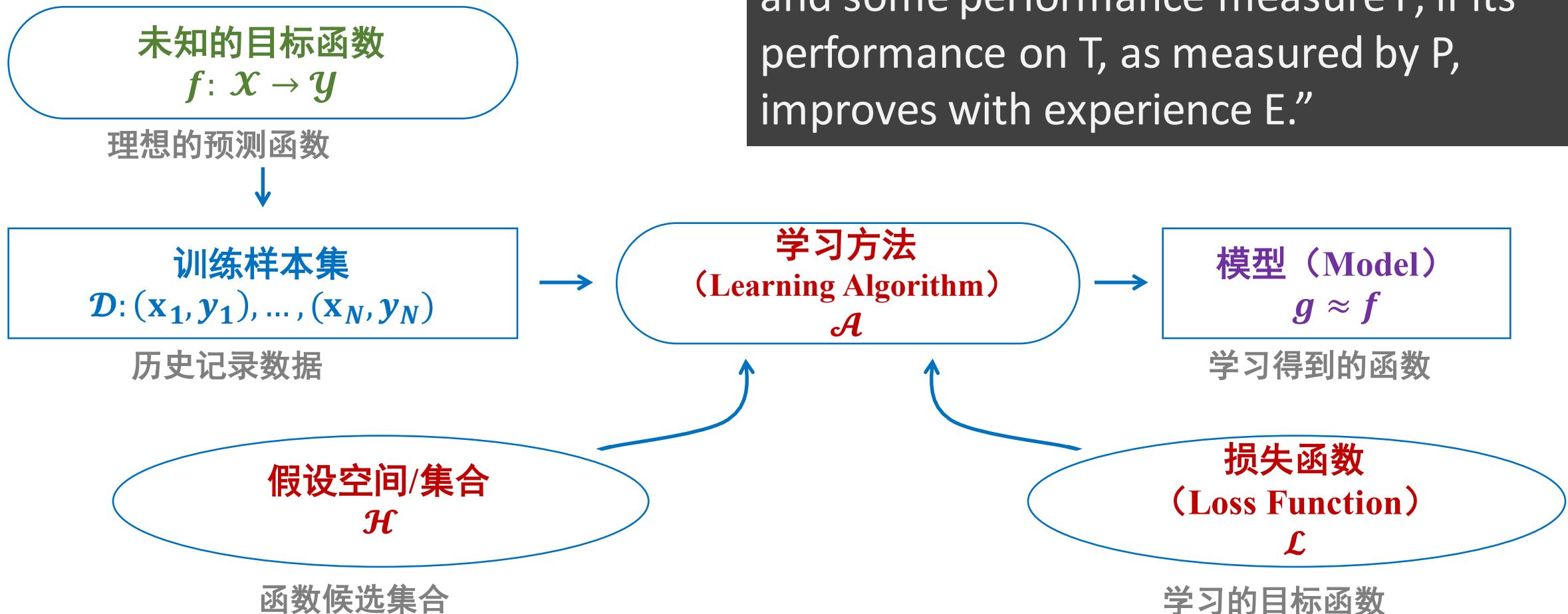
# 学习方法

• Of the following examples, which would you address using an unsupervised learning algorithm? (Check all that apply.)

- Given email labeled as spam/not spam, learn a spam filter.
- Given a set of news articles found on the web, group them into set of articles about the same story.
- Given a database of customer data, automatically discover market segments and group customers into different market segments.
- Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.

# 学习方法

## • 数学描述



# 学习方法

## • 损失函数 ( Loss Function )

- 均方损失 ( Squared Loss ) : 分类问题

$$\ell(y, \hat{y}) = (y - \hat{y})^2$$

- 绝对值损失 ( Absolute Loss ) : 分类问题

$$\ell(y, \hat{y}) = |y - \hat{y}|$$

- 二值损失 ( Binary Loss ) : 回归问题

$$\ell(y, \hat{y}) = \begin{cases} 0 & \text{if } y = \hat{y} \\ 1 & \text{otherwise} \end{cases}$$

# 学习方法

## • 优化 ( Optimization )

- 理想情形：最小化期望误差 ( Expected Error )

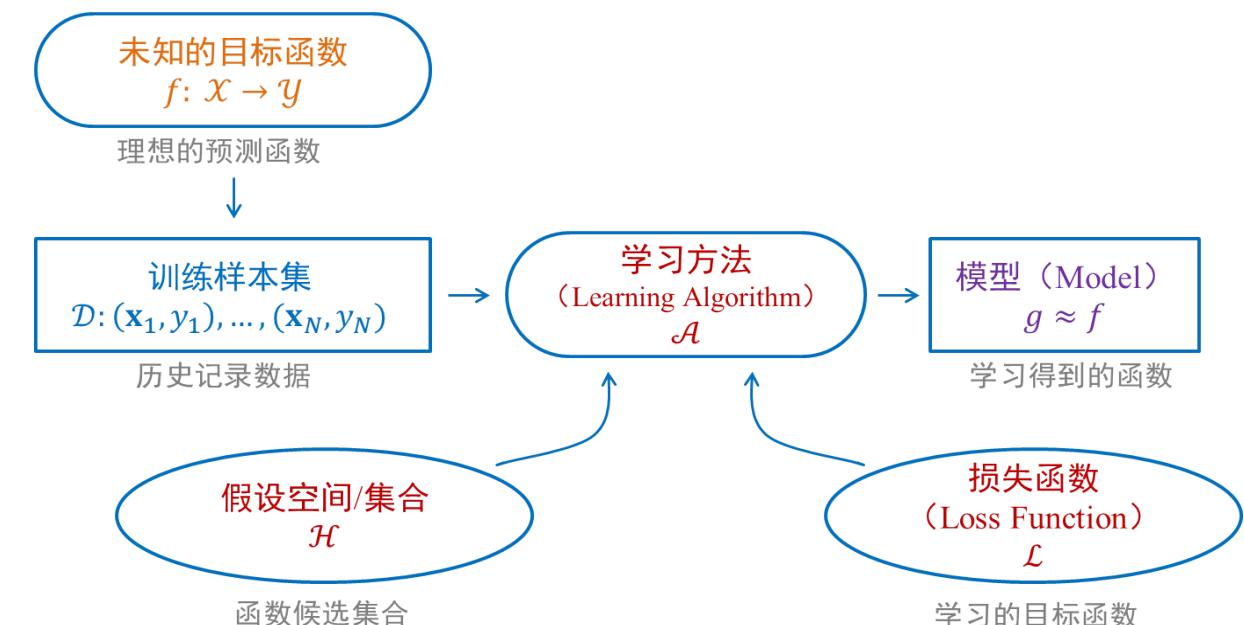
$$\epsilon \triangleq \mathbb{E}_{(x,y) \sim \mathcal{D}} [\ell(y, f(x))] = \sum_{(x,y)} \mathcal{D}(x, y) \ell(y, f(x))$$

- 学习过程，最小化训练误差 ( Training Error )

$$\hat{\epsilon} \triangleq \frac{1}{N} \sum_{n=1}^N \ell(y_n, f(x_n))$$

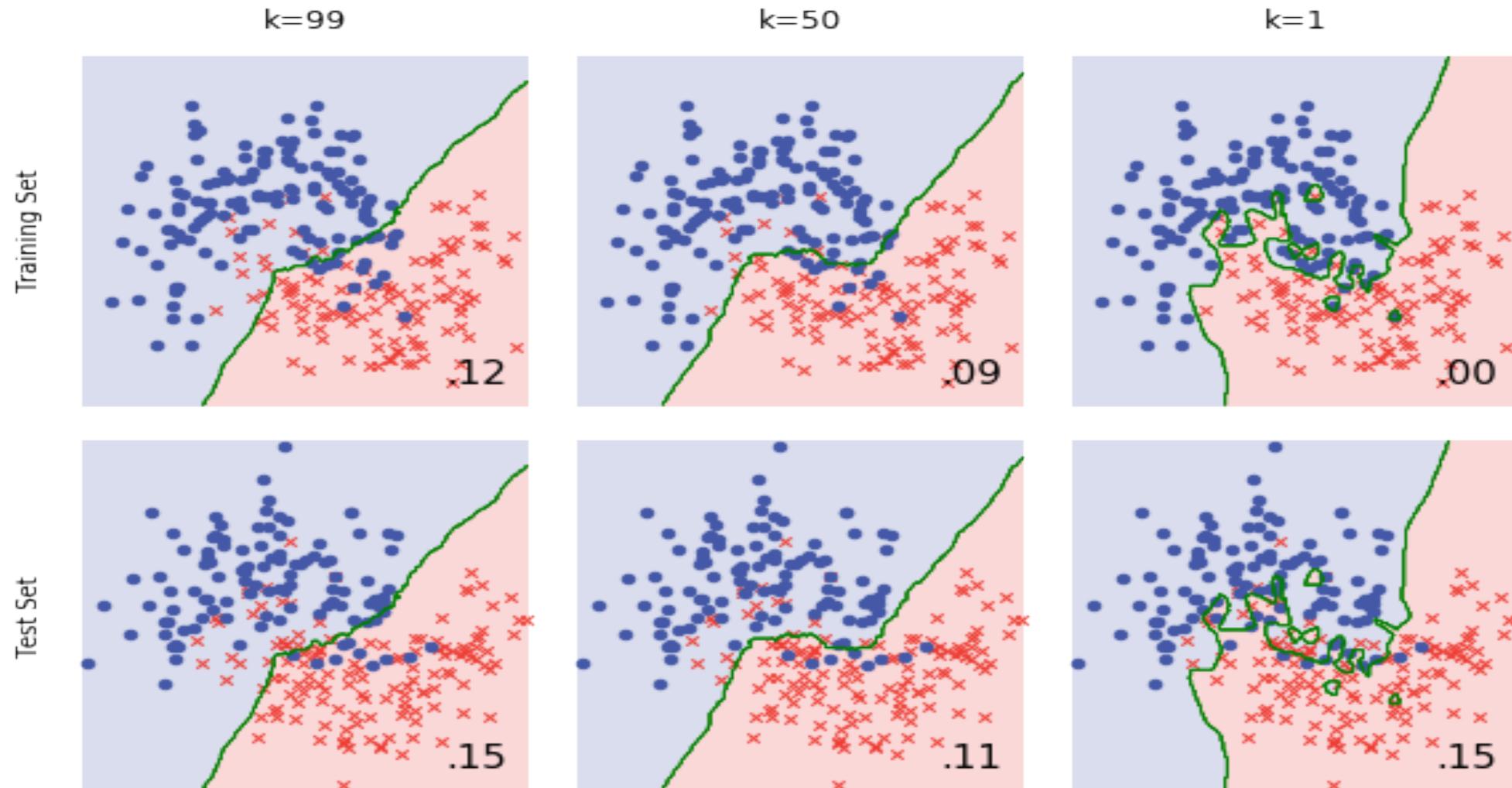
- 问题

- 过拟合 ( Overfitting )
- 欠拟合 ( Underfitting )



# 学习方法

- 例：聚类，欠拟合 vs 过拟合



# 小结

## • 应用背景

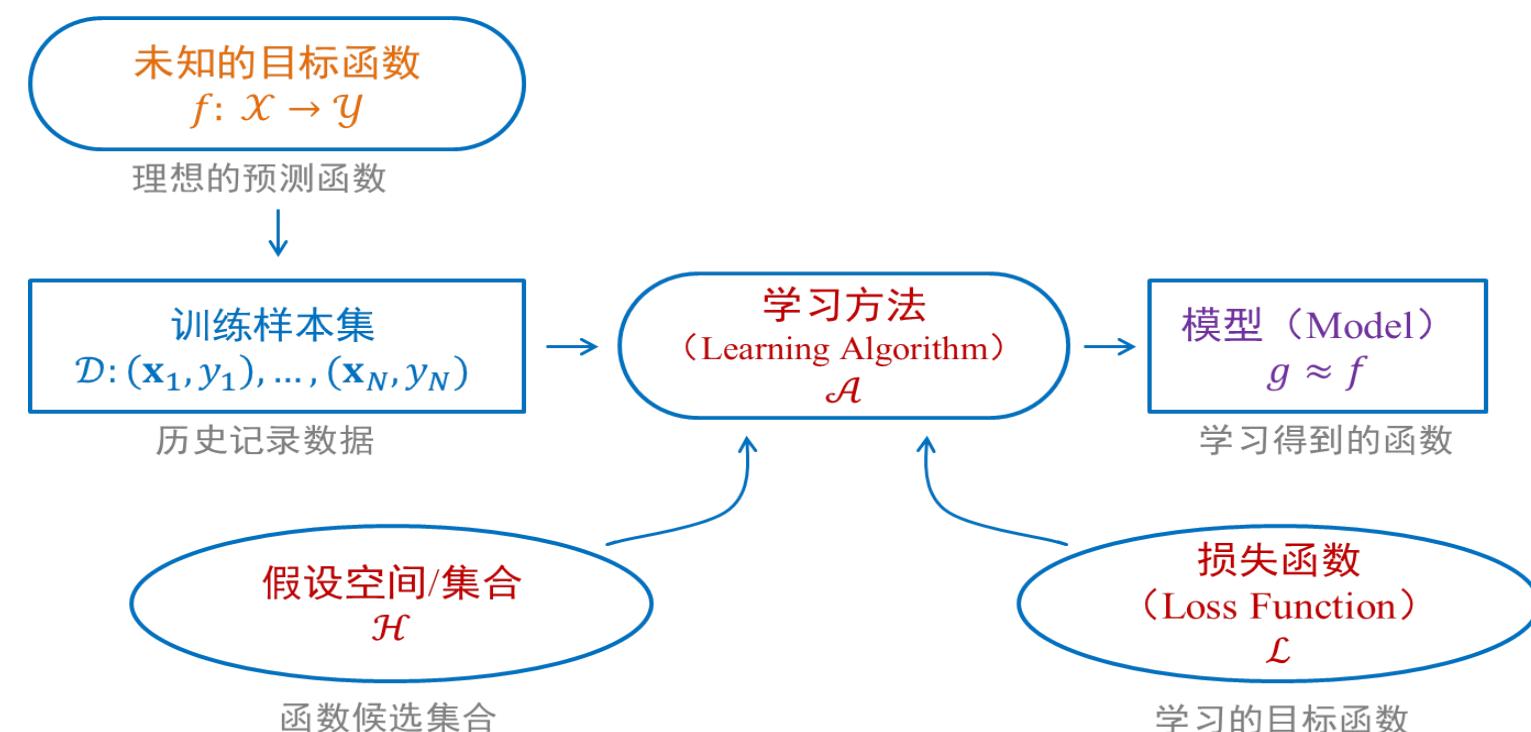
- 机器学习应用广泛且发展前景广阔

## • 基本概念

- 训练、测试、样本、特征、标记、学习算法

## • 学习方法

- 分类、回归、排序
- 损失函数
- 过拟合
- 欠拟合



END

# 机器学习

Machine Learning



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# 基本概念

## • 机器学习的基本术语 I

人	机器
书籍	先验 (Prior)
习题	训练 (Train)
测验	预测 (Predict)
题集	数据集 (Data Set)
题目	示例/样本 (Instance/Example)
习题集	训练集 (Training Set)
试题库	测试集 (Test Set)
试题不同于习题	泛化 (Generalize)
成绩	性能 (Performance)