ch1: Intro

- Artificial Intelligence & Machine Learning & Deep Learning(P10)
- **Traditional Programming vs Machine Learning(P14-P15)**
- **what is machine learning(P37)**
  - A subset of artificial intelligence which uses statistical methods (model) to enable machine to improve (optimization) towards an objective (loss function) using (data) without requiring explicit programming by human(人工智能的一个子集，它使用统计方法（模型）使机器能够使用（数据）改进（优化）到一个目标（损失函数），而不需要人类的显式编程。)
- **Key Elements of Machine Learning(P36)**
  - Data (Experience)
  - Model (Hypothesis)
  - Loss Function (Objective)
  - Optimization Algorithm
- 如何处理一个机器学习的问题

① consider the nature of available data **D**

- how much amount of data can you obtain? how would it cost (in time, computation, human efforts)?

② select a representation for the input **X**

- data preprocessing, feature extraction, etc.

③ choose a set of possible models **H** (hypothesis space)

- set of functions h: X → Y

④ choose the performance measure **P** (loss function)

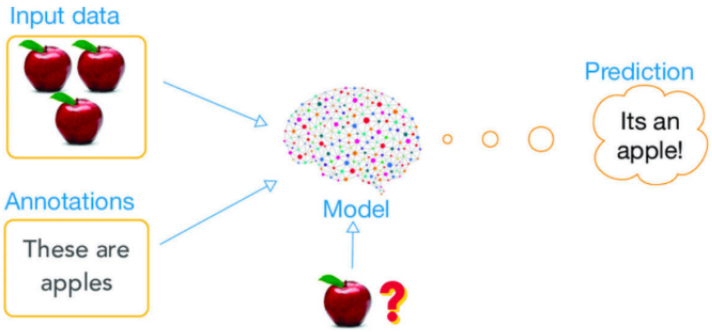
⑤ choose or design a learning algorithm

- for using examples (**E**) to converge on a member of **H** that optimizes **P** 用于使用例子(E)收敛于H中的一个优化P的成员

Categories of Machine Learning Algorithms（P52）

- Supervised Learning

- The learner is provided with a set of inputs together with the corresponding desired outputs.



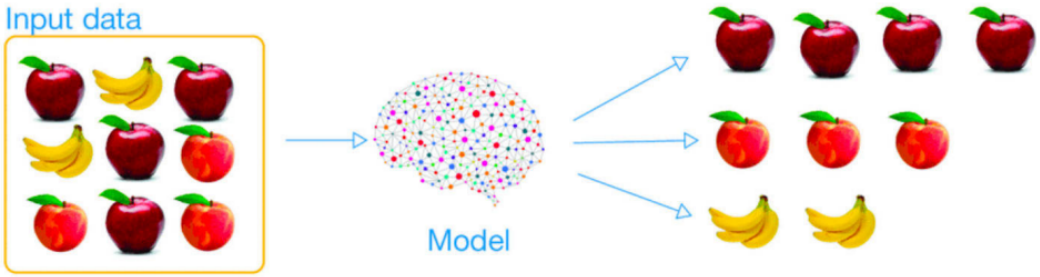
- has a "teacher"

Example

- teaching kids to recognize different animals.
- graded examinations with correct answers provided.

- 应用：
  - **Classification**
  - **Regression**
- Unsupervised Learning

Training examples as input patterns, with no associated output.



- no teacher
- similarity measure exists to detect groupings / clusterings

- 应用：
  - **Clustering**
  - **Probability Estimation**
  - **Data Generation**
  - **Topic Modeling –** learning latent（潜在的） topics from documents
  - **Outlier Detection（离群值观测）** – find the least likely observations from a dataset
  - **Dimension Reduction and Feature Selection**
- Supervised vs. Unsupervised Learning（P65）

Supervised Learning

Data: (x, y)
x is data, y is label

Goal: Learn function to map
$x \rightarrow y$

Examples: Classification, regression, object detection, semantic segmentation, etc.

Unsupervised Learning

Data: x
x is data, no label

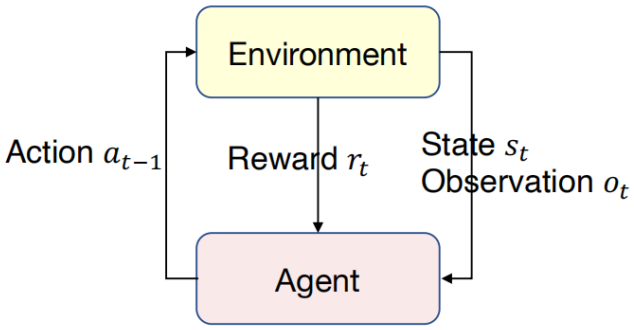
Goal: Learn the hidden or underlying structure of the data.

Examples: Clustering, feature or dimensionality reduction, etc.

- Reinforcement Learning(强化学习)

  - Learning from **interacting** with an **environment.**

  Learning a mapping from states to actions to maximize long-term reward.



- ❑ a set of environment states S;
- ❑ a set of actions A;
- ❑ rules of transitioning between states;
- ❑ rules that determine the scalar immediate reward of a transition; and
- ❑ rules that describe what the agent observes.

Goal: maximize the expected long-term payoff

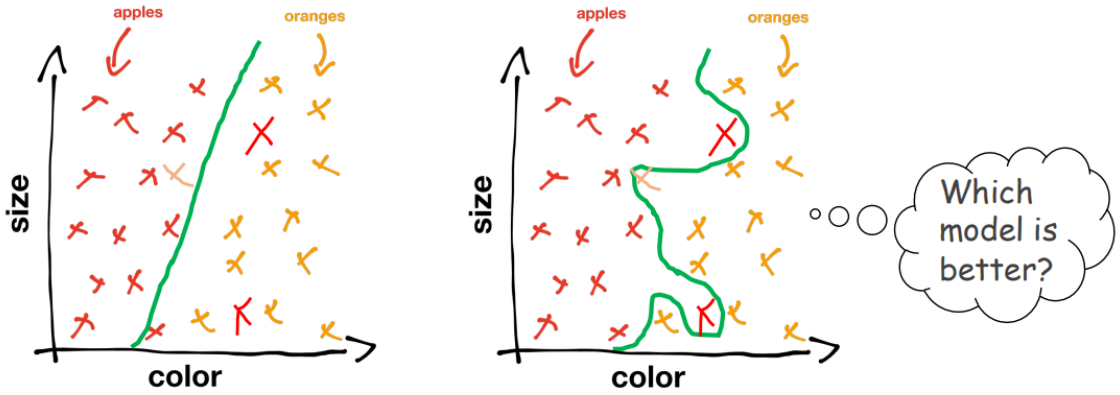
Example: graded examinations with only overall scores but no correct answers

- 应用：
  - **Monte-Carlo Reinforcement Learning**

Important ML concepts

- **Generalization（泛化）（P72）**

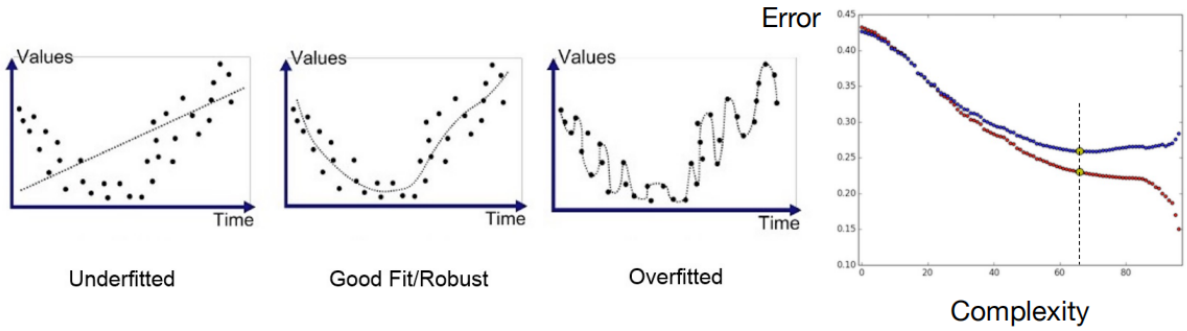
The issue of generalization: whether ML models are encouraged to learn generic patterns or simply remember details?



- **Bias and Variance（P73）**
  - Bias – how close does the assumed model fit for the observed data?
  - Variance – how complex (e.g., freedom) the assumed model is?
- **Overfitting & unfitting(P76)**

Underfitting – the model isn't complex enough to capture the real knowledge, the assumption may not be true.

Overfitting – the model is too complex and thus describes the details of data (e.g., random noise) instead of underlying knowledge



- **Prevent Overfitting(P78)**

Widely used approaches (to prevent overfitting)

- Increase training data
- Regularization (penalizing model complexity) （惩罚模型复杂性）
- Hold-out & cross validation (unseen data to ensure generalization)
- Early stopping 保留和交叉验证（未见数据以确保泛化）
- Prior knowledge (e.g., Bayesian prior)
- …

- 这些方法的详细叙述在P79-82

▼ **No free lunch theorem**

There is no universally best model. Different types of models have to be developed to suit the
nature of the data in real applications.