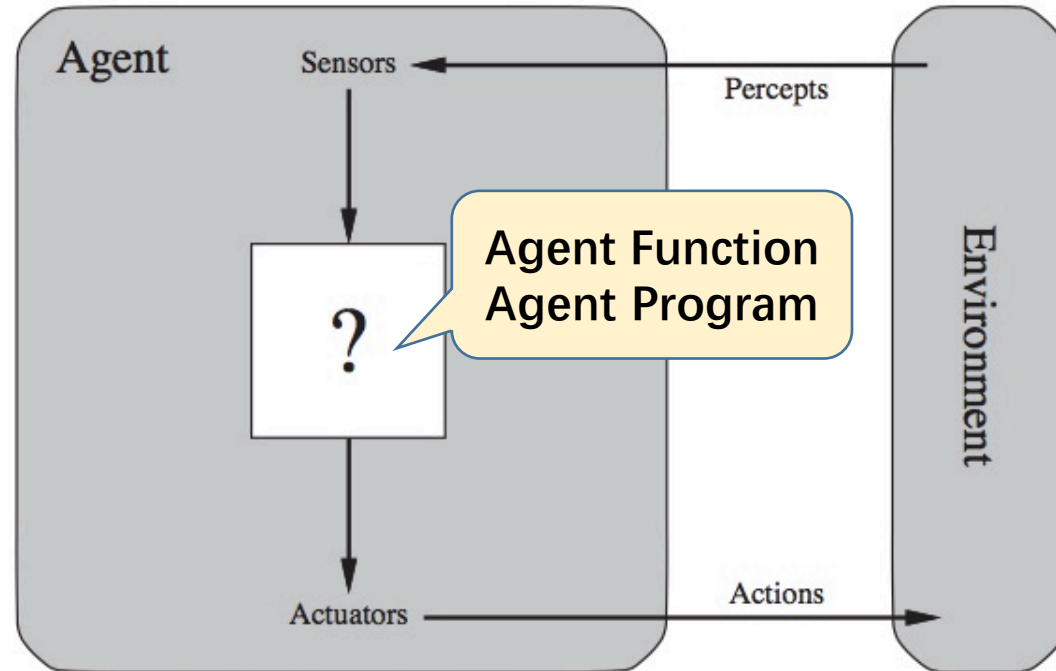


I. What is Learning

Why Learning is Important for AI?



- When interact with the environment, we (human) take some input and give some output.

Why Learning is Important for AI?

- Intuitively, our behavior is not determined by some rigid/static program, i.e., we might behave different as growing up.
- Learning is universal and a major source of our behavior changing.
- From an engineering perspective, it is also intractable to implement/code an agent function/program that encompasses all possible input/output pairs in the complex world. Thus an AI with learning ability would also help.

What is Learning (in AI)?

- Examples for human learning
 - Learn similarity between objects
 - Learn to recognize objects
 - Learn to pass the college entrance examination
- A process to achieve an agent function from scratch, or to improve the agent function based on **observations received from the environment**.
- More concretely: Given some observations (data) from the environment, and (possibly) some prior knowledge, how could an agent improve its agent function?

II. Key Questions for Learning

Key Questions for Learning

- In AI, a learning process is implemented by algorithms and programs.
- Given some **observations (data)** from the environment, and (possibly) some **prior knowledge**, how could an agent **improve** its **agent function**?
 - What is the format of the data? (data representation)
 - What is the prior knowledge?
 - What does the agent function look like? (model representation)
 - How to measure the “improvement” ? (objective function)
 - What is the learning algorithm? (to get a good agent function)

Representation + Algorithm + Evaluation

Key Questions for Learning

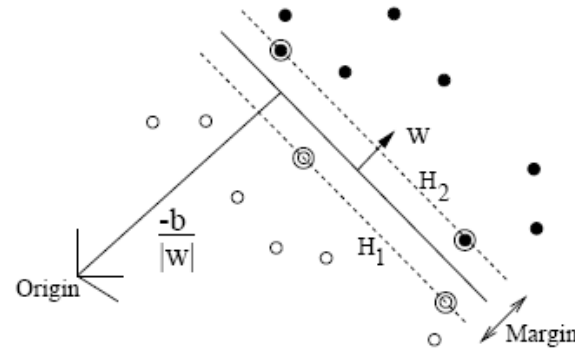
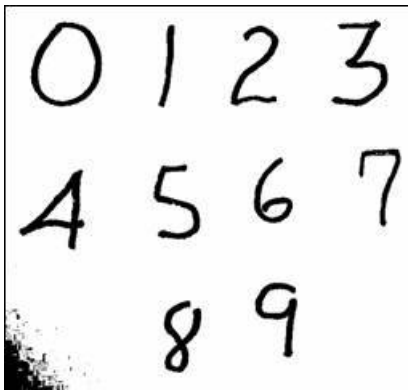
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 - What is the learning algorithm?

Search in a
model/hypothesis space

Representation + Algorithm + Evaluation

An example

- Hand-written Digit Recognition
 - Data: image of a hand-written digit
 - No prior knowledge
 - Agent function: a linear function of input
 - Improvement: how many images can be recognized correctly.



III. Learning Paradigms and Principles

Inductive vs. Deductive

- Inductive: Learning from data (prior knowledge not required)
 - E.g., Hand-written digit recognition
- Deductive: Learning from prior knowledge and data.
 - E.g., People in the same country speak the same language (prior knowledge) + I speak Chinese (observation/data), then you speak Chinese

Supervised, Unsupervised and Reinforcement Learning

- Supervised learning: the correct answer is available to the learning algorithm.
- Unsupervised: no correct answer is available.
- Reinforcement: the only feedback is the reward of an output (action), e.g., the output is correct or not (in case of incorrect, the correct answer is **not** given).

Learning Principles

- **Generalization**: the learned agent function is expected to be able to handle previously unseen situations. (举一反三，不要刻舟求剑)
- How to estimate the generalization? : Key to design the objective function for learning.
- Occam' s Razor: An explanation of data should be made as simple as possible, but no simpler, i.e., **model complexity** should be controlled.
- Overfitting: the model perfectly fit the seen data perfectly, but cannot generalize well.
- Occam' s Razor and overfitting is closely related.

Summary

- The learning process for an AI is basically the search for a model/hypothesis/rule that can map an input from the environment to an appropriate output, such that we don't need to program them in advance.
- Different settings of learning may lead to different learning algorithms.
- Generalization is the ultimate goal of learning, but usually uneasy to measure/achieve.