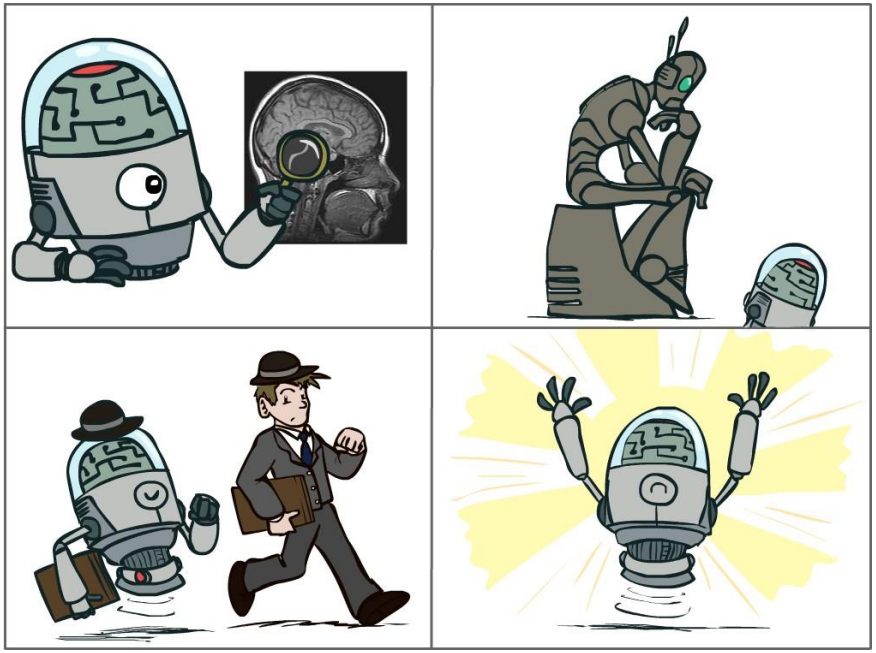
人工智能技术及应用

Artificial Intelligence and Application

What is AI?

The science of making machines that:

Think like people



Think rationally

Act like people

Act rationally

Rational Agent

Rational Decisions

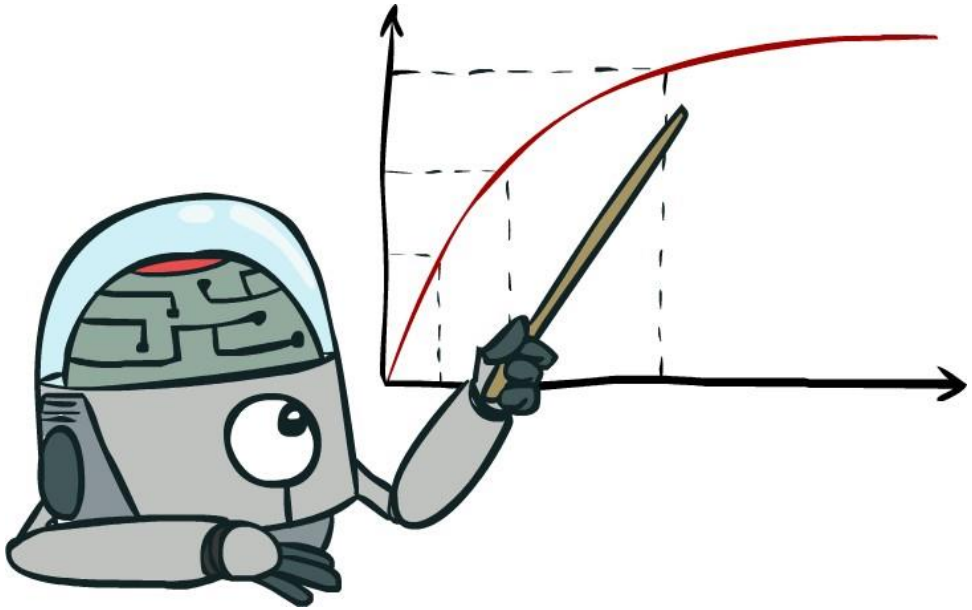
- We'll use the term **rational** in a very specific, technical way:
  - Rational: maximally achieving pre-defined goals
  - Rationality only concerns what decisions are made (not the thought process behind them)
  - Goals are expressed in terms of the **utility** of outcomes
  - Being rational means **maximizing your expected utility**

A better title for this course would be:

Computational Rationality

Rational Agent

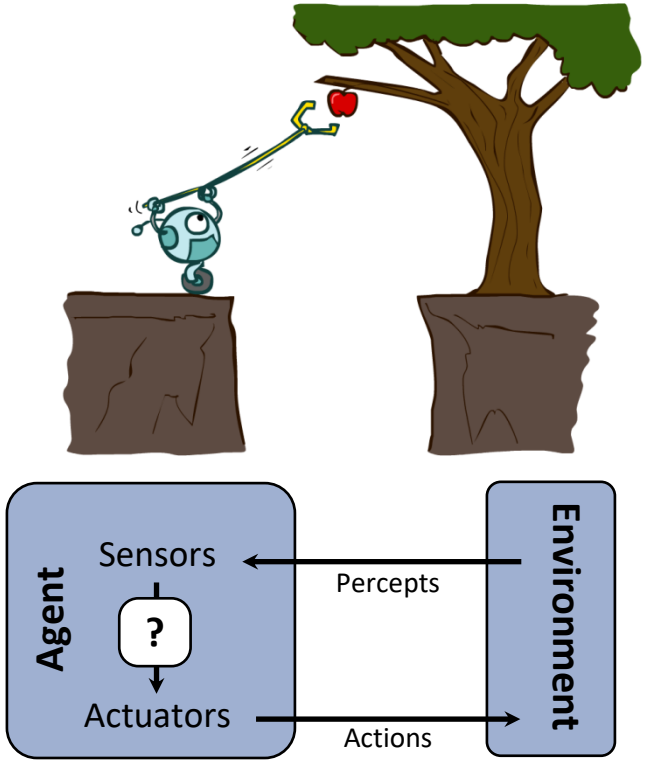
Maximize Your Expected Utility



Rational Agent

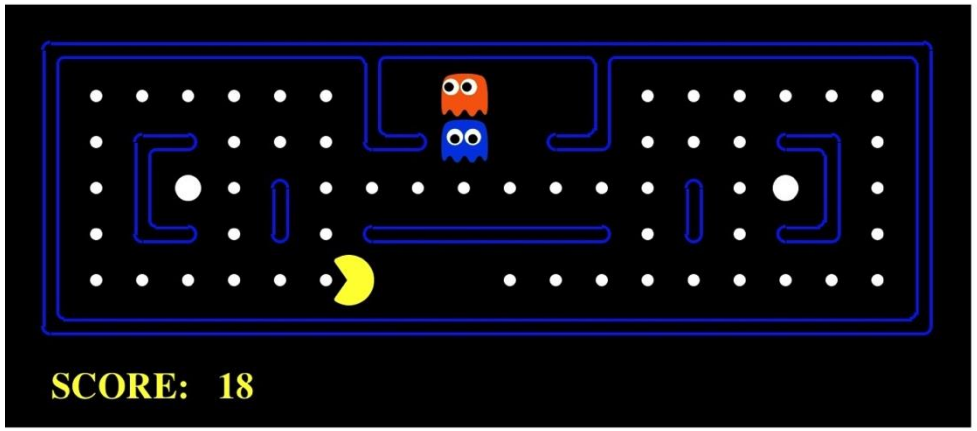
Designing Rational Agents

- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) **utility**.
- Characteristics of the **percepts, environment,** and **action space** dictate techniques for selecting rational actions
- **This course** is about:
  - General AI techniques for a variety of problem types
  - Learning to recognize when and how a new problem can be solved with an existing technique



Rational Agent

Pac-Man as an Agent



Rational Agent

Agent and Environment

Intelligent agent refers to an autonomous entity which acts, learns or uses knowledge towards achieving goals, upon an environment using observation through sensors and consequent actuators.

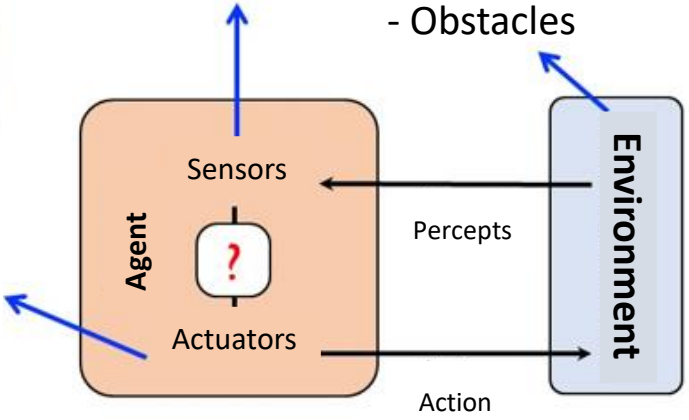
Audio Control

People Tracking

Sensors:
- Camera
-Microphone

Environment:
- Streets
- Pedestrians
- Obstacles

Actuators:
- Steering
- Chain
- Brake



Towards artificial general intelligence with hybrid Tianjic chip architecture. Nature. 2019.

Rational Agent

Two Views

- Intelligence Agent
  - Think like human
  - Act like human

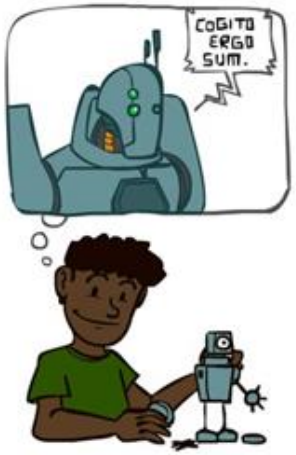
how can we create intelligence?

Perception Robotics Language

Knowledge Reasoning Learning

- AI Tools
  - Try to solve problems
  - Human cannot do well

how can we benefit society?



- Planning
- Scheduling
- Medical
- Image
- Topic Model
- Prediction

Rational Agent

Intelligence Agent

Keep Knowledge
- Procedural: coding, riding bike, ...
- Declarative: where is classroom, ...

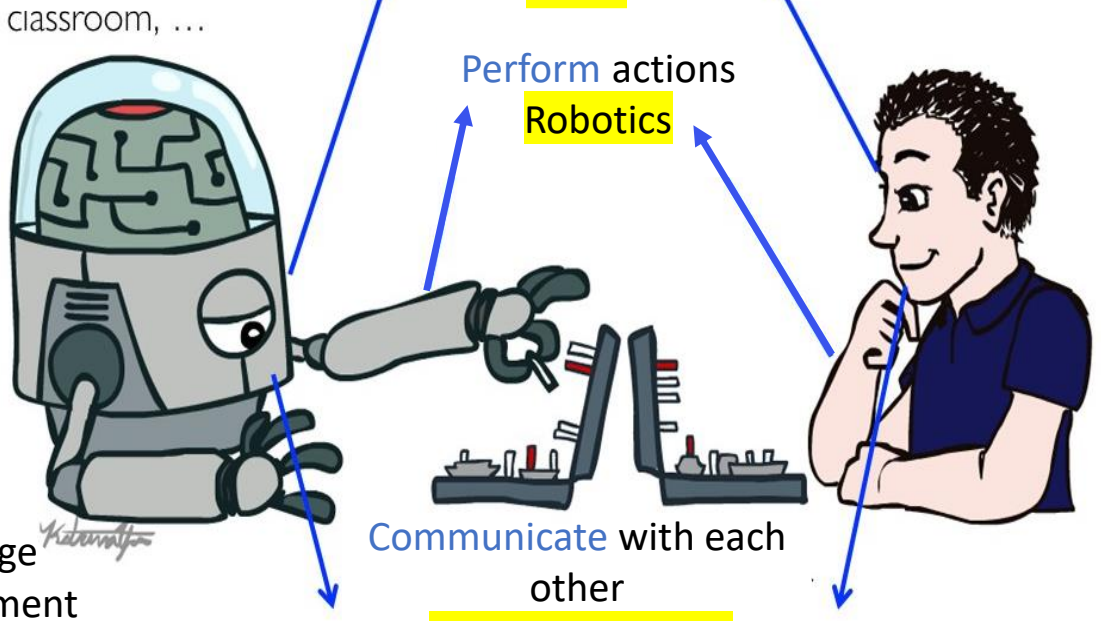
Reasoning
- Inference: exam, ...
- Decision: dining hall for lunch, ...

Learning
- Learn new knowledge
- Adapt new environment

Think Like Human

Perceive the world
Computer vision

Perform actions
Robotics



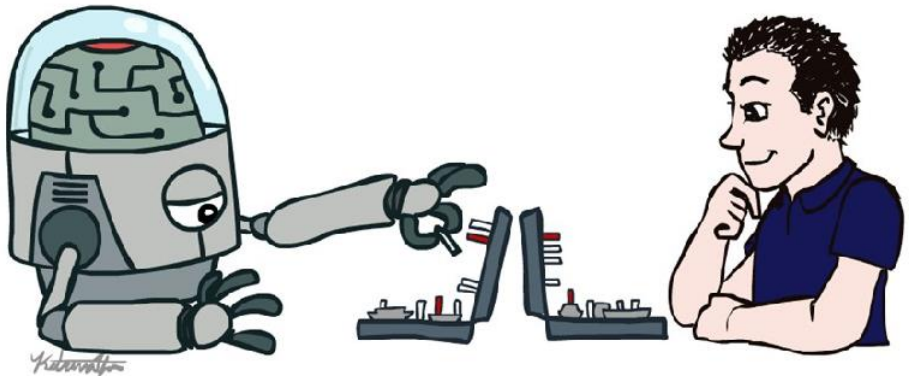
Communicate with each other
Natural language Processing

Act Like Human

Rational Agent

Are We There Yet

Machines	Human
narrow tasks, millions of examples	diverse tasks, very few examples

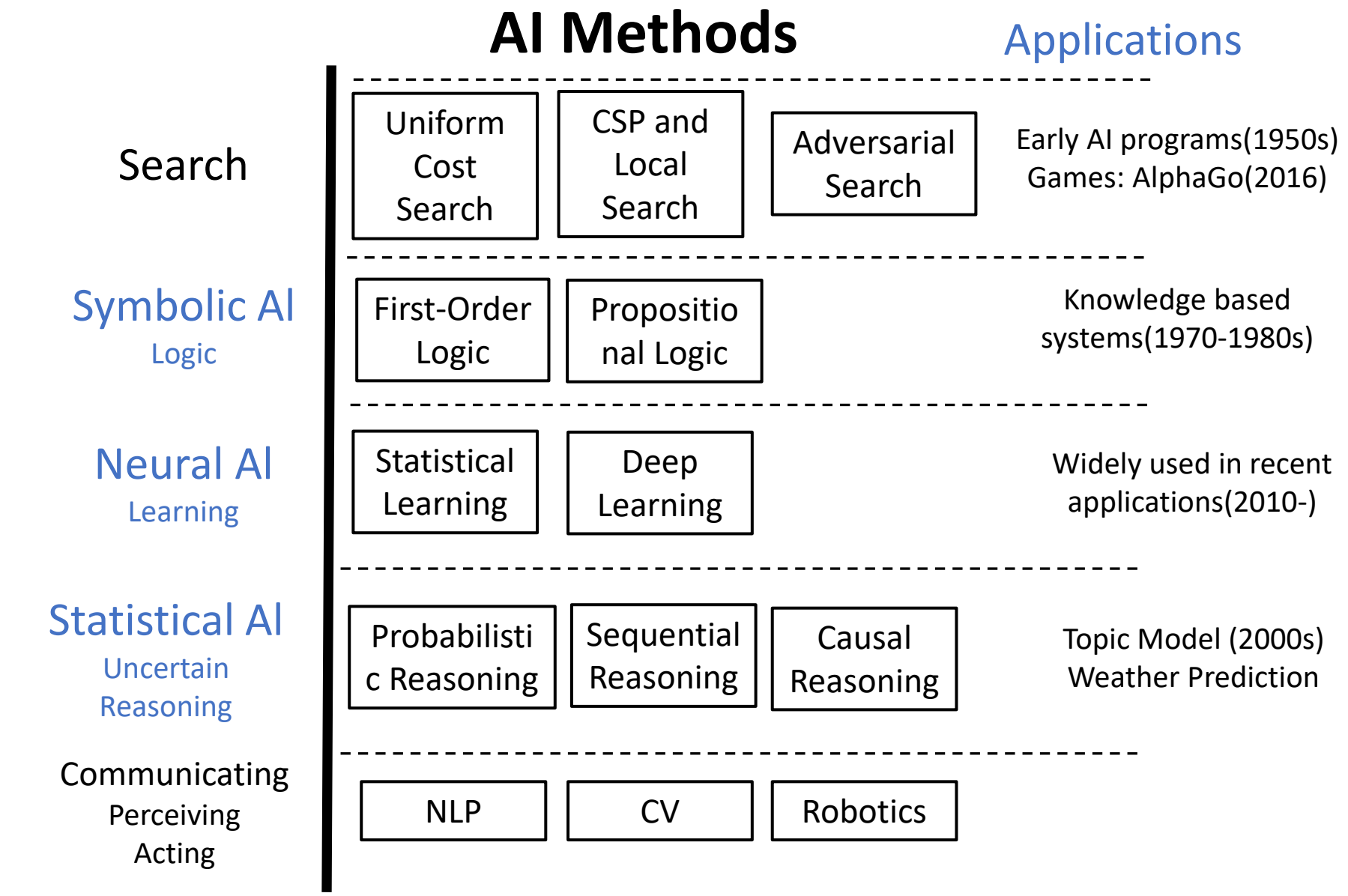


AlphaGo
- Learn from 19.6 million games
- Only play one game Go

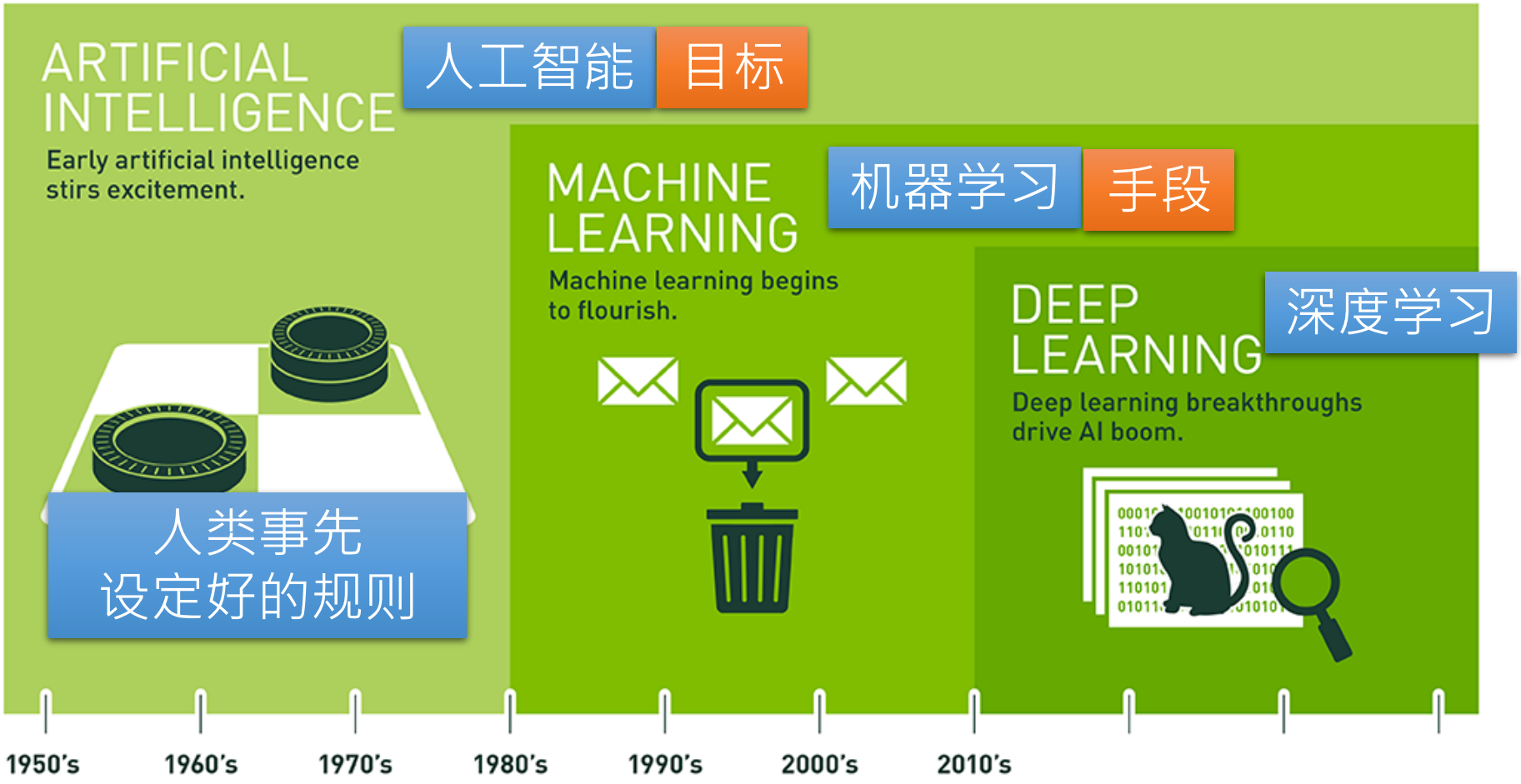
Human
- Learn from wide set of experiences
- Do lot of tasks

We are still very far away from Artificial General Intelligence (AGI).

Towards AI


AI Methods
Applications
Search
Uniform Cost Search
CSP and Local Search
Adversarial Search
Early AI programs(1950s)
Games: AlphaGo(2016)
Symbolic AI
Logic
First-Order Logic
Propositio nal Logic
Knowledge based systems(1970-1980s)
Neural AI
Learning
Statistical Learning
Deep Learning
Widely used in recent applications(2010-)
Statistical AI
Uncertain Reasoning
Probabilisti c Reasoning
Sequential Reasoning
Causal Reasoning
Topic Model (2000s)
Weather Prediction
Communicating
Perceiving
Acting
NLP
CV
Robotics

什么是
机器学习？



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Source of image: https://blogs.nvidia.com.tw/2016/07/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

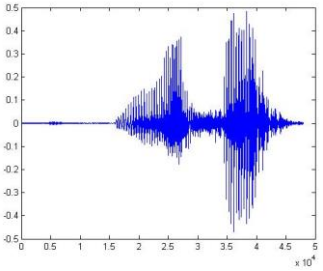
人类事先设定好的规则（rule-based）

- E.g. You want to build a Chat-bot …
  - If there is “turn off” in the input, then “turn off the music” (hand-crafted rules)
    - You can say “Please turn off the music” or “Can you turn off the music?”. Smart?
    - What if someone says “Please don’t turn off the music” ……
- Weakness of hand-crafted rules
  - Hard to consider all possibilities
    - 永远无法超越创造者
  - Lots of human efforts (not suitable for small industry)

人类事先设定好的规则

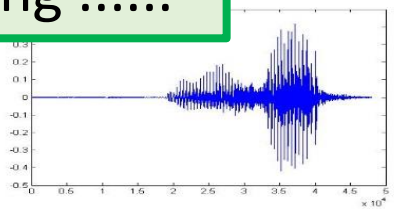
- AI?

机器学习登场！
（learning-based）

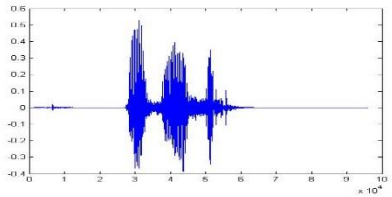


You said “Hello”

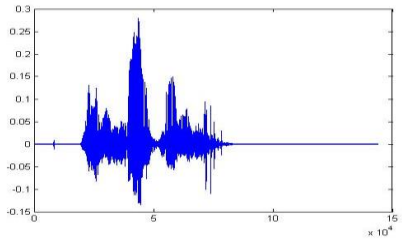
Learning ……



“Hi”



“How are you”



“Good bye”

A large amount of audio data

You write the program for learning.

机器学习登场！

Learning .....

This is “cat”

You write the program for learning.

“monkey”

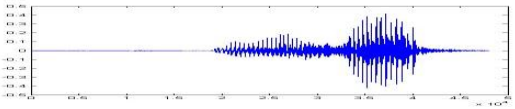
“cat”

“dog”

A large amount of images

机器学习
≈ 找一个函数的能力 根据数据

- Speech Recognition

$f($  $)=$ “How are you”

- Image Recognition

$f($  $)=$ “Cat”

- Playing Go

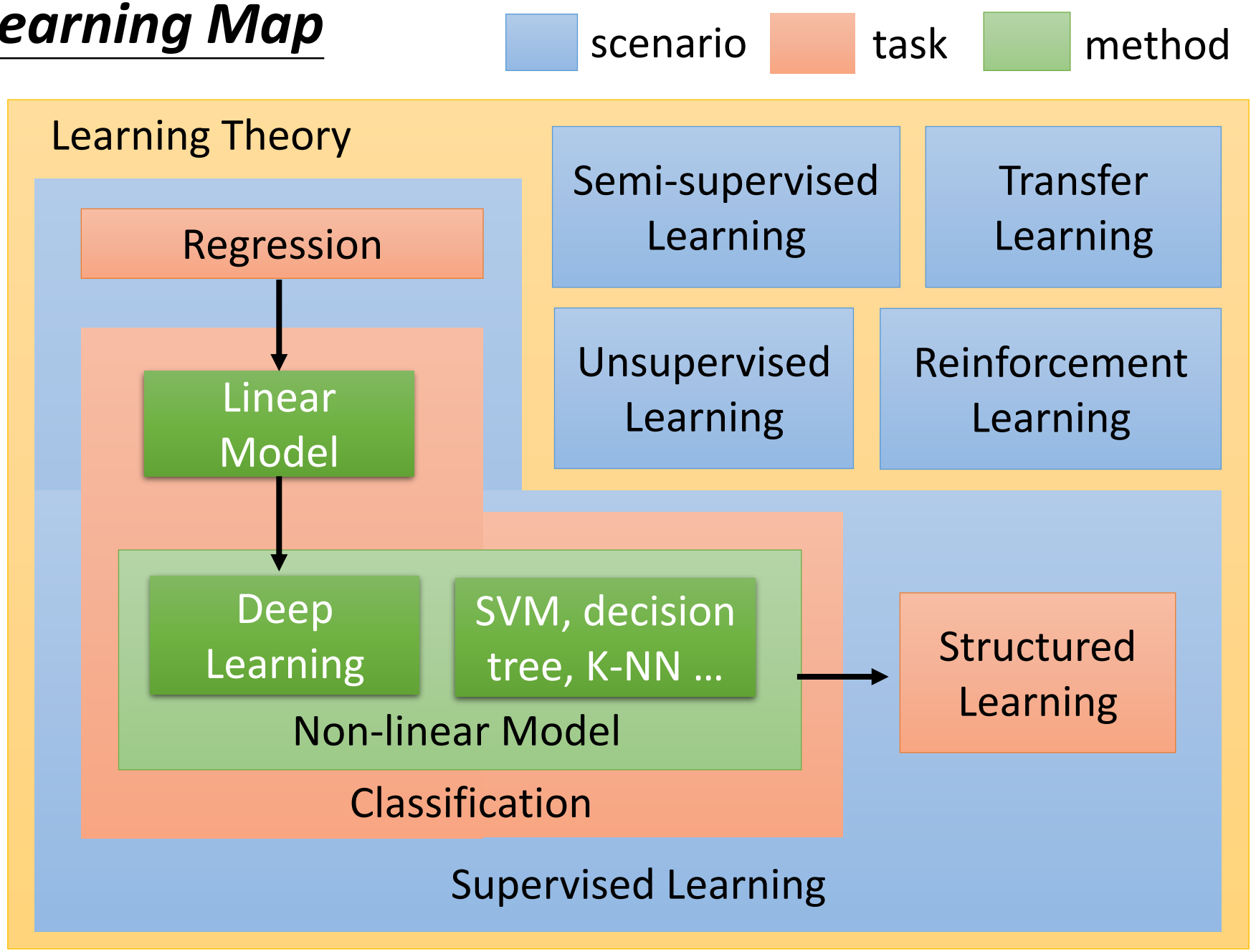
$f($  $)=$ “5-5” (next move)

- Dialogue System

$f($ “How are you?” $)=$ “I am fine.”

(what the user said) (system response)

Learning Map



Step 0

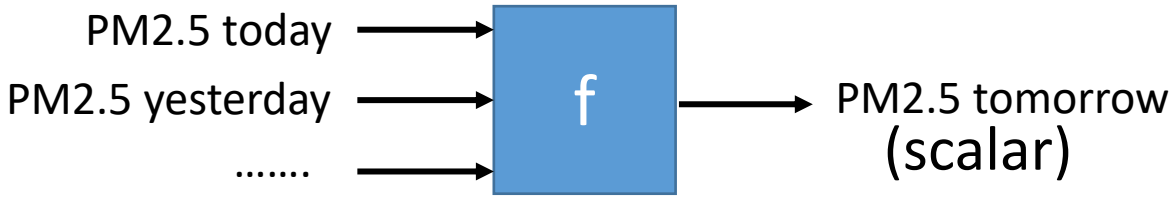
你想找
什么样的函数？

Regression (回归)

Regression

The output of the target function f is "scalar".

Predict PM2.5



Training Data:

Input:

9/01 PM2.5 = 63 9/02 PM2.5 = 65

Output:

9/03 PM2.5 = 100

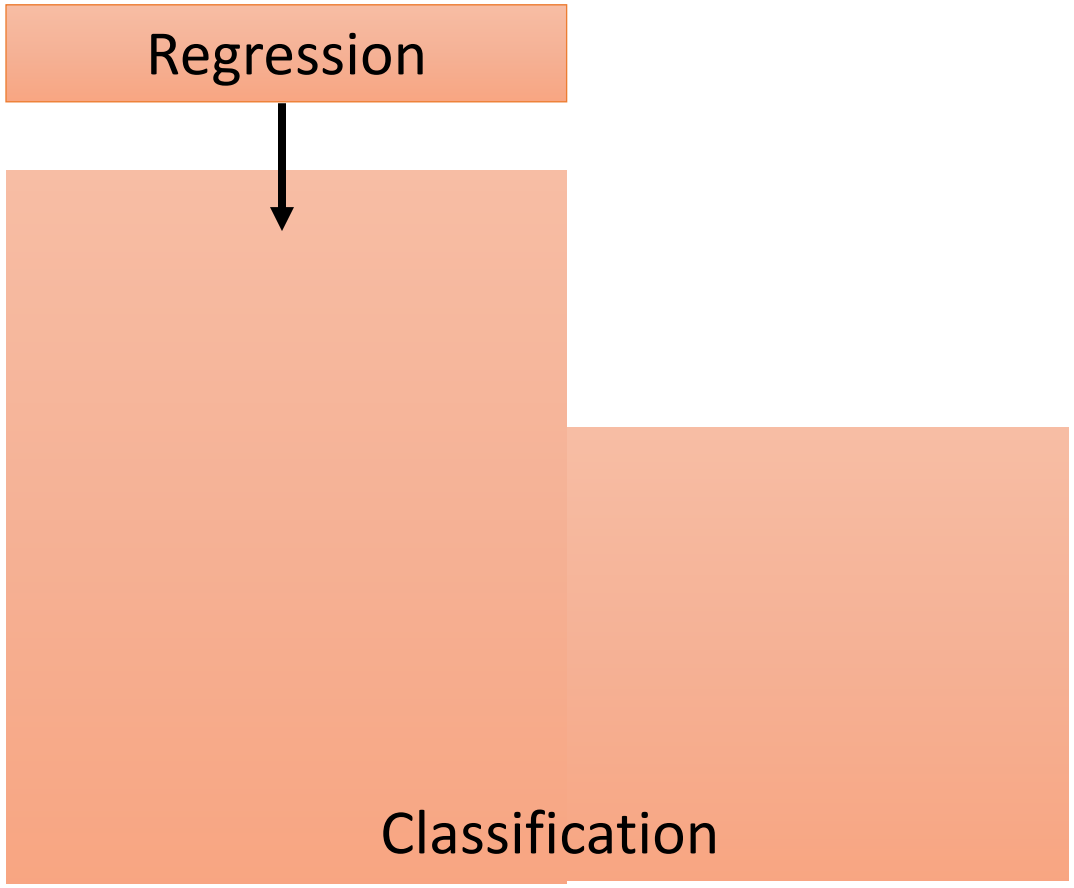
Input:

9/12 PM2.5 = 30 9/13 PM2.5 = 25

Output:

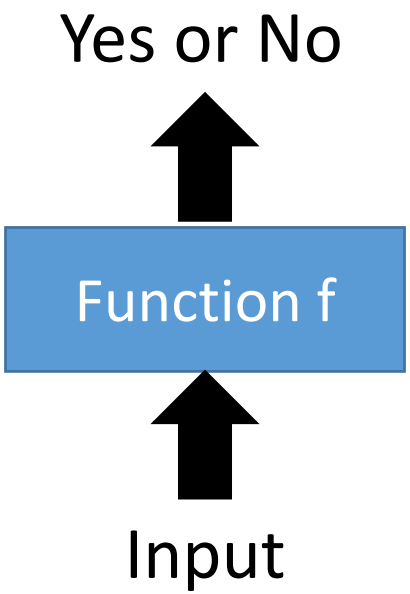
9/14 PM2.5 = 20

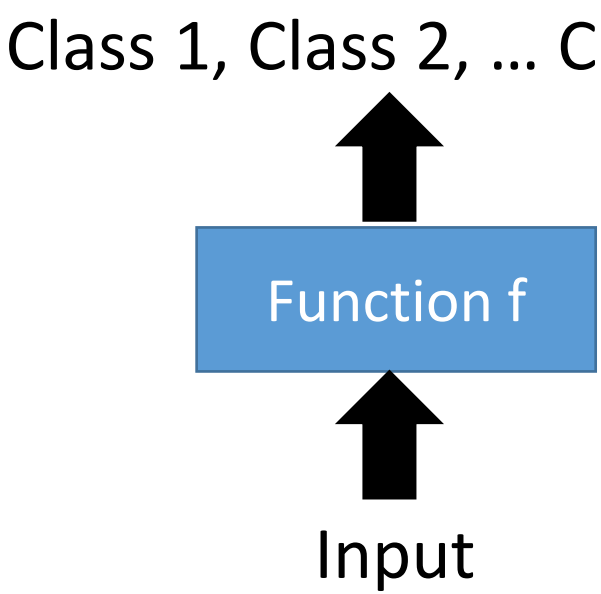
Learning Map



Classification (分类)

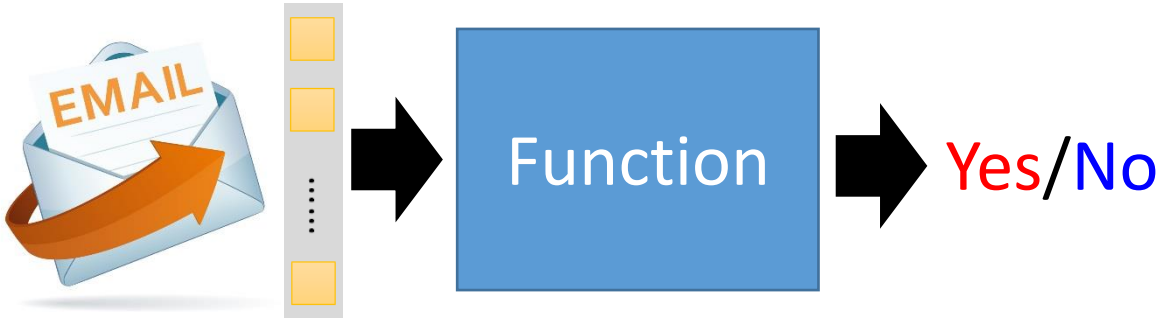
- Binary Classification (二元分类)
- Multi-class Classification (多类别分类)





二元分类

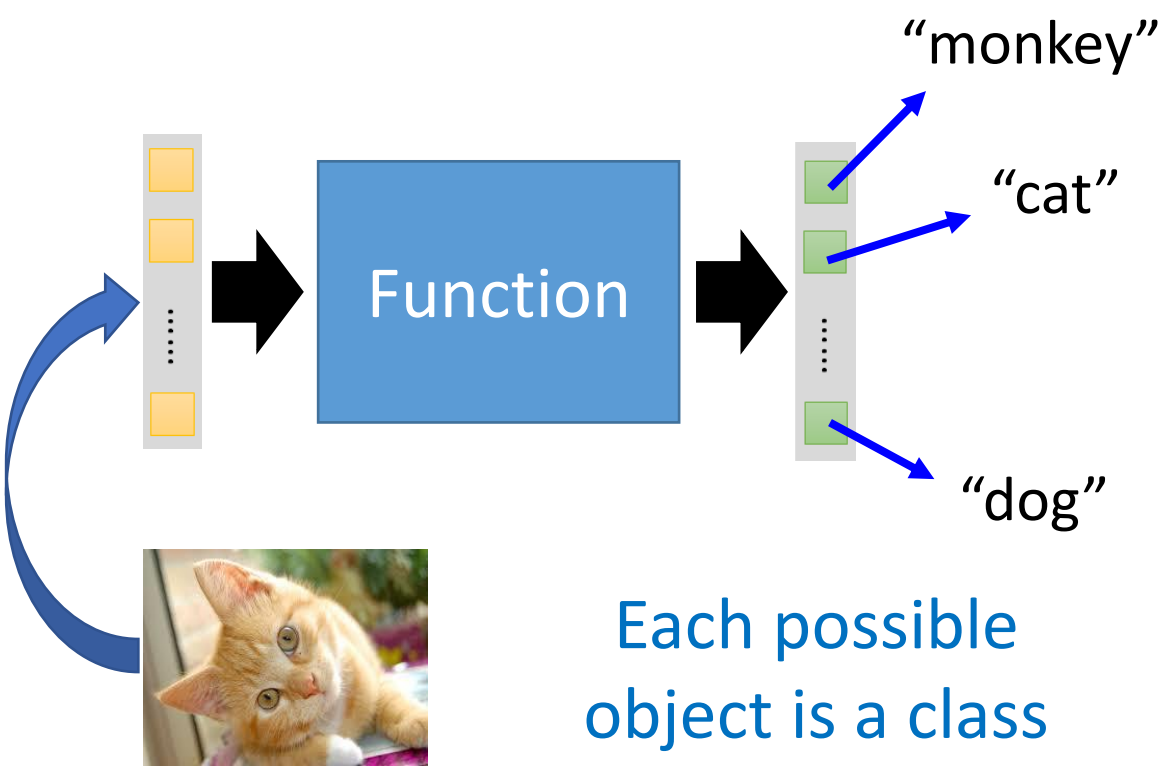
Spam filtering



Training Data

多类别分类

Image Recognition



Each possible object is a class

Training Data

多类别分类

Playing GO

Function

Each position is a class

(19 x 19 classes)

右上星位

左下星位

天元

Next move

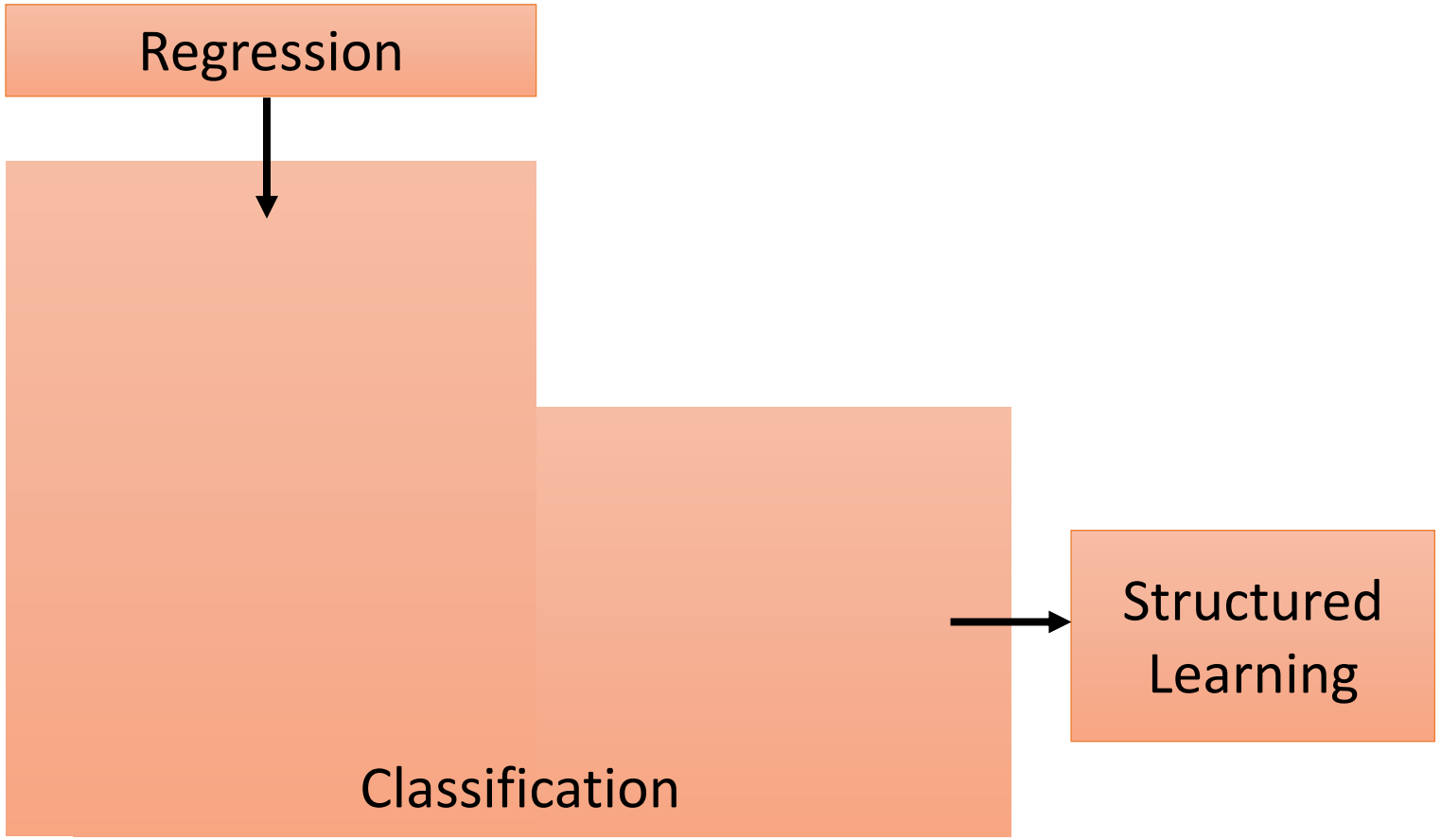
Generation (生成)

产生有结构的复杂数据
(例如：文本、图片)

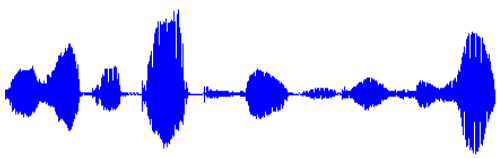
拟人化的讲法—创造

Regression,
Classification

Learning Map



Structured Learning - Beyond Classification



f

“大家好，欢迎大家选修机器学习”

Speech Recognition

“机器学习”

f

“Machine Learning”

Machine Translation

卡卡西

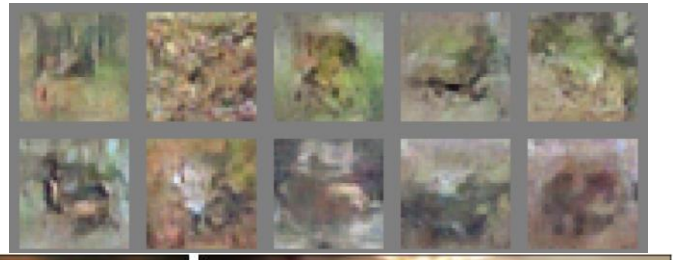
佐助

鸣人

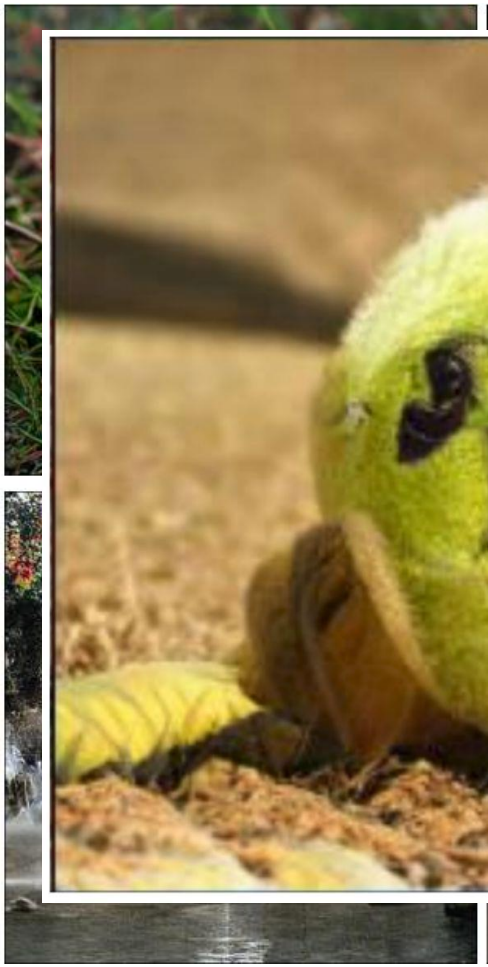
人脸识别

Image Generation

https://papers.nips.cc/paper/5423-generative-adversarial-nets.pdf

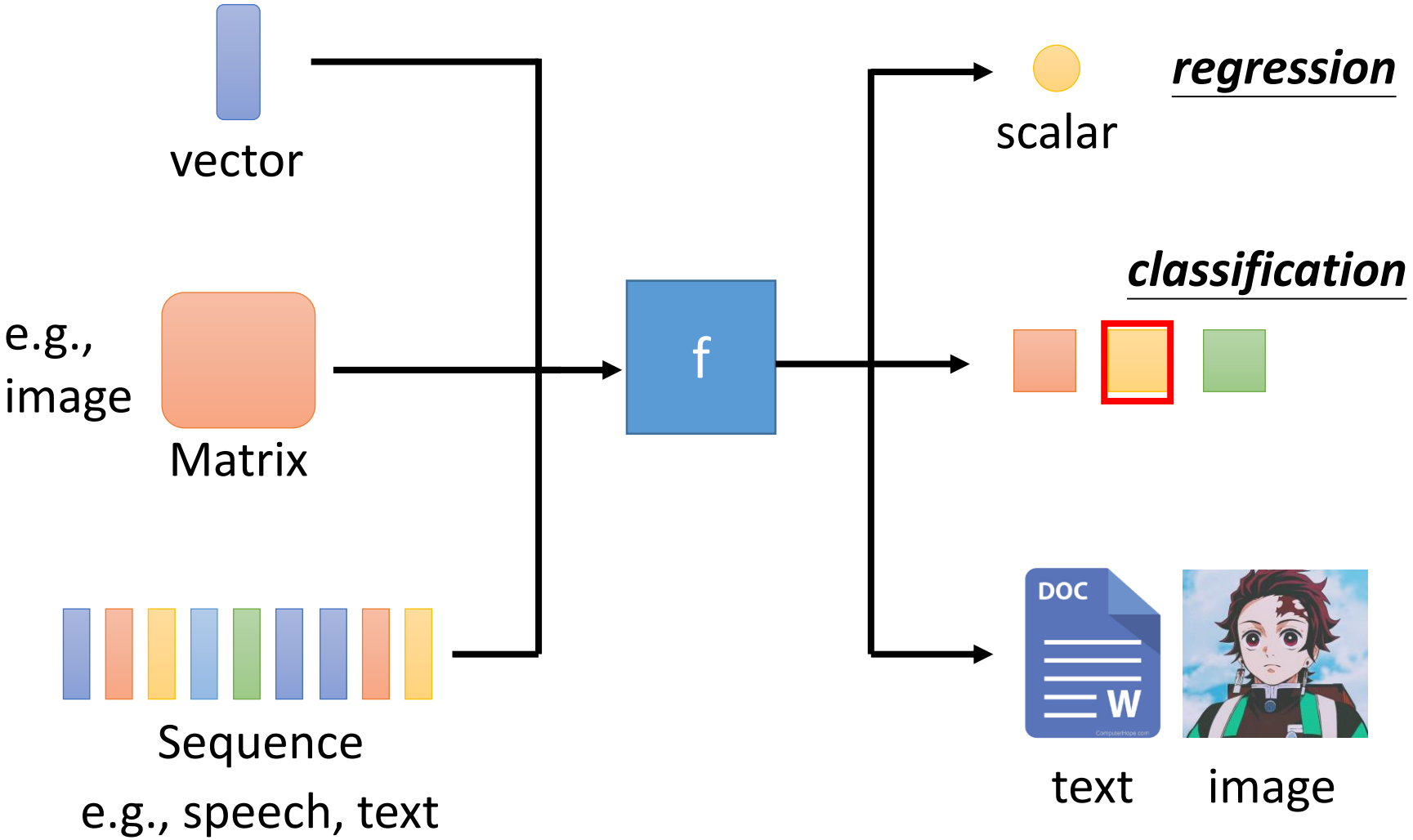


https://arxiv.org/abs/1809.11096

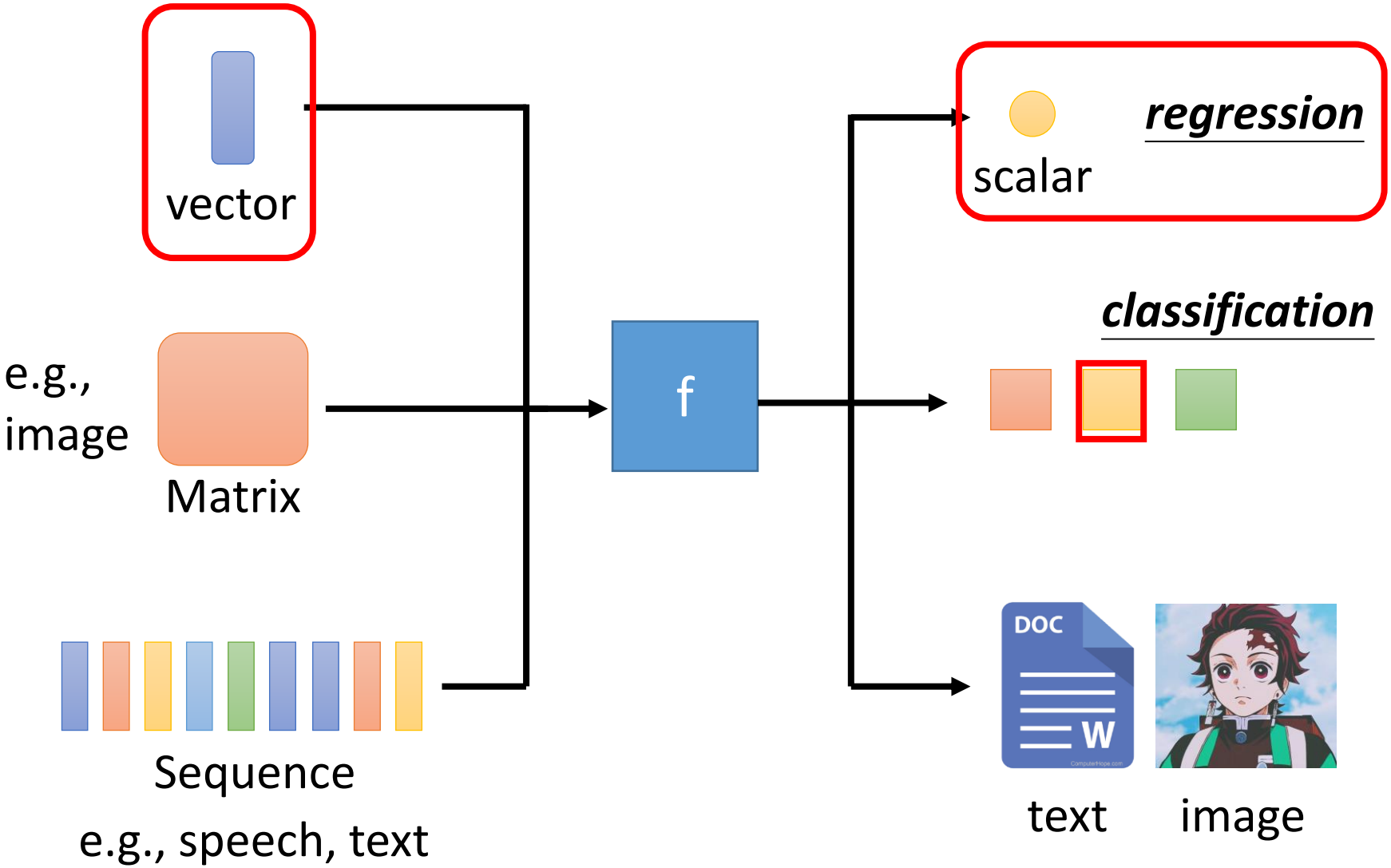


Generative Models: variational auto-encoder (VAE), generative adversarial network (GAN), Flow-based generative model, etc.

Different types of Functions



PM2.5 Prediction



Phoneme Classification

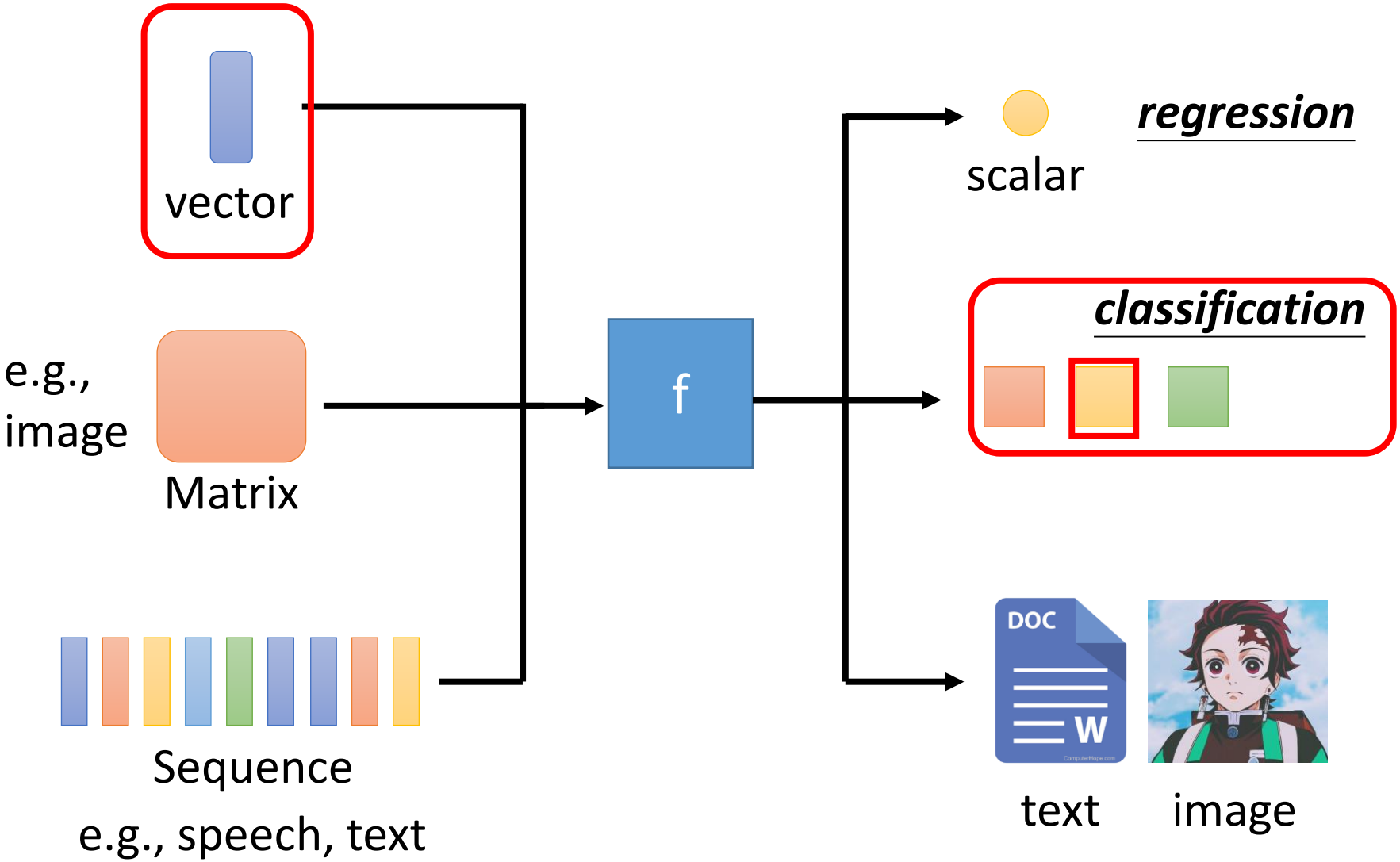
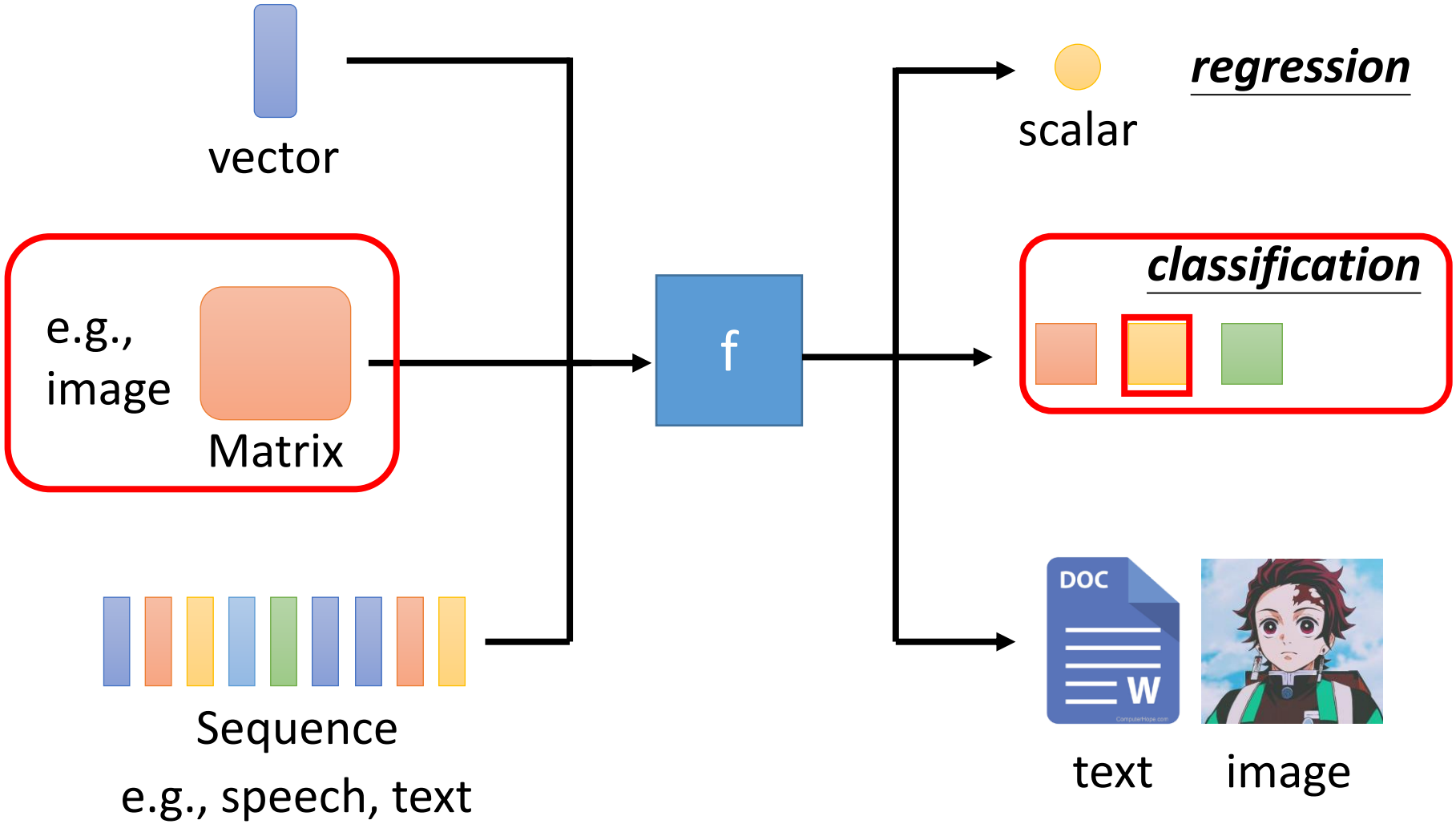
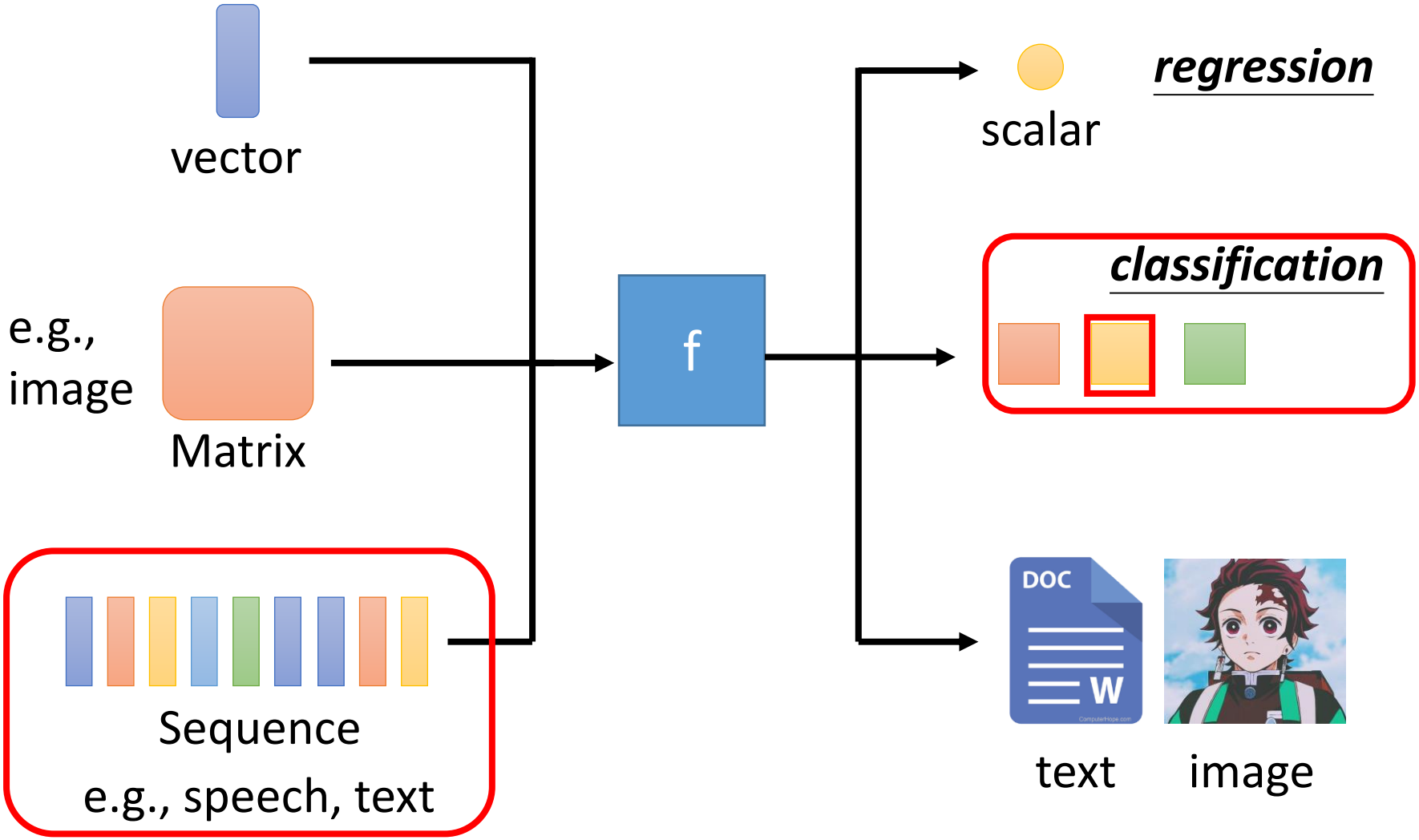


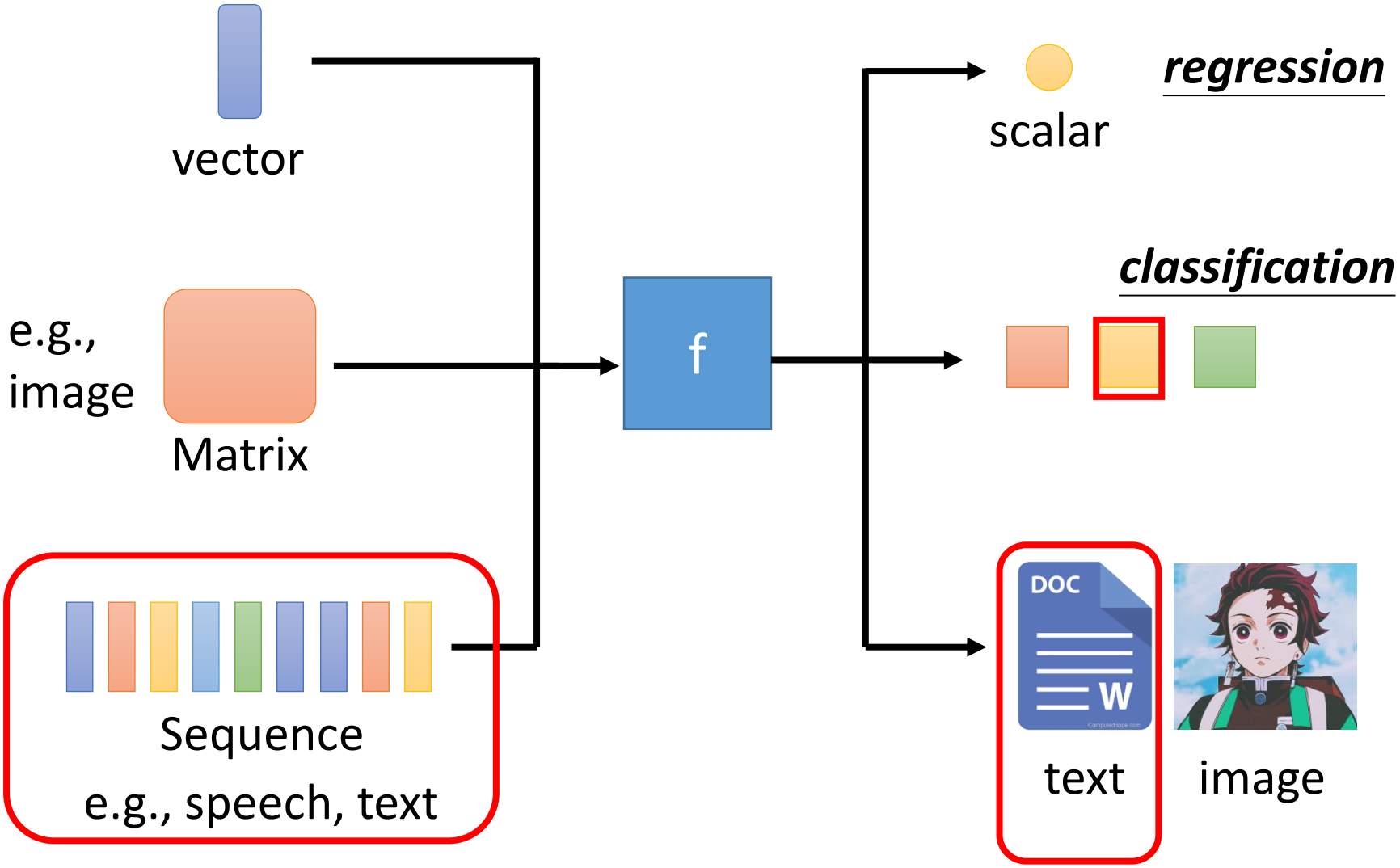
Image Classification



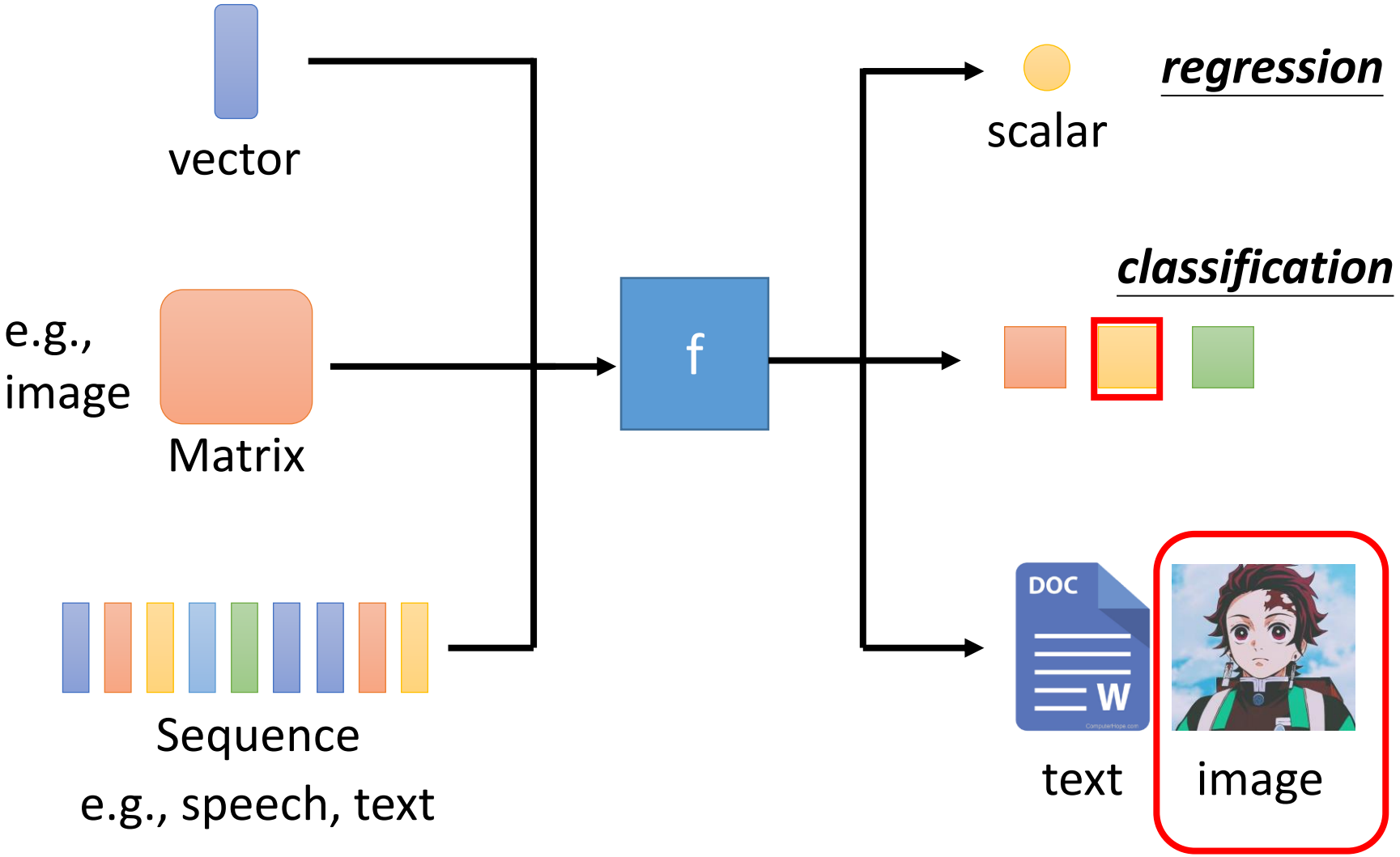
Speaker Classification



Machine Translation



Anime Face Generation

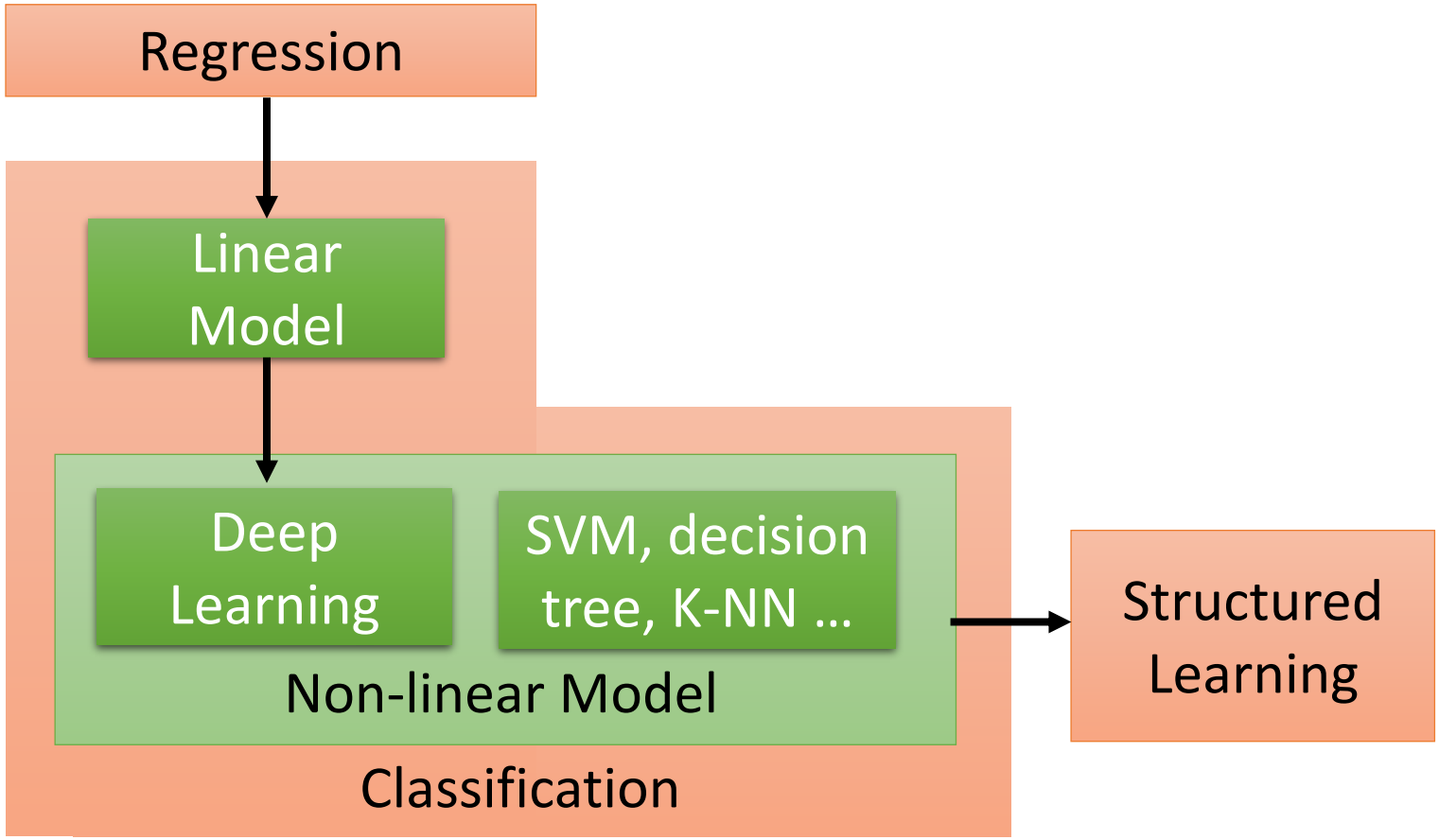


如何找到
想要的函数？

Step 1

划定一个函数集（确定一个模型）

Learning Map



Step 2

机器如何判断找到的函数好不好？（教会机器的几种方法）

Framework

Image Recognition:

$f($  $)=$ “cat”

A set of function

Model

$f_1, f_2 \cdots$

$f_1($  $)=$ “cat”

$f_2($  $)=$ “monkey”

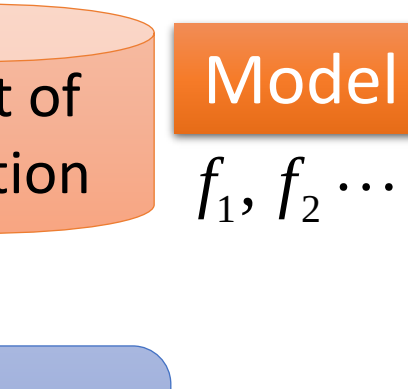
$f_1($  $)=$ “dog”

$f_2($  $)=$ “snake”

Framework

Image Recognition:

$f($  $) =$ "cat"



Model

$f_1, f_2 \cdots$

$f_1($  $) =$ "cat"

$f_2($  $) =$ "monkey"

Better!

$f_1($  $) =$ "dog"

$f_2($  $) =$ "snake"

Supervised Learning (监督学习)

function input:   

function output: "monkey" "cat" "dog"

Framework

Image Recognition:

$f($  $) =$ "cat"

Training

Testing

A set of function

Model

$f_1, f_2 \cdots$

Step 1

Goodness of function f

Step 2

Pick the "Best" Function

f^*

Step 3

Training Data

"monkey"

"cat"

"dog"

"cat"

Using f^*

Supervised Learning

x

"Cat"

y

x_1:  y_1:"Cat"

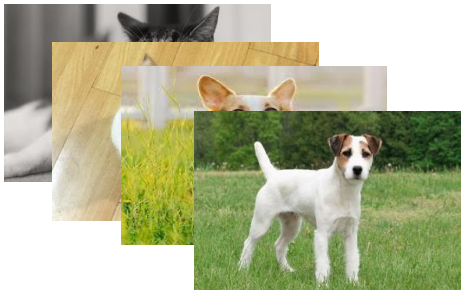
x_2:  y_2:"Cat"

x_3:  y_3:"Dog"

x_4:  y_4:"Dog"

Labelled Data

函数的 Loss



x_1 / x_2 / x_3 / x_4

f_1

Loss = 50%

“Dog”/“Dog”

/

“Dog”/“Dog”

x_1:  y_1:“Cat”

x_2:  y_2:“Cat”

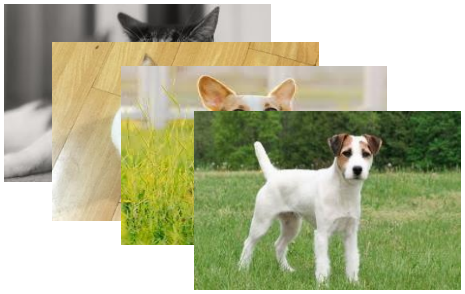
x_3:  y_3:“Dog”

x_4:  y_4:“Dog”

Labelled Data

函数的 Loss

接下来机器会自动找出 Loss 最低的函数



x_1 / x_2 / x_3 / x_4

f_2

Loss = 0%

“Cat”/“Cat”/“Dog”/“Dog”

x_1:  y_1:“Cat”

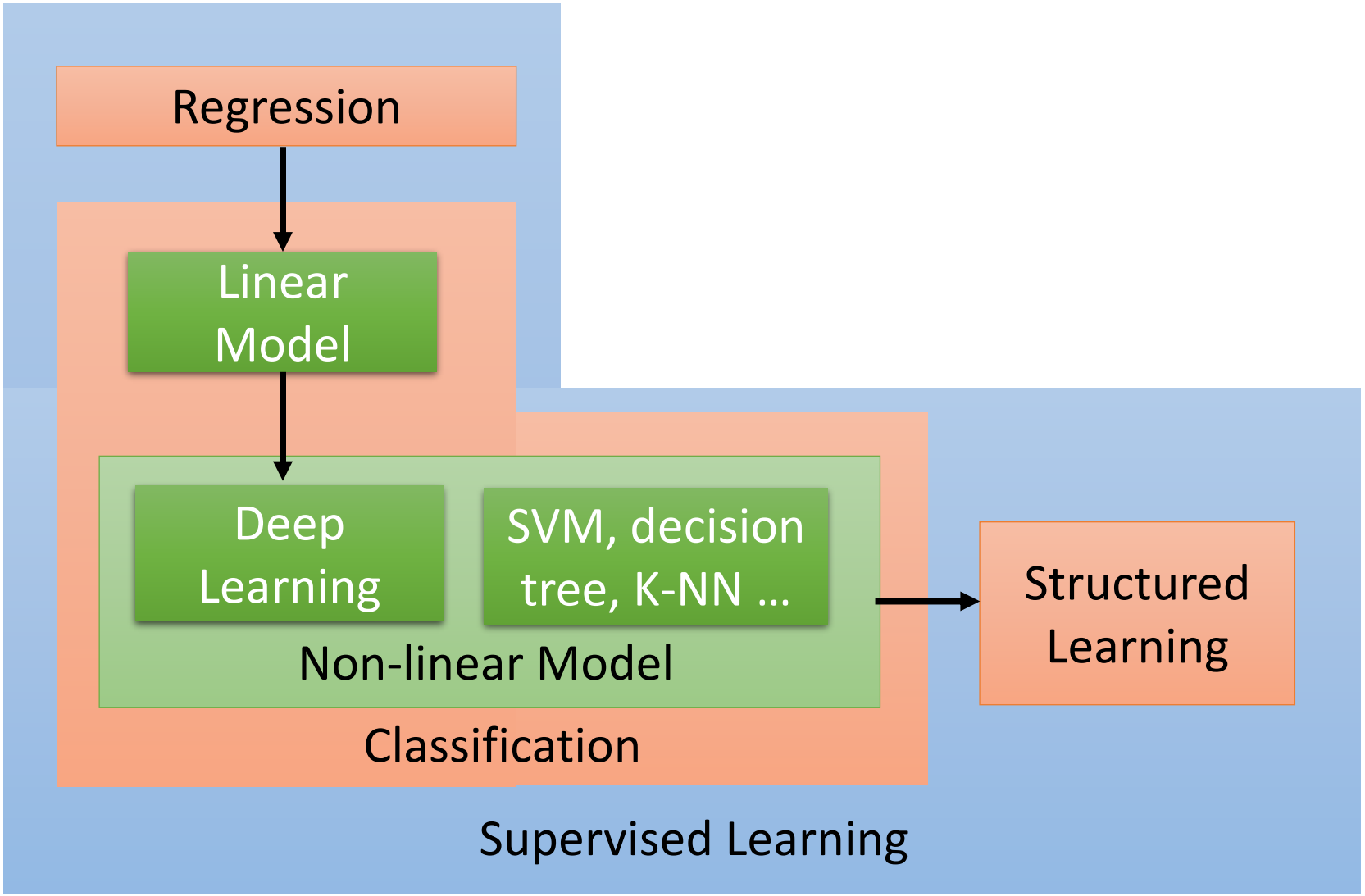
x_2:  y_2:“Cat”

x_3:  y_3:“Dog”

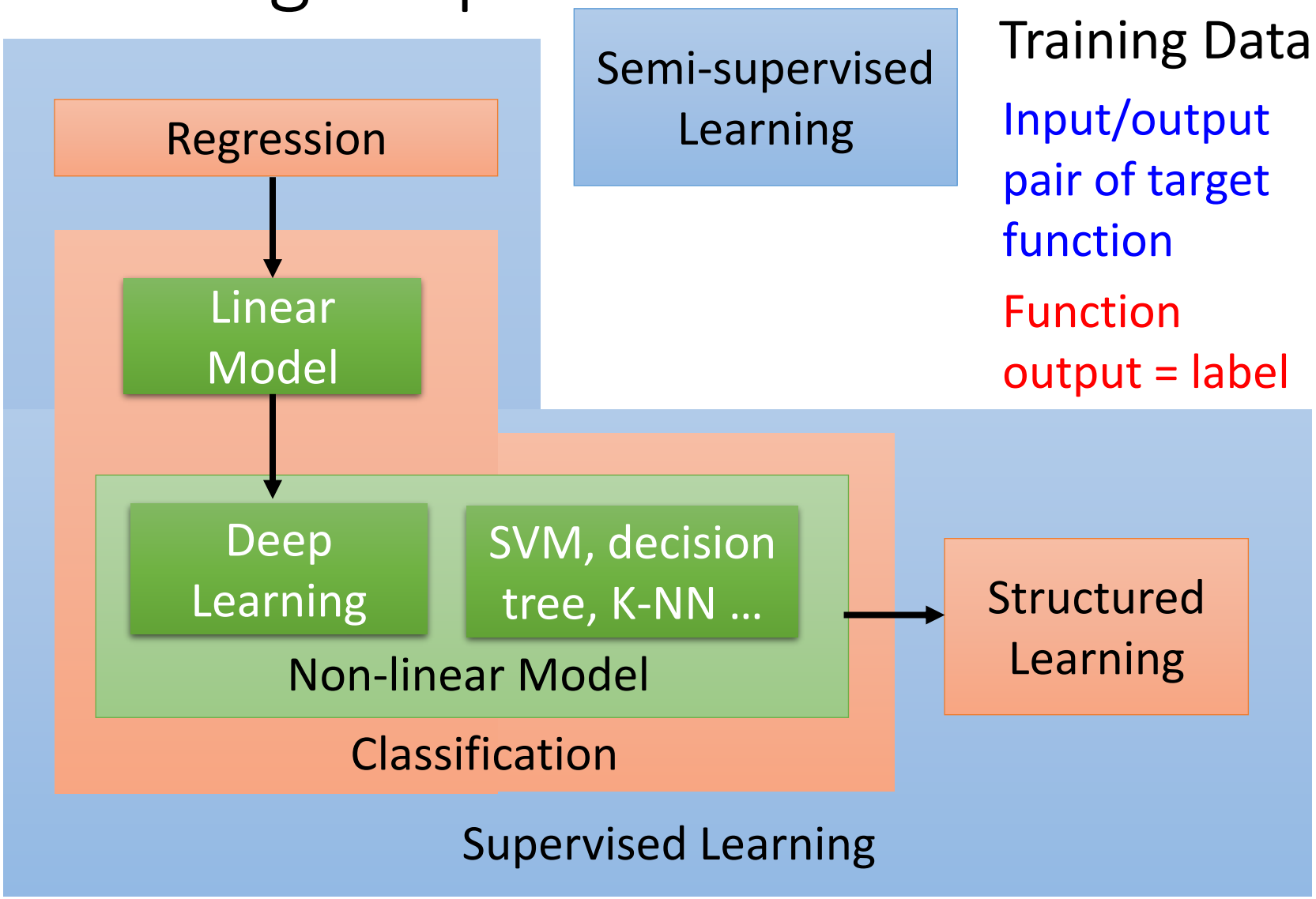
x_4:  y_4:“Dog”

Labeled Data

Learning Map



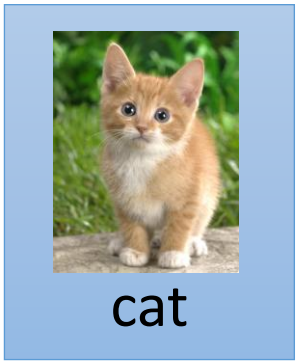
Learning Map



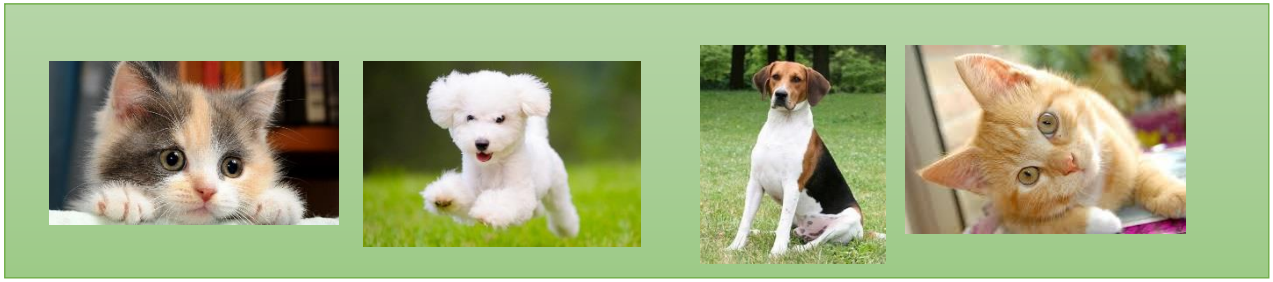
Semi-supervised (半监督学习)

For example, recognizing cats and dogs

Labelled data

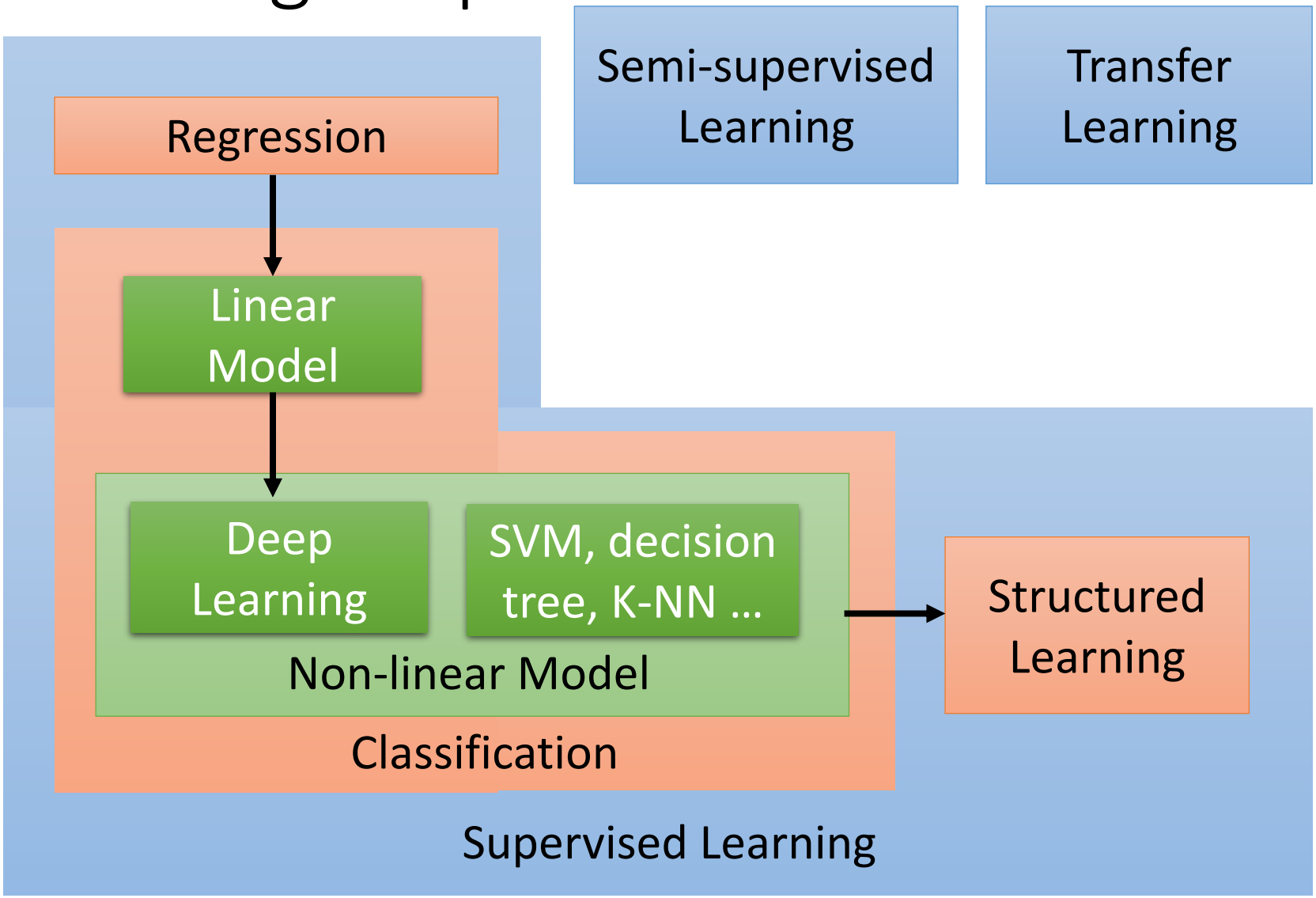


Unlabeled data



(Images of cats and dogs)

Learning Map



Transfer Learning (迁移学习)

For example, recognizing cats and dogs

Labelled data

cat

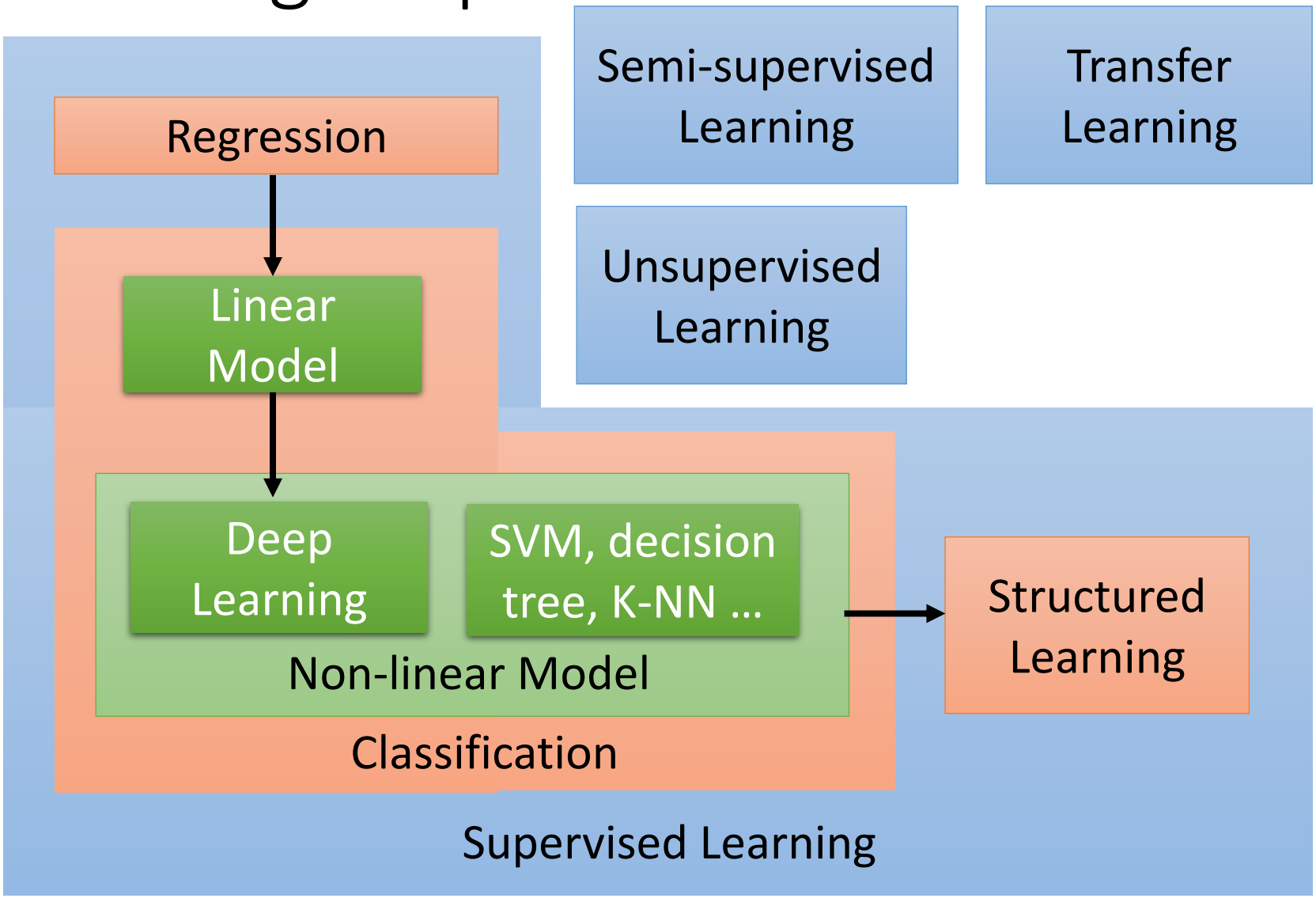
dog

elephant

Naruto

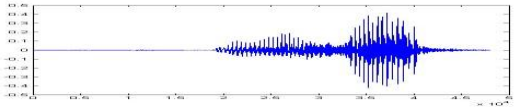
Data not related to the task considered
(can be either labeled or unlabeled)

Learning Map



Unsupervised (无监督学习)

Training AI ***without paired data***



x

Speech Recognition

"How are you"

y

Supervised

x_1: 

y_1: Hello

x_2: 

y_2: Good

x_3: 

y_3: I am fine

Unsupervised

AI listening in the environment

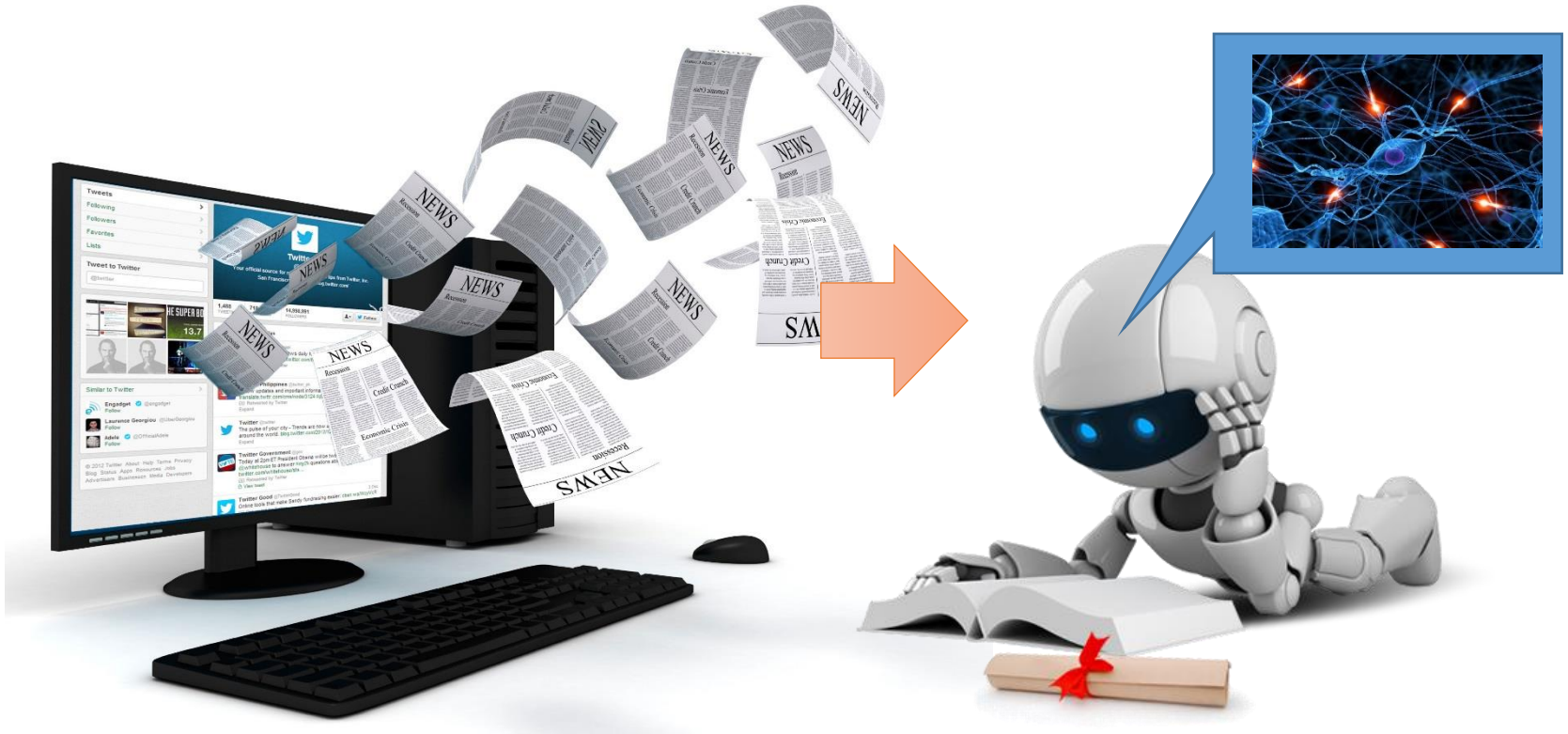
Audio x

Text y

AI reading documents on the Internet

Unsupervised (无监督学习)

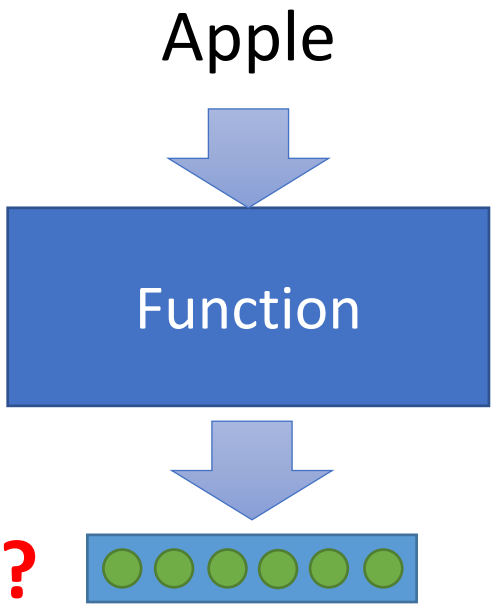
- Machine Reading: Machine learns the meaning of words from reading a lot of documents



http://top-breaking-news.com/

Unsupervised (无监督学习)

- Machine Reading: Machine learns the meaning of words from reading a lot of documents



Training data is a lot of text

https://garavato.files.wordpress.com/2011/11/stacksdocuments.jpg?w=490

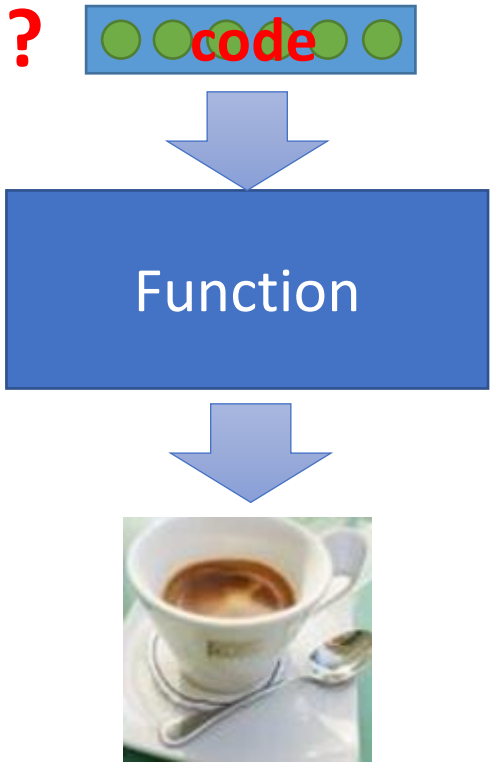
Unsupervised Learning

Draw something!

http://ttic.uchicago.edu/~klivescu/MLSLP2016/
(slides of Ian Goodfellow)

Unsupervised Learning

- Machine Drawing

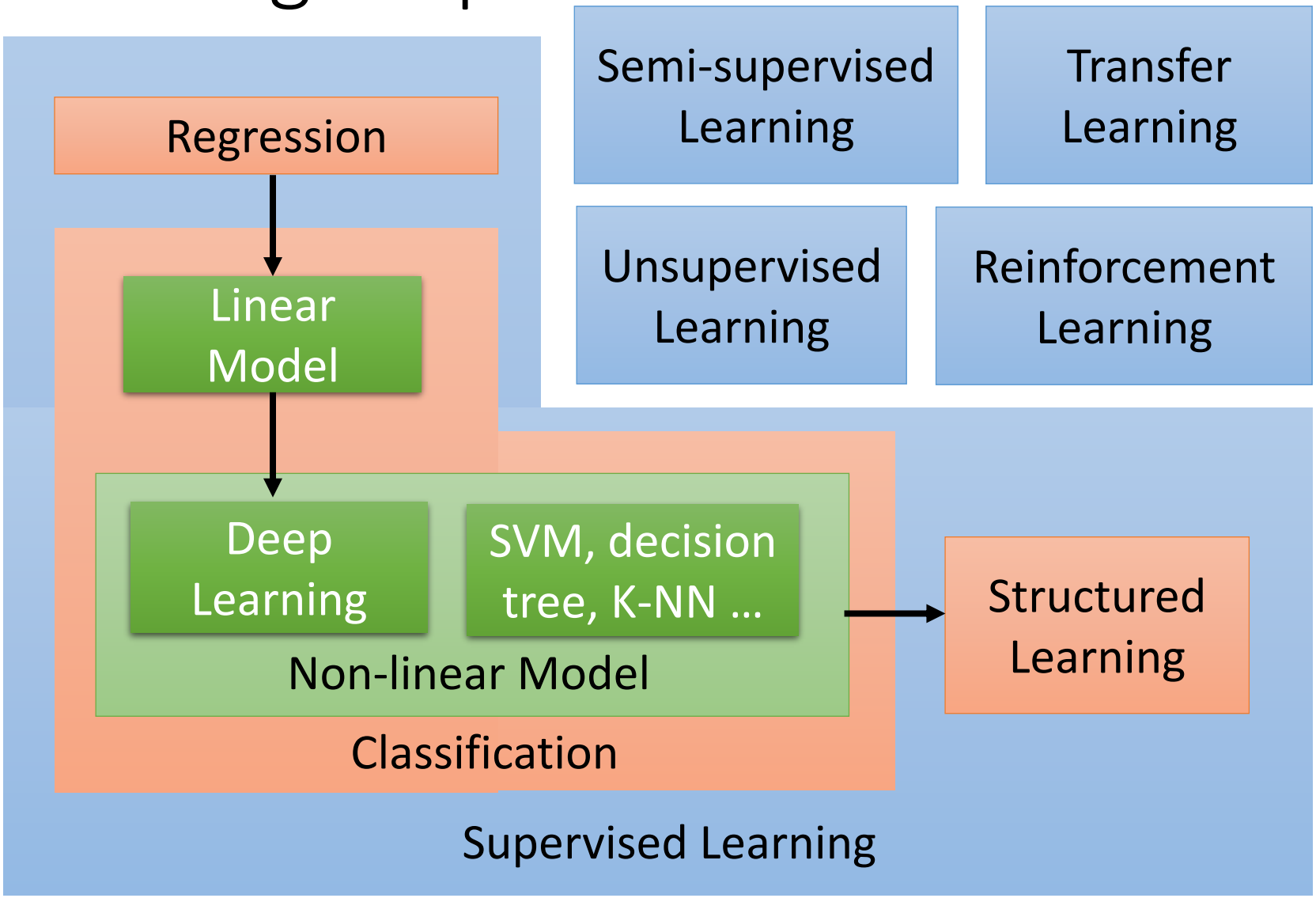


Training data is a lot of images

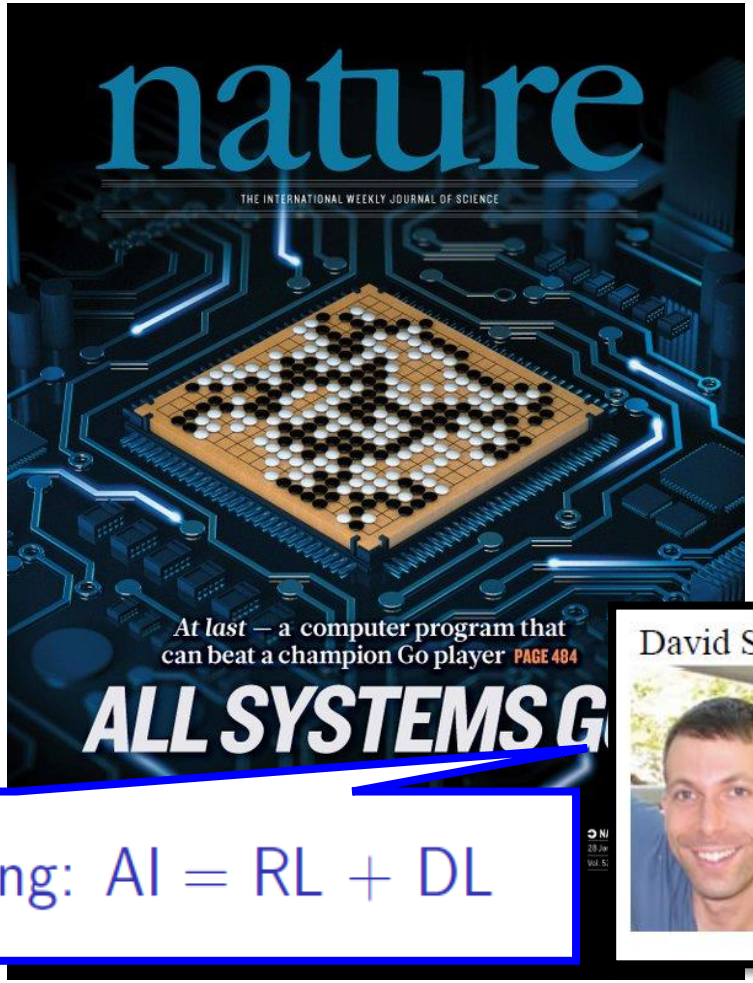
Unsupervised (无监督学习)

- Machine Reading: Machine learns the meaning of words from reading a lot of documents
- ELMO/BERT

Learning Map



Reinforcement Learning (强化学习)

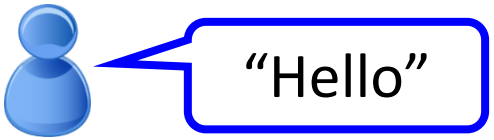


Deep Reinforcement Learning: AI = RL + DL

Supervised v.s. Reinforcement

- Supervised

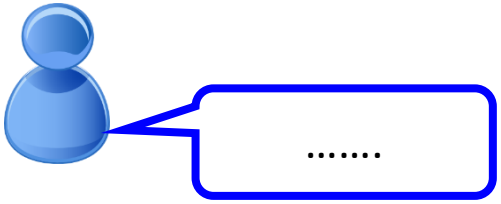
Learning from teacher

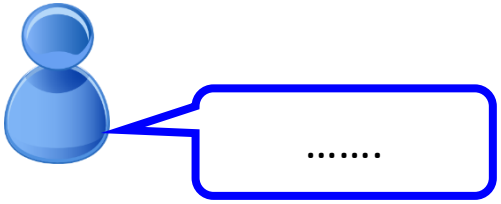


Say “Hi”

Say “Good bye”

- Reinforcement

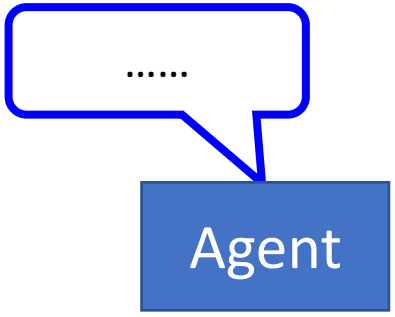




.....

Bad

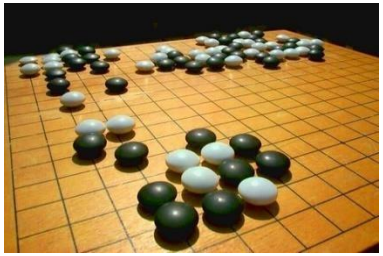
Learning from critics



Supervised v.s. Reinforcement

- Supervised:

Next move:
"5-5"



Next move:
"3-3"

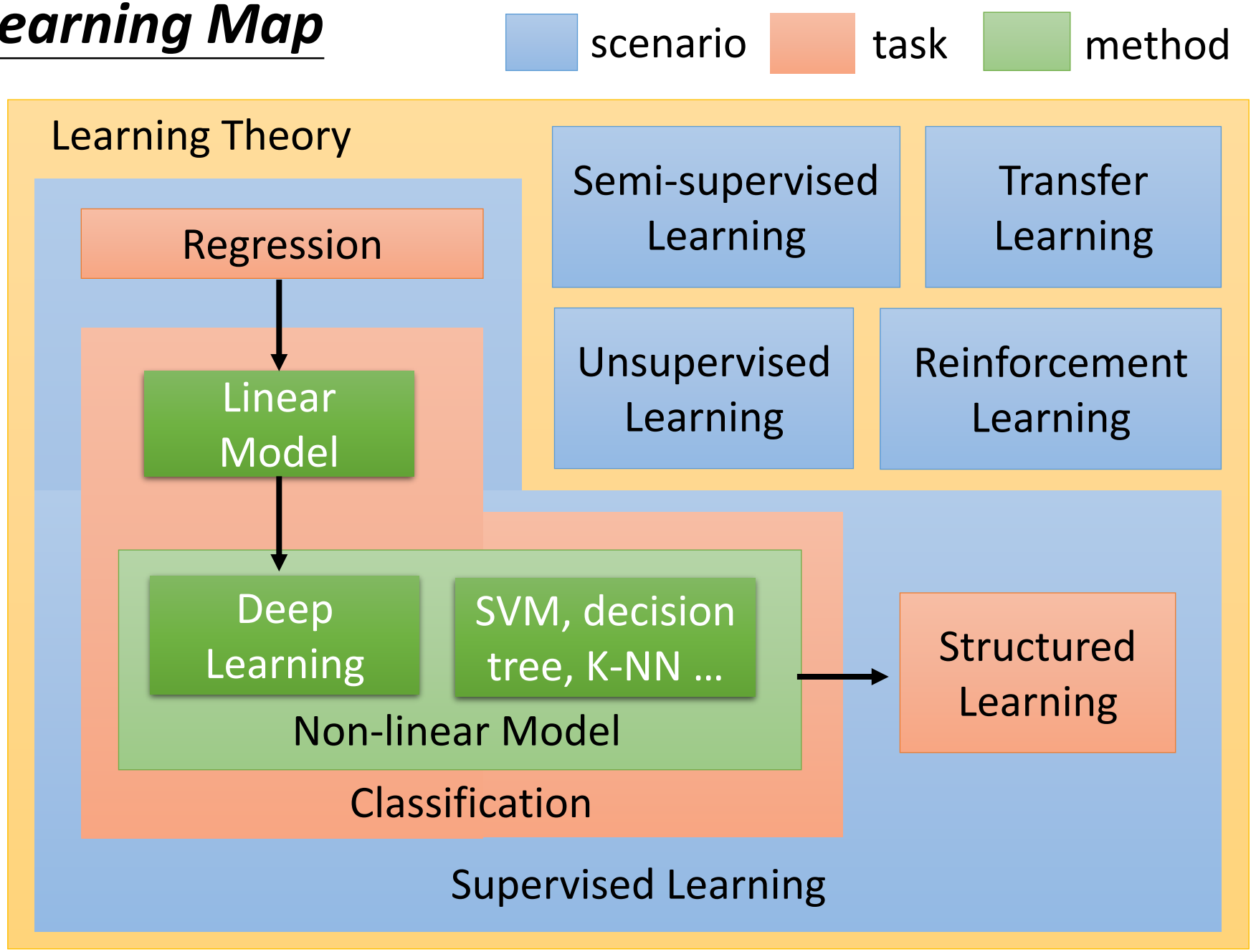
- Reinforcement Learning

(Reward)

First move → …… many moves …… → Win!

Alpha Go is supervised learning + reinforcement learning.

Learning Map



Step 3

如何找到
最好的函数？

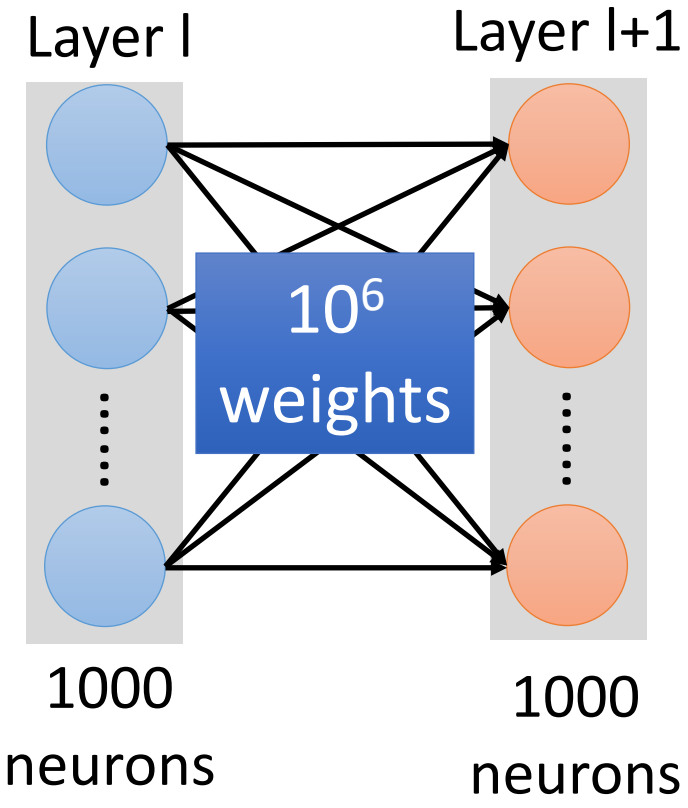
如何找出最好的 function ?

Enumerate all possible values

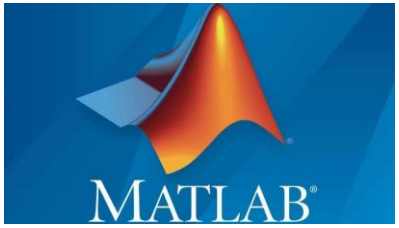
Network parameters $\theta = \{w_1, w_2, w_3, \cdots, b_1, b_2, b_3, \cdots\}$

Millions of parameters

Today a network can have more than 100M parameters.



Gradient Descent



机器学习很简单 ……

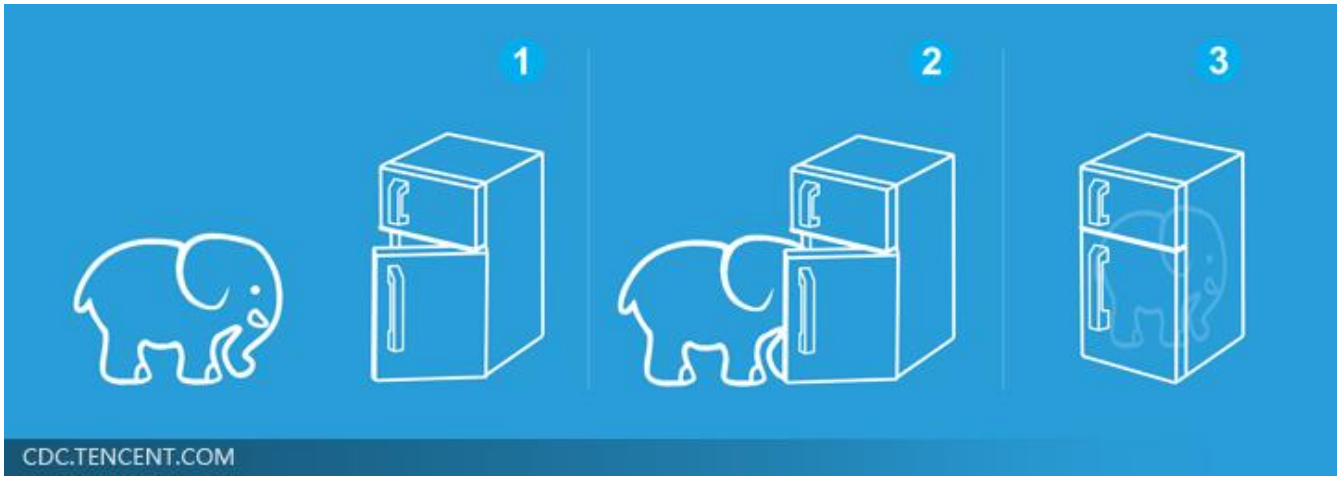
Step 0: What kind of function do you want to find?

Step 1: define a set of function

Step 2: goodness of function

Step 3: pick the best function

就好像把大象装进冰箱 ……



机器学习很简单 ……

Step 0: What kind of function do you want to find?

Regression, Classification, Generation ……

Step 1: define a set of function

Deep Learning
SVM
Decision Tree
……

Step 2: goodness of function

Supervised
Transfer
Reinforcement
……

Step 3: pick the best function

Gradient Descent
……