Intro to Artificial Intelligent

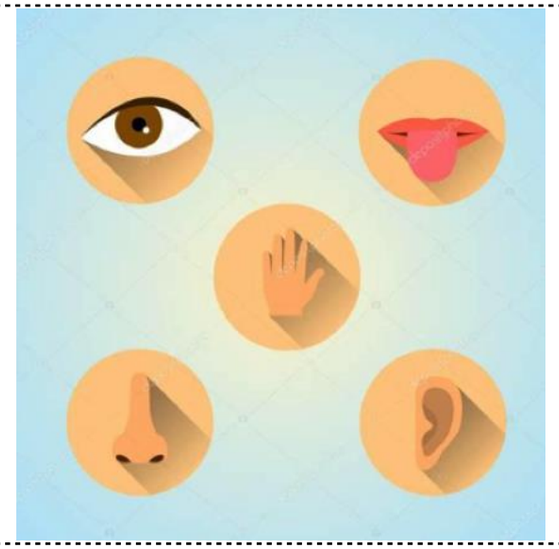
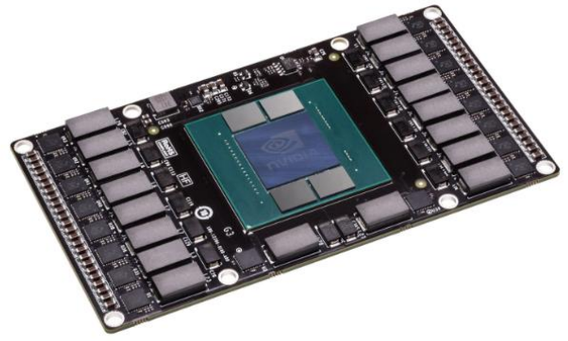
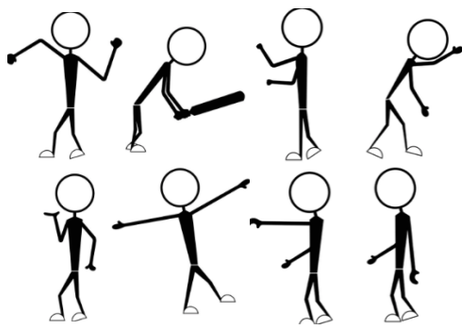
Lu Liang

What is AI?

Definition of AI

Perception, Thinking, Action

Perception/Thinking/Action in Human&Machine

	Human	Machine
Perception		
Thinking	 **Name** **Logic** **Imagine** **....**	  **Data & Algorithm**
Action	 **Speak** **Touch** **Write** **...**	  

What is their relationship? ⟶ **Model**

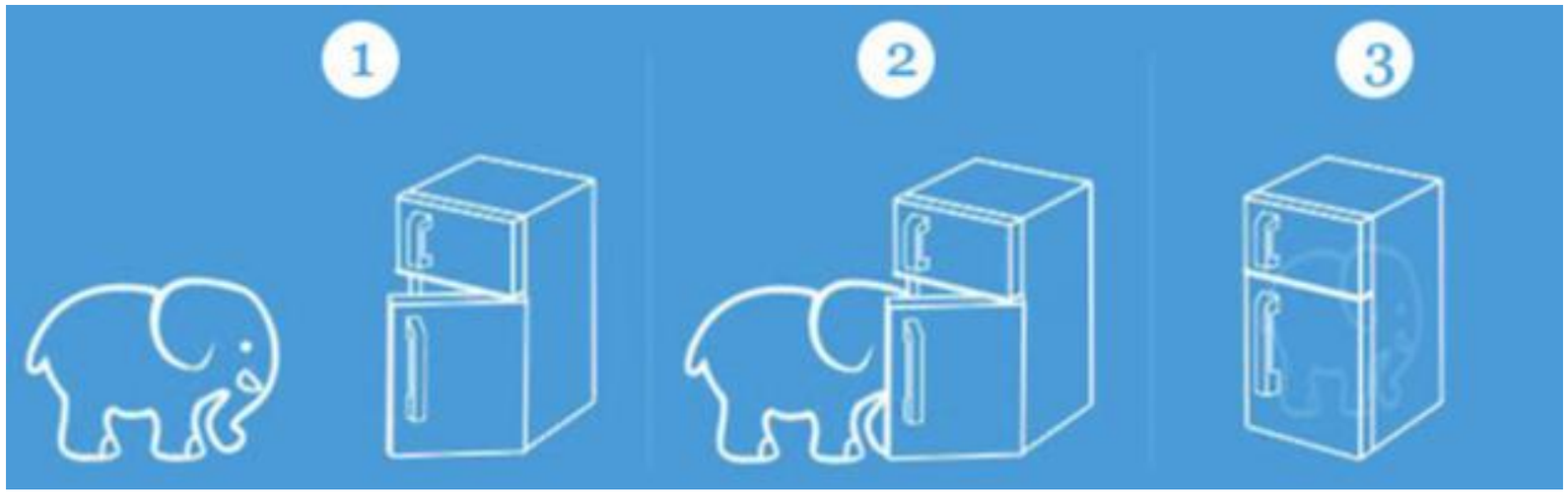
Definition of AI

Models targeted at

Perception, Thinking, Action

Representation

How many steps does it take to put an elephant in the freezer?



	Start	1	2	3
Freezer open(1)/close(0)	0	1	1	0
Elephant Inside(1)/Not inside(0)	0	0	1	1

Farmer, fox, goose, grain problem

How to represent?

Poetry Prose Proverb

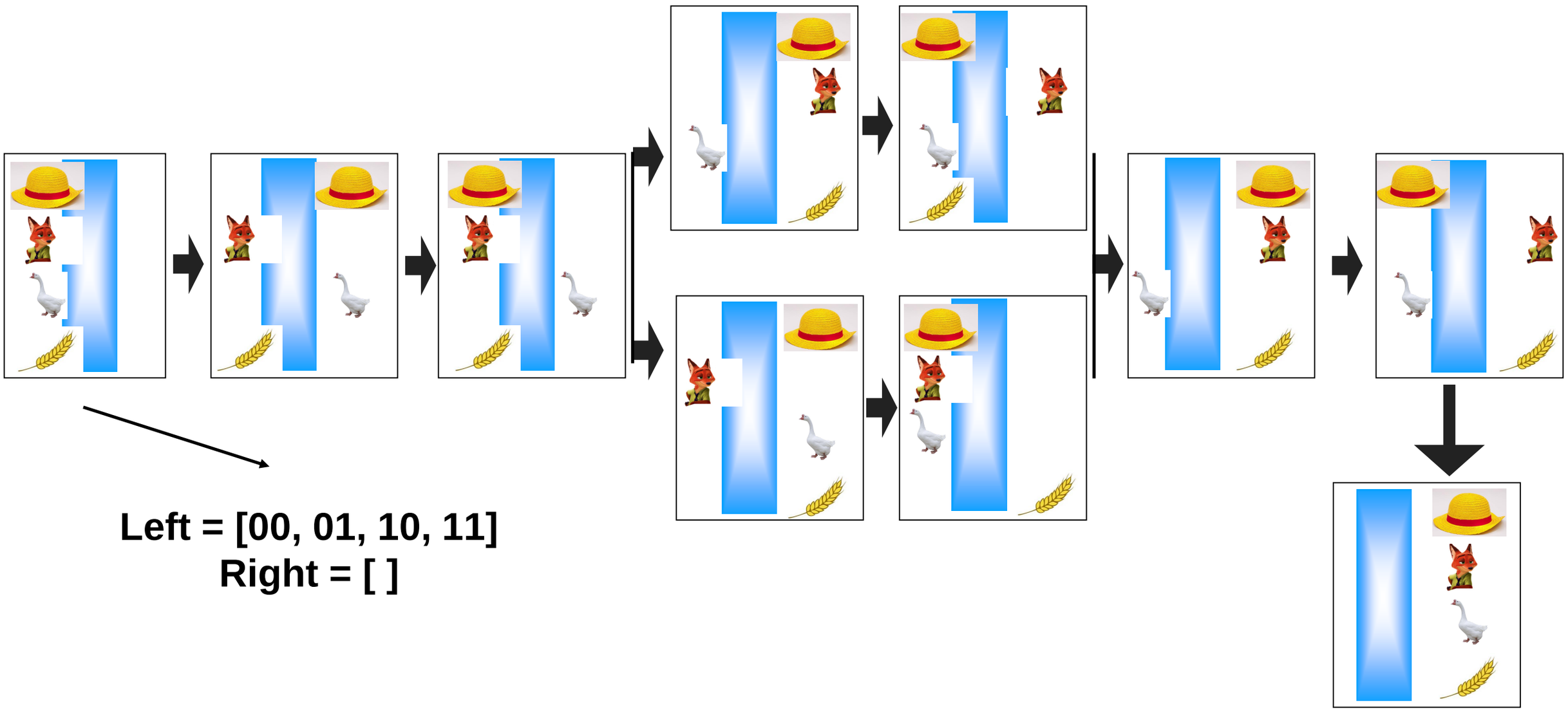
Inaccurate

00

01

10

11



Left = [00, 01, 10, 11]
Right = [ ]

Definition of AI

Algorithm enabled by

Constraints exposed by

Representations that support

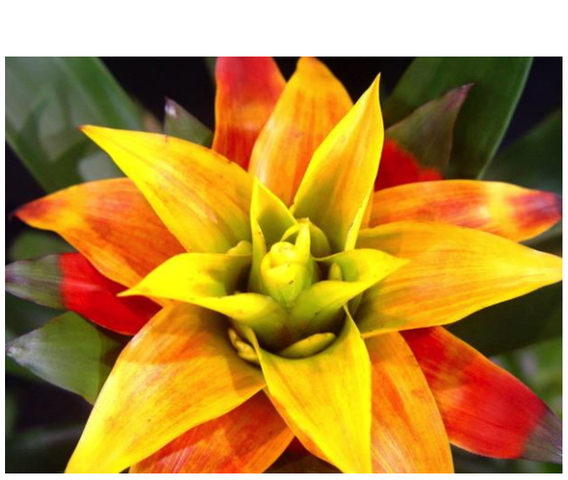
Models targeted at

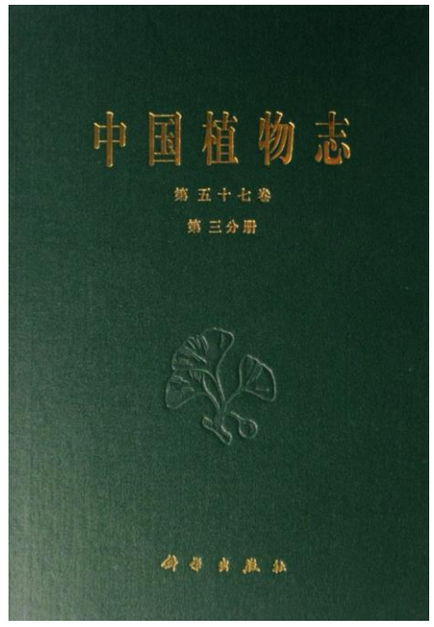
Perception, Thinking, Action

Generation and Test

The Rumpelstiltskin Principle:

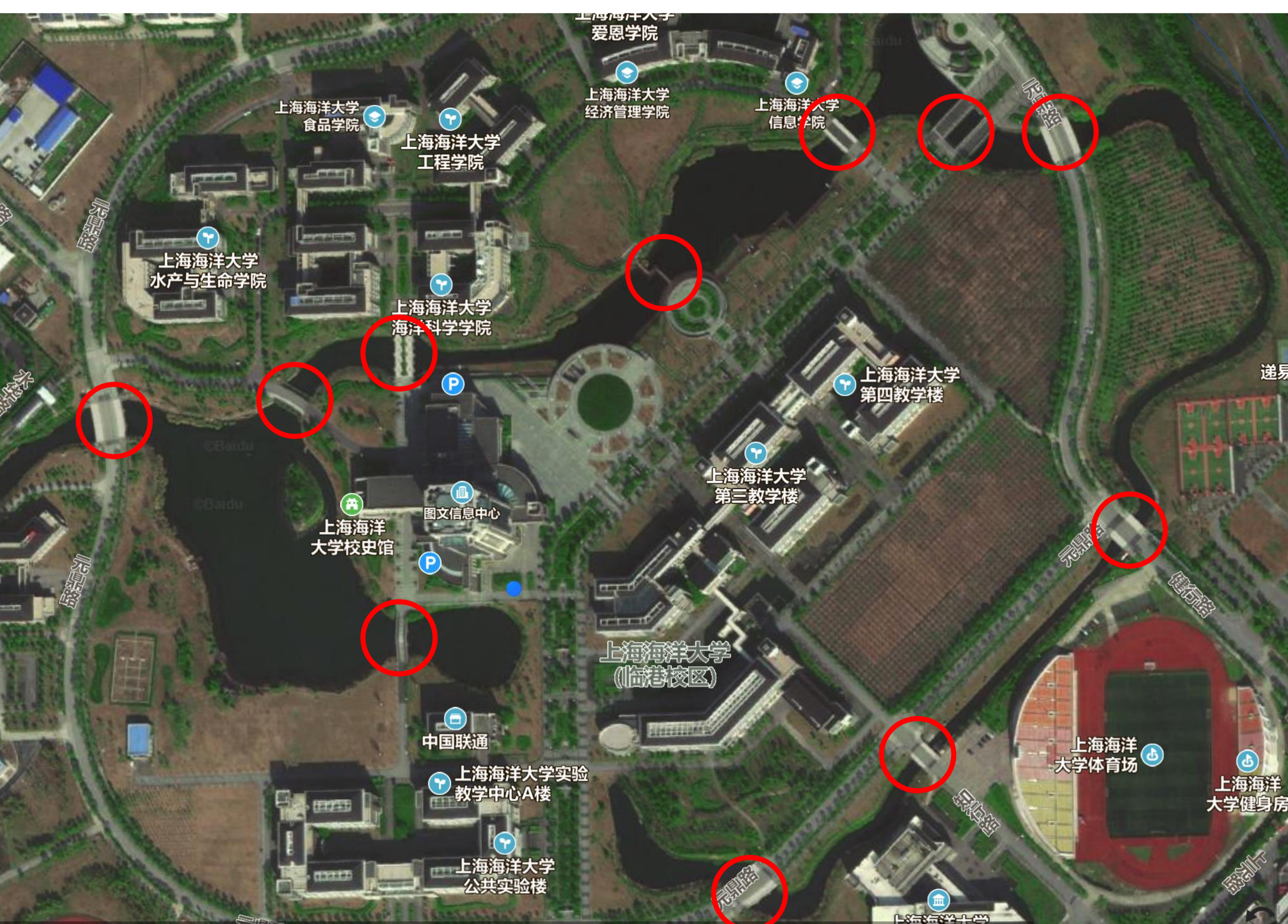
Once you can name something, You get power over it.



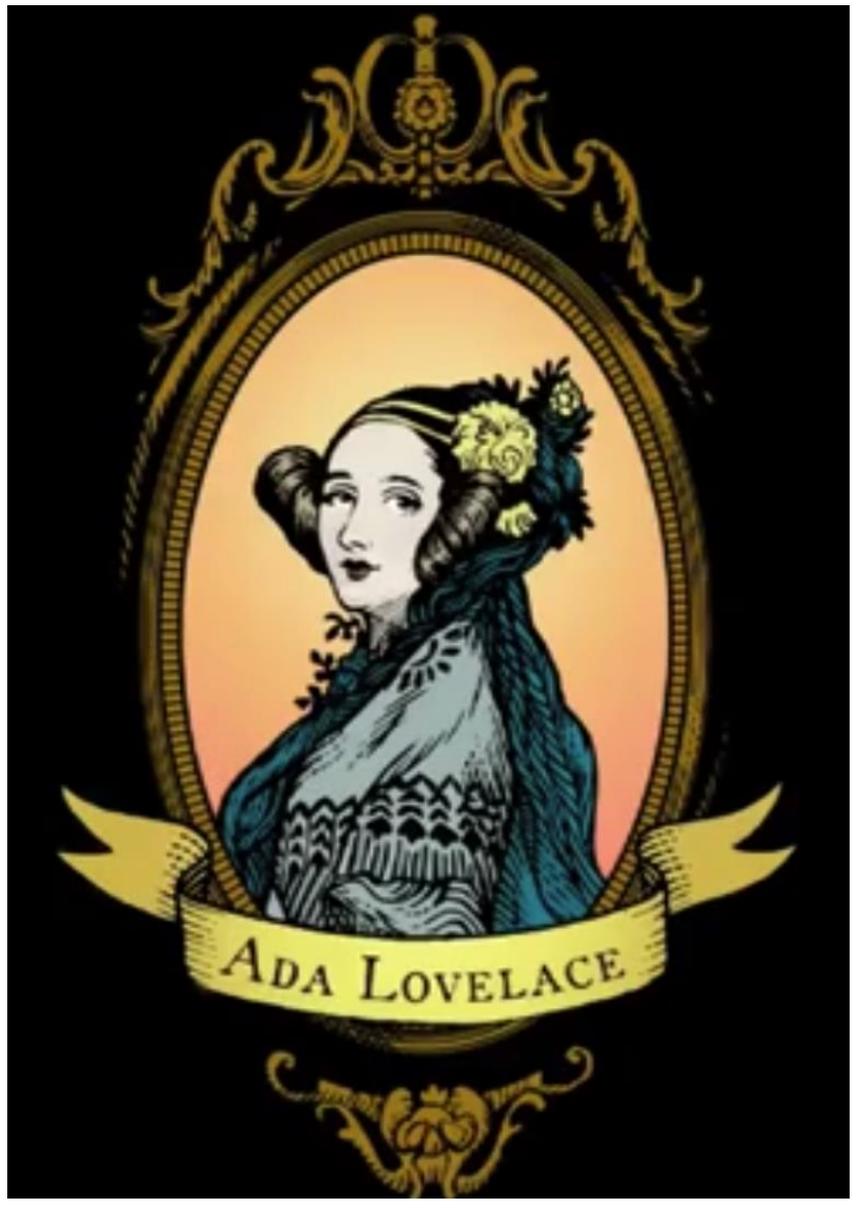


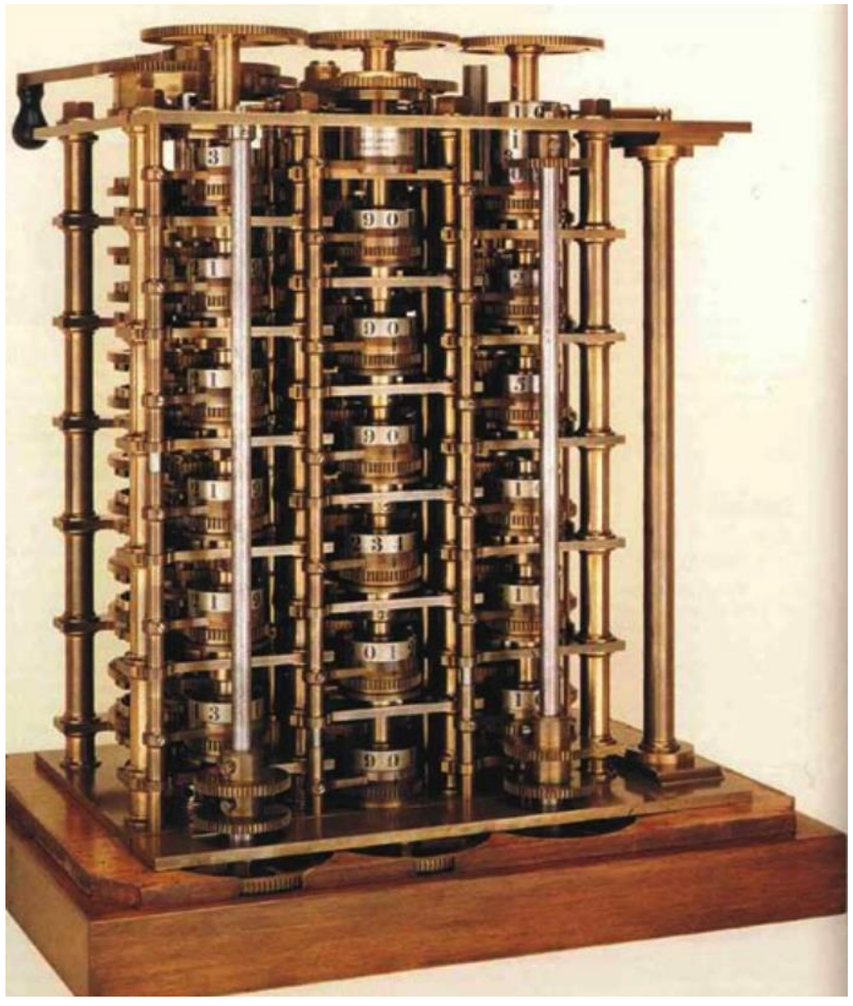
Name

How many bridges are there in our school?


上海海洋大学
爱恩学院
上海海洋大学
经济管理学院
上海海洋大学
信息学院
上海海洋大学
食品学院
上海海洋大学
工程学院
元昌路
上海海洋大学
水产与生命学院
上海海洋大学
海洋科学学院
上海海洋大学
第四教学楼
上海海洋大学
第三教学楼
上海海洋
大学校史馆
图文信息中心
上海海洋大学
(临港校区)
中国联通
上海海洋大学实验
教学中心A楼
上海海洋大学
公共实验楼
健行路
上海海洋
大学体育场
上海海洋
大学健身房

Speculation

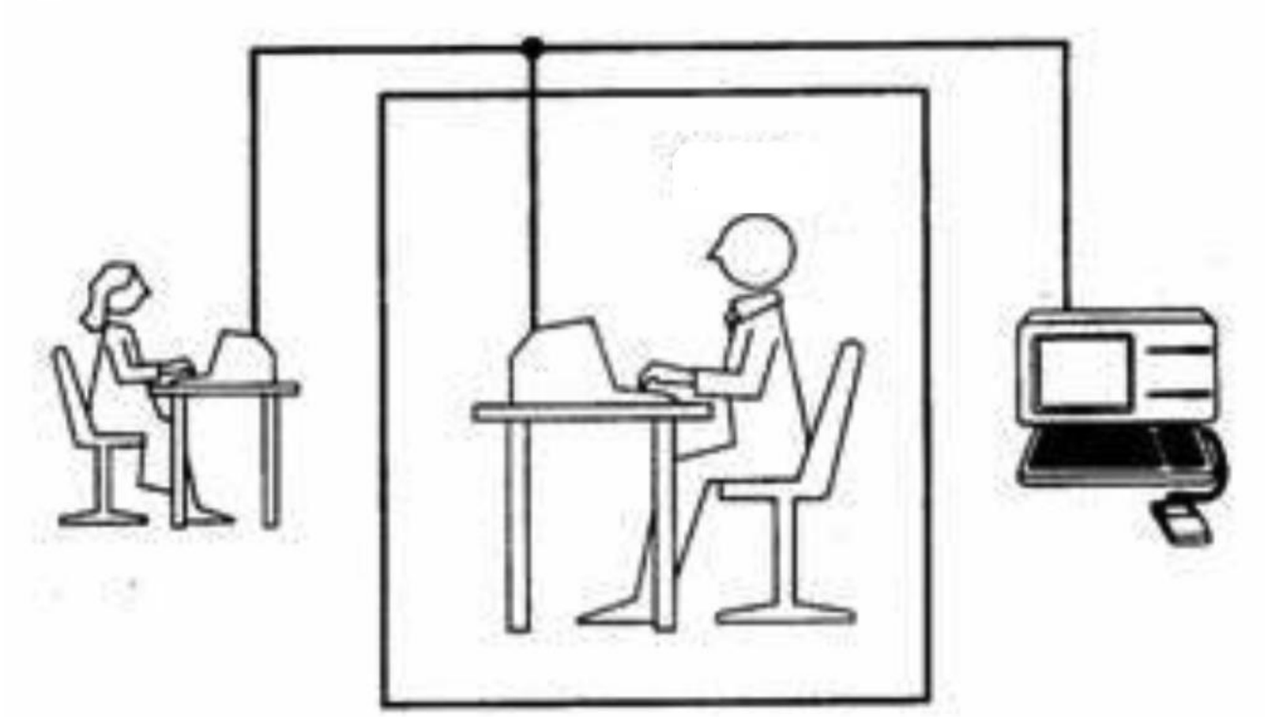


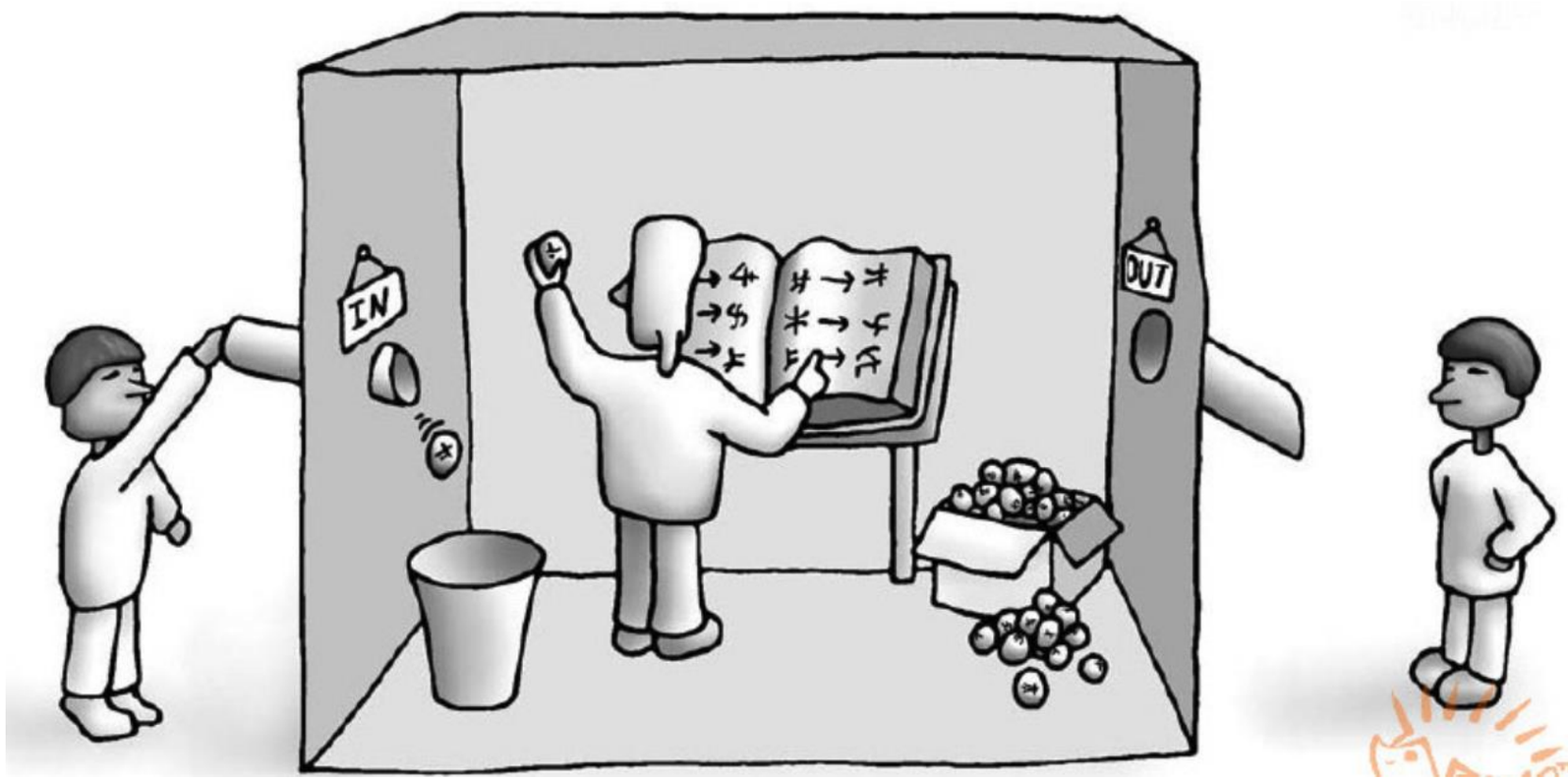


1815~1852

The Analytical Engine has no pretensions to originate anything, It can do whatever we know how to order it to perform.

Turing Test and Chinese Room





Chat bot: Eliza

Talk to Eliza

> Hello, I am Eliza.
* How much is 1 plus 1.
> What is it that you really want to know?
* I want to know The ultimate answer to the universe.
> Suppose you got to know The ultimate answer to the universe?
* I should say 42.
> Come, come, elucidate your thoughts.
* I think you are stupid.
> Perhaps you would like to be stupid?

Input:

Integration program

(1) $(C)'=0$,

(2) $(x^{\mu})'=\mu x^{\mu-1}$,

(3) $(\sin x)'=\cos x$,

(4) $(\cos x)'=-\sin x$,

(5) $(\tan x)'=\sec^2 x$,

(6) $(\cot x)'=-\csc^2 x$,

(7) $(\sec x)'=\sec x\tan x$,

(8) $(\csc x)'=-\csc x\cot x$,

(9) $(a^x)'=a^x\ln a$,

(10) $(e^x)'=e^x$,

(11) $(\log_a x)'=\dfrac{1}{x\ln a}$,

(12) $(\ln x)'=\dfrac{1}{x}$,

(13) $(\arcsin x)'=\dfrac{1}{\sqrt{1-x^2}}$,

...

(14) $(\arccos x)'=-\dfrac{1}{\sqrt{1-x^2}}$,

(15) $(\arctan x)'=\dfrac{1}{1+x^2}$,

(16) $(\operatorname{arccot} x)'=-\dfrac{1}{1+x^2}$.

$\int \sin x\,dx=-\cos x+c$

$\int \cos x\,dx=\sin x+c$

$\int \sin(x+b)\,dx=-\cos(x+b)+c$

$\int \sin(ax+b)\,dx=-\dfrac{1}{a}\cos(ax+b)+c$

$\cos 2x=1-2\sin^2 x$

$\cos 2x=2\cos^2 x-1$

$\int \sin^2 x\,dx=\int\dfrac{1-\cos 2x}{2}dx=\dfrac{1}{2}\left[x-\dfrac{1}{2}\sin 2x\right]+c$

$\int \cos^2 x\,dx=\int\dfrac{1+\cos 2x}{2}dx=\dfrac{1}{2}\left[x+\dfrac{1}{2}\sin 2x\right]+c$

$\int \sin^4 x\,dx=\int\left(\dfrac{1-\cos 2x}{2}\right)^2 dx$

$\int \cos^4 x\,dx=\int\left(\dfrac{1+\cos 2x}{2}\right)^2 dx$

$=\dfrac{1}{4}\int(1-2\cos 2x+\cos^2 2x)dx$

$=\dfrac{1}{4}\int(1+2\cos 2x+\cos^2 2x)dx$

$=\dfrac{1}{4}\left[x-\sin 2x+\dfrac{1}{2}\int(1+\cos 4x)\,dx\right]+c$

$=\dfrac{1}{4}\left[x+\sin 2x+\dfrac{1}{2}\int(1+\cos 4x)\,dx\right]+c$

$=\dfrac{1}{4}\left[\dfrac{3}{2}x-\sin 2x+\dfrac{1}{4}\sin 4x\right]+c$

$=\dfrac{1}{4}\left[\dfrac{3}{2}x+\sin 2x+\dfrac{1}{4}\sin 4x\right]+c$

$\int \sin x\,dx=-\int d\cos x=-\cos x+c$

$\int \cos x\,dx=\int d\sin x=\sin x+c$

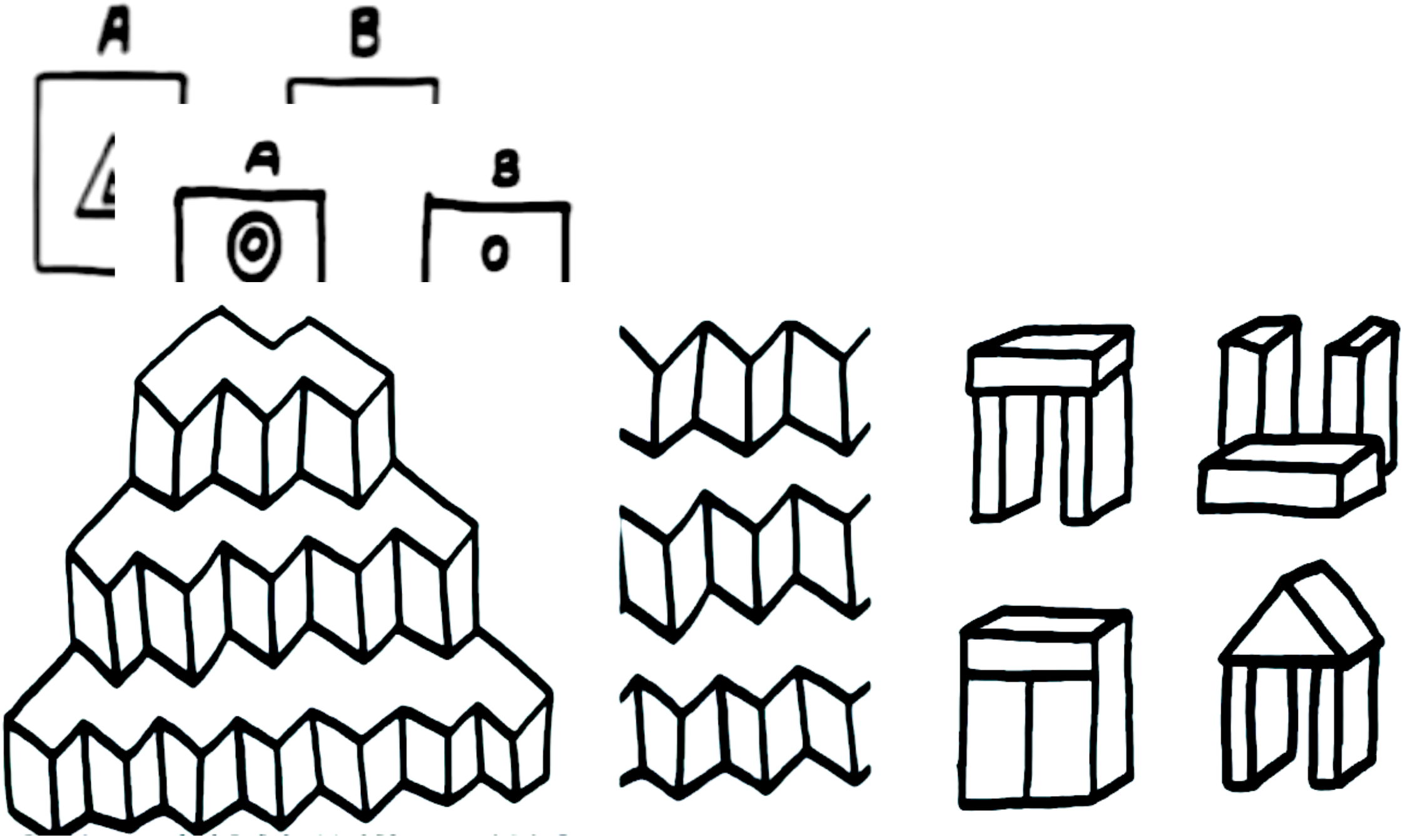
$\int \sin x\cos x\,dx=\int \sin x\,d\sin x=\dfrac{1}{2}\sin^2 x+c$

$\int \sin x\cos x\,dx=-\int \cos x\,d\cos x=-\dfrac{1}{2}\cos^2 x+c$

...

$$\int \frac{x^4}{(1-x^2)^{5/2}}dx=\frac{1}{3}\tan^3(\arcsin x)-\tan(\arcsin x)+\arcsin x$$

Analogy



Expert System

Bulldozer: Deep Blue

50 **Turing and Turing test**

Perceptron

60 **Marvin Minsky 《Steps toward Artificial Intelligence》**

James Slagle build Symbolic integration program for integral

Eliza chat bot

70 **Expert system**

80 **Symbol learning**

90 **Error Back Propagation Training (BP)**

SVM

00

ANNs, CNNs ...

10

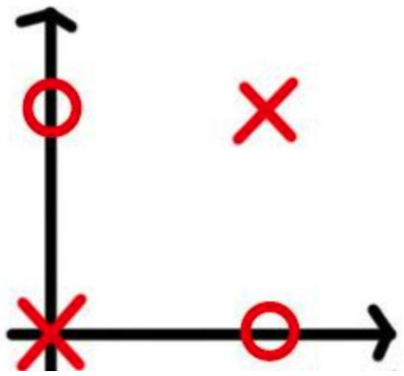
GANs ...

Now

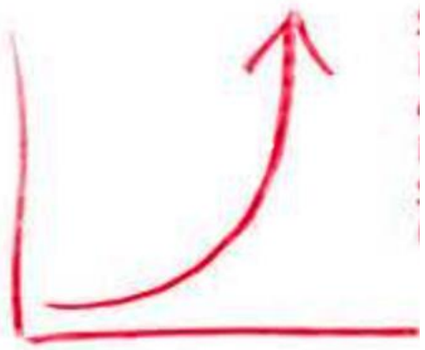
What problem of them?

Algorithm problem

XOR problem (Perceptron)



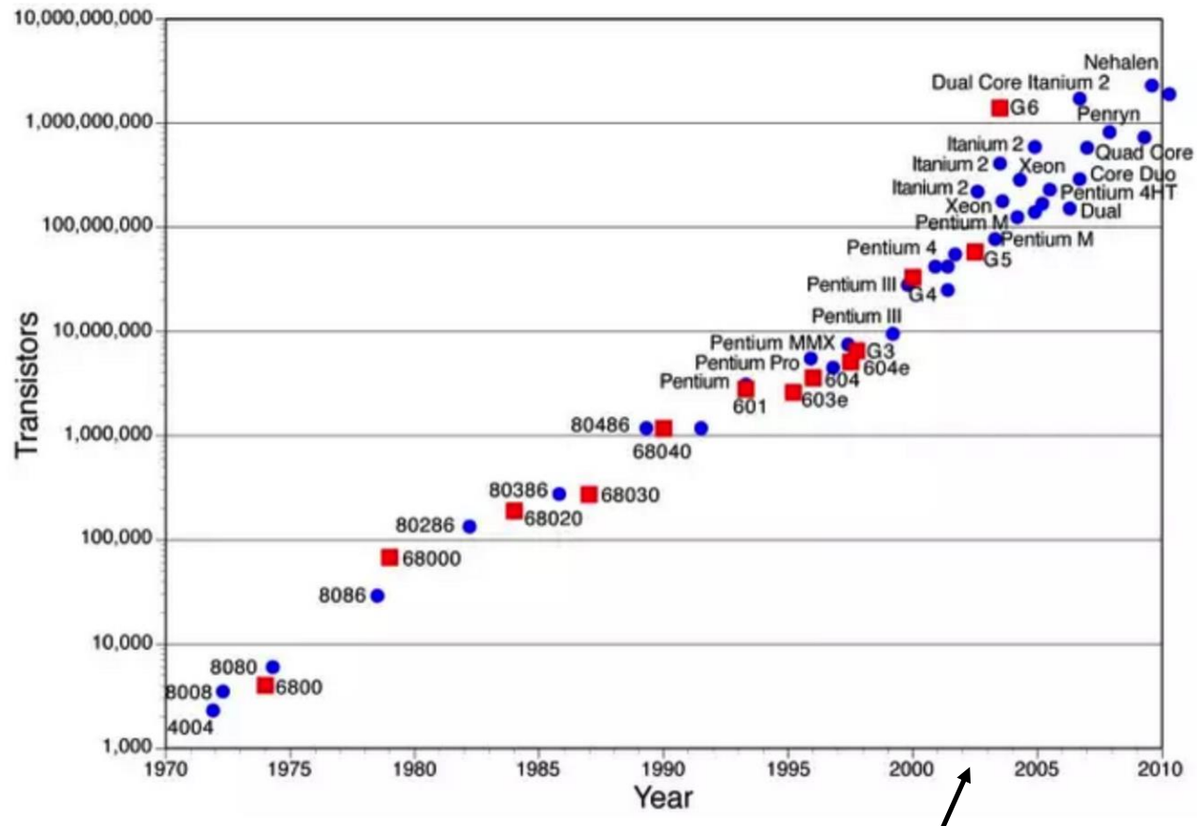
Parameter explosion



Lack of brain research support

...

Hardware problem



Not enough computing power before this

Now

New Algorithm

Gradient Descent	梯度下降
Deep learning	深度学习
Neural Networks	神经网络
Reinforcement learning	强化学习
Generative Adversative Nets	对抗神经网络
Convolutional neural network	卷积神经网络
Recurrent Neural Network	循环神经网络

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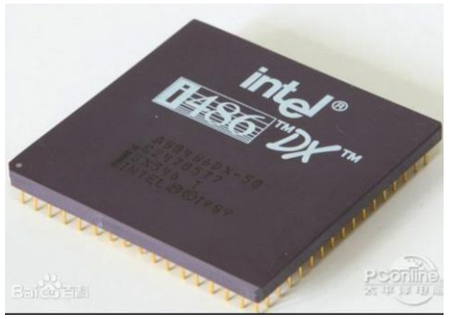
.
.

Powerful Hardware

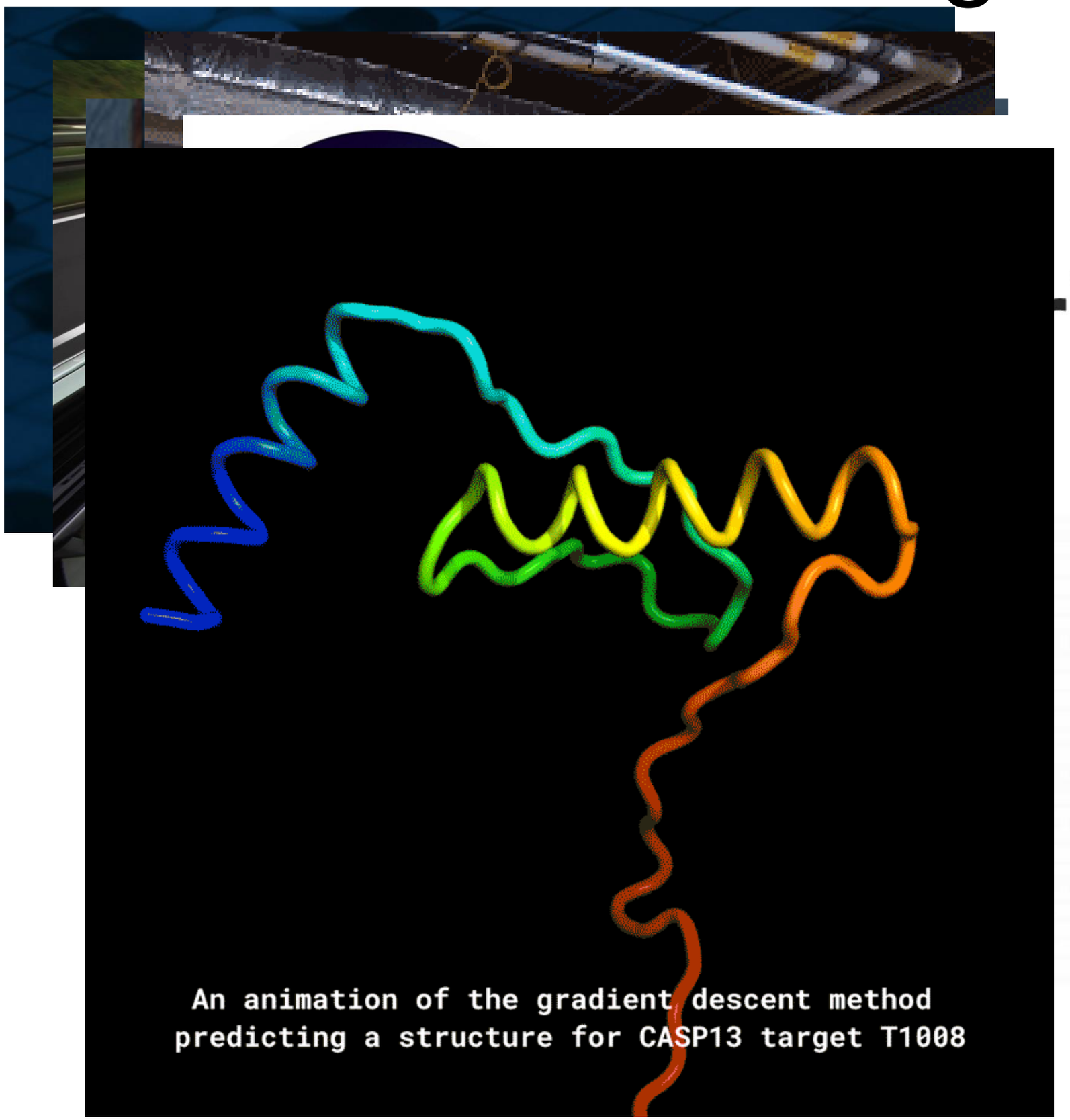


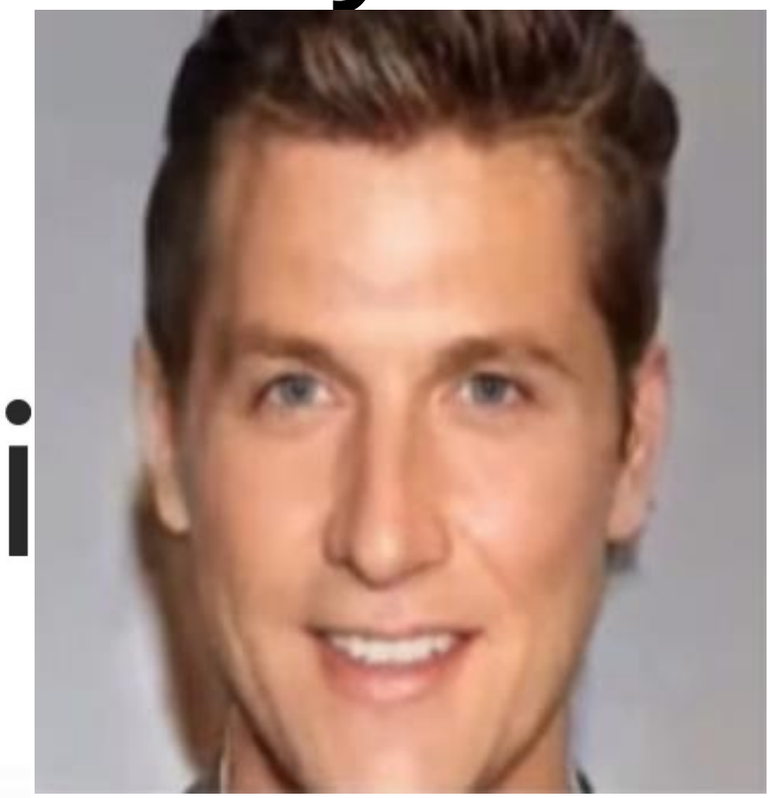
intel 80486
~1989
0.1GHz
1 core
10^6FLOPS

Intel Platinum 8180
2017
2.5GHz
28 core
10^12FLOPS

NVIDIA Tesla V100
~2017
1.4GHz
5120core
10^13FLOPS

Now: The Right Way





Google

YouTube

Baidu 百度

bing

Gradient Descent	梯度下降
★ Deep learning	深度学习
Neural Networks	神经网络
Reinforcement learning	强化学习
★ Generative Adversative Nets	对抗神经网络
★ Convolutional neural network	卷积神经网络
Recurrent Neural Network	循环神经网络

Deep Learning

≈ Machine Learning
≈ Neural Network

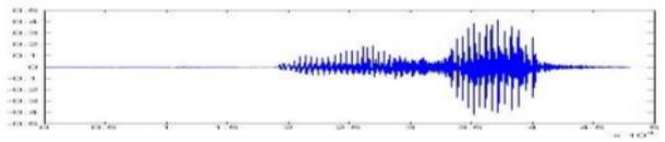
Fully Connect Feedforward Network

Keywords about Deep Learning

Maximum likelihood estimation and Bayesian statistics	最大似然估计和贝叶斯统计
Stochastic gradient descent	随机梯度下降
Supervised learning and unsupervised learning	监督学习和无监督学习
Back propagation	反向传播
Adaptive learning algorithm	自适应学习算法
Convolutional neural network	卷积神经网络
Recurrent neural network	循环神经网络
Recurrent neural network	递归神经网络
Deep neural network and deep stacking network	深度神经网络和深度堆叠网络
Principal component analysis	主成分分析
Characterization learning	表征学习
Monte Carlo	蒙特卡洛
Restricted Bozeman machine	受限波兹曼机
Deep trust network	深度置信网络
KNN and SVM	KNN和SVM
Generate a confrontation network	生成对抗网络
Directed generation network	有向生成网络
Machine vision and image recognition	机器视觉和图像识别
Natural language processing	自然语言处理
Speech recognition and machine translation	语音识别和机器翻译
Limited Markov	有限马尔科夫
Dynamic planning	动态规划

Machine Learning
≈ Looking for a Function

- Speech Recognition

$f($  $)=$ “How are you”

- Image Recognition

$f($  $)=$ “Cat”

- Playing Go

$f($  $)=$ “5-5” (next move)

- Dialogue System

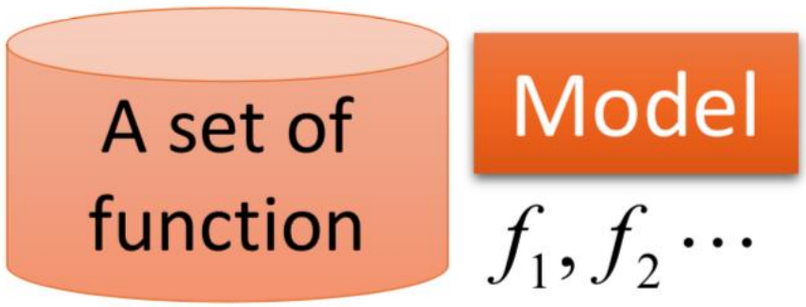
$f($ “Hi” $)=$ “Hello”

(what the user said) (system response)

Framework

Image Recognition:

$f($  $) =$ "cat"



$f_1($  $) =$ "cat"

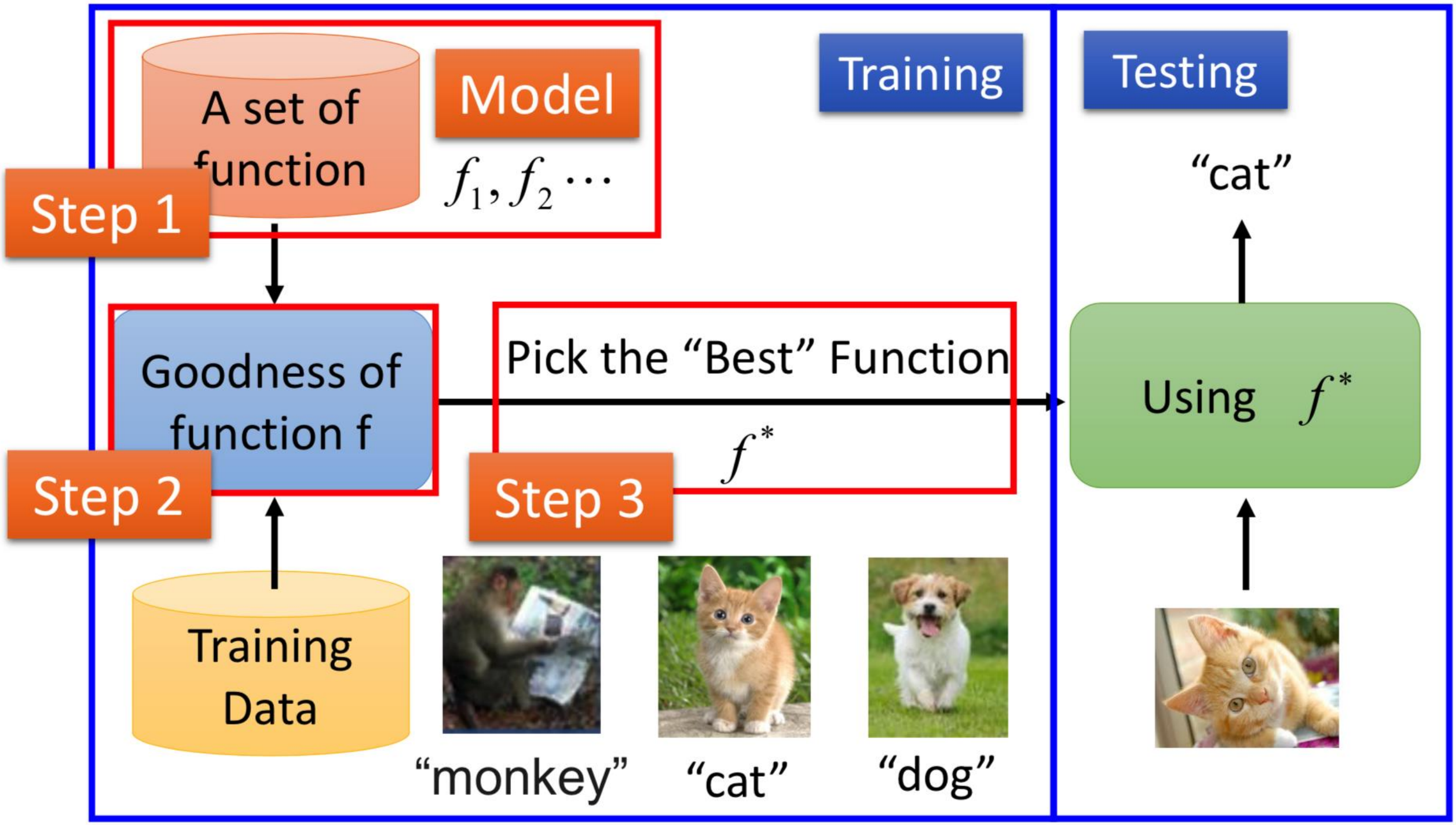
$f_2($  $) =$ "money"

$f_1($  $) =$ "dog"

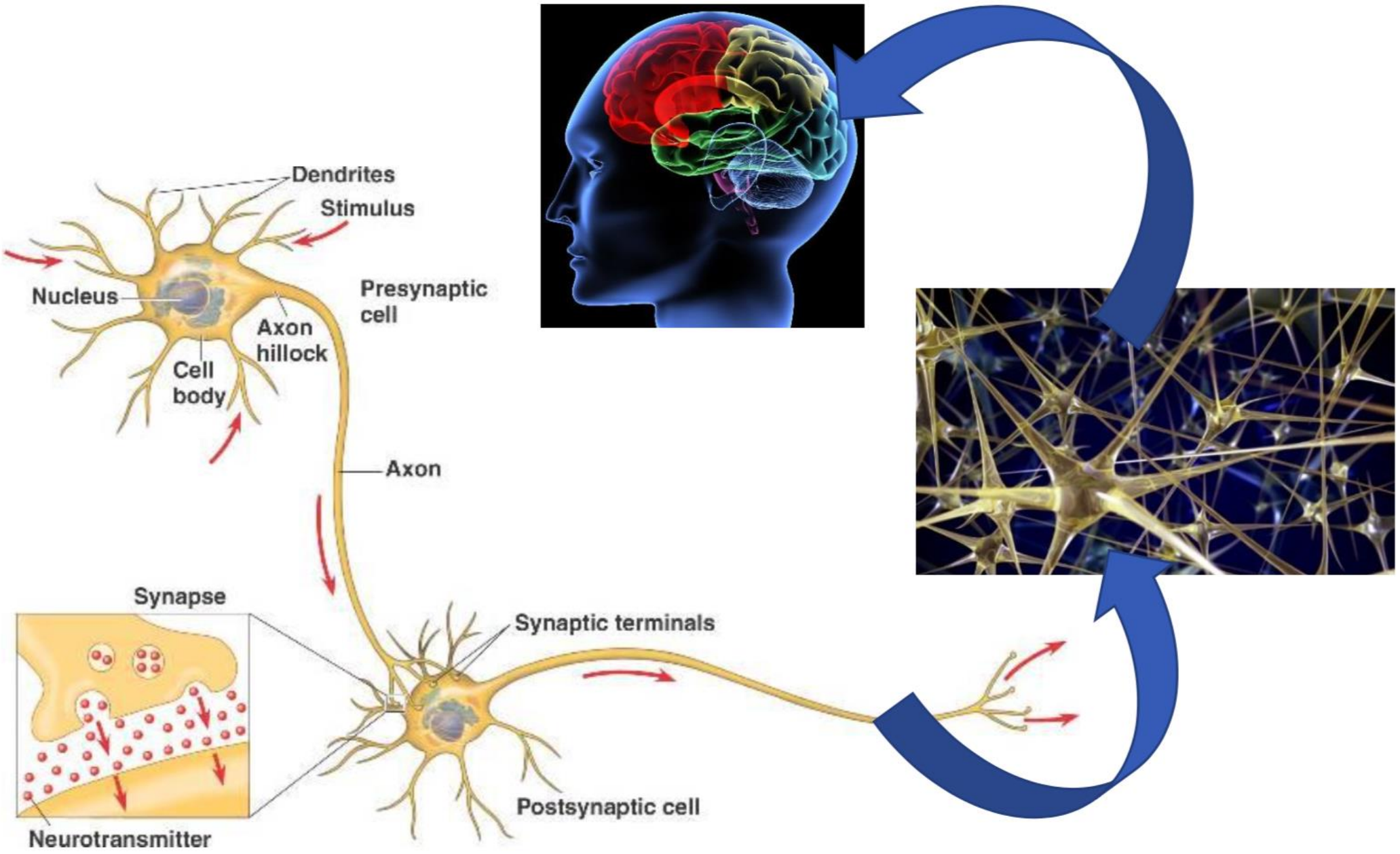
Better!

$f_2($  $) =$ "snake"

Framework

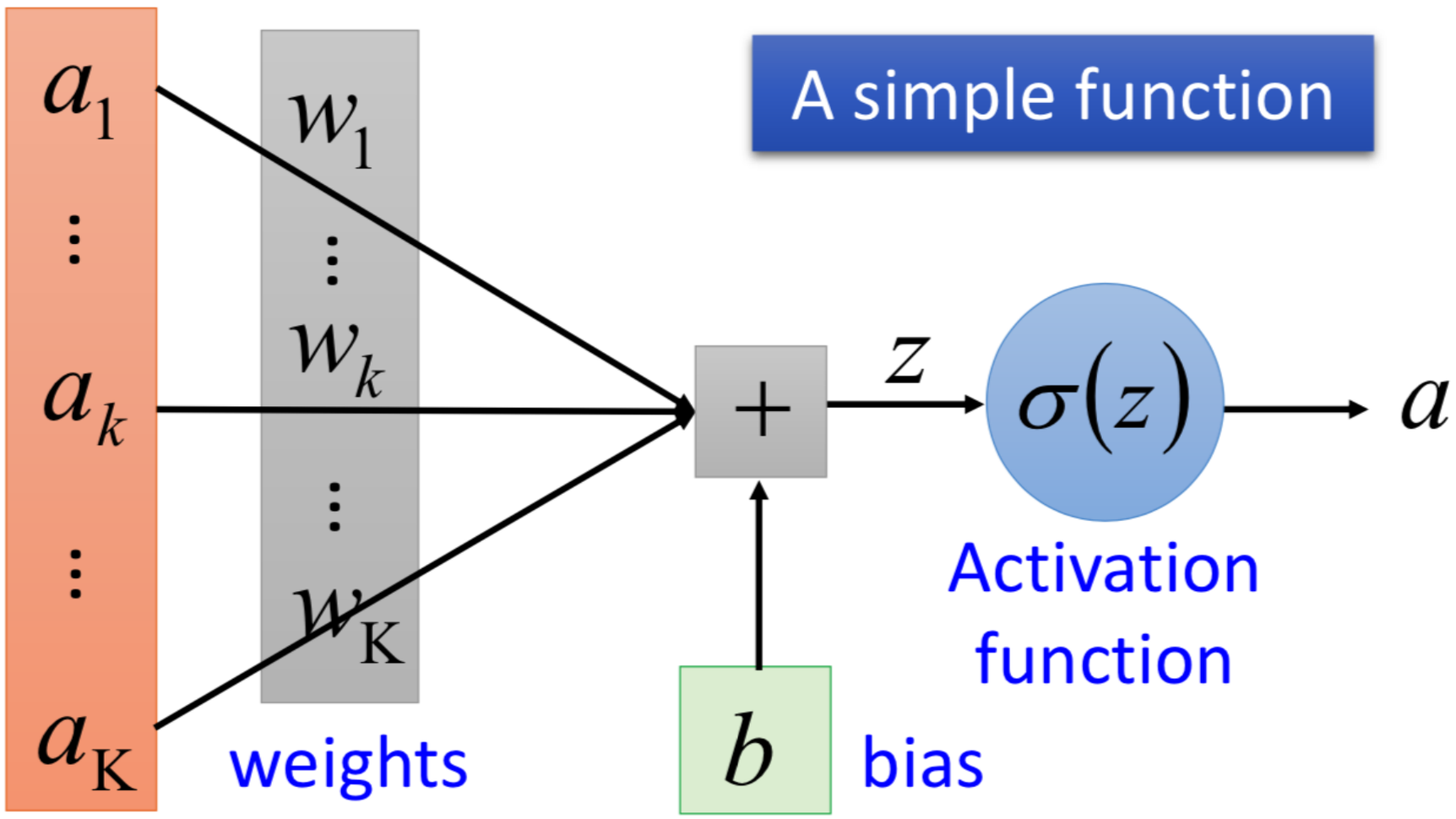

Training
Testing
Step 1
A set of function
Model
$f_1, f_2 \cdots$
Step 2
Goodness of function f
Step 3
Pick the "Best" Function
f^*
Training Data
"monkey"
"cat"
"dog"
"cat"
Using f^*

Human Brain


Dendrites
Stimulus
Nucleus
Presynaptic cell
Axon hillock
Cell body
Axon
Synapse
Synaptic terminals
Neurotransmitter
Postsynaptic cell

Neuron

$$z = a_1 w_1 + \cdots + a_k w_k + \cdots + a_K w_K + b$$



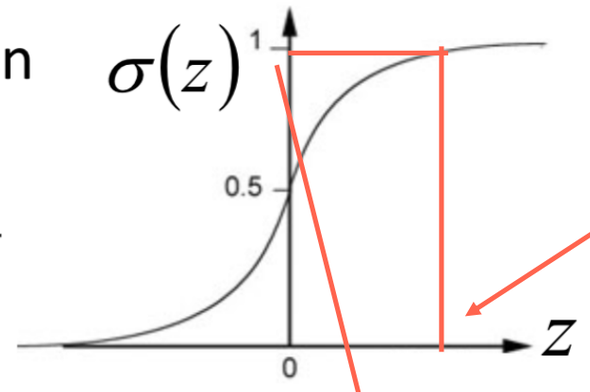
A simple function

Neural Network

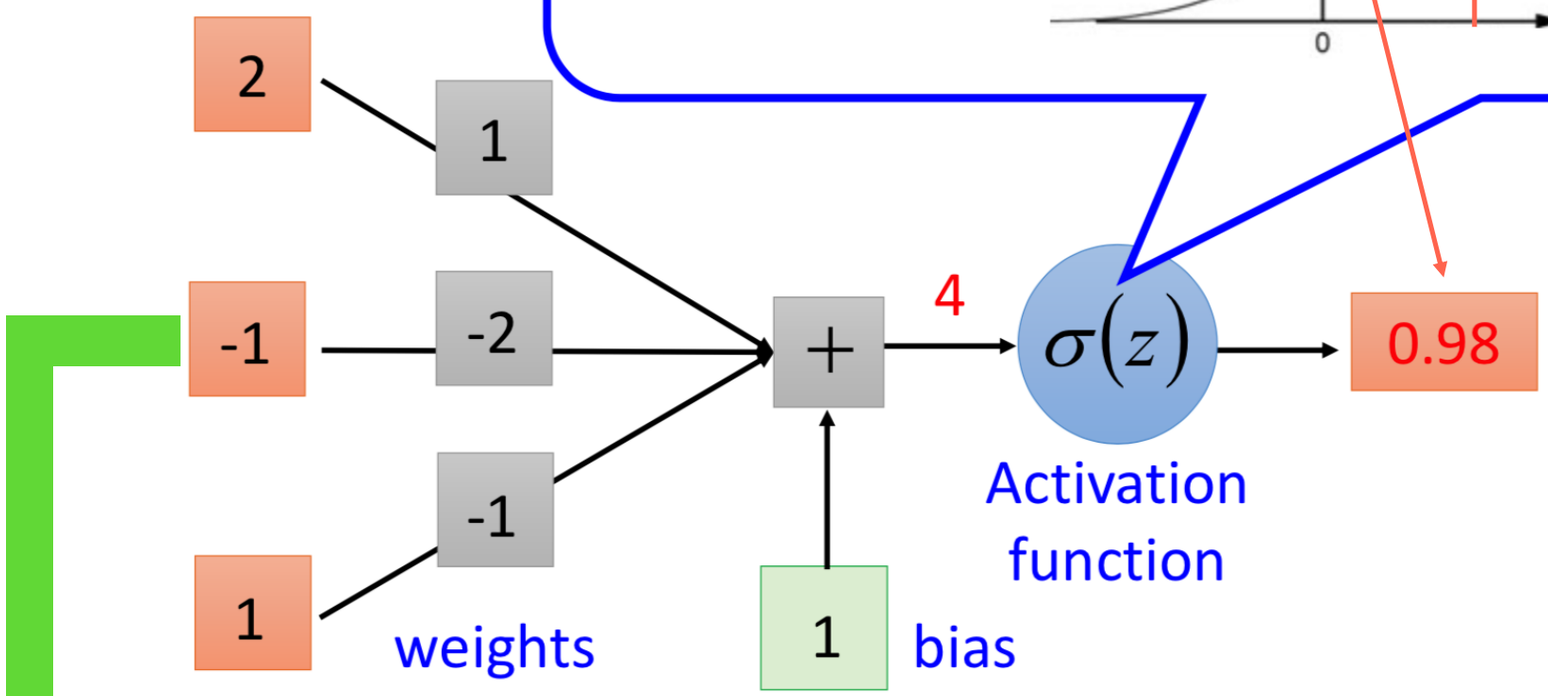
Neuron

Sigmoid Function

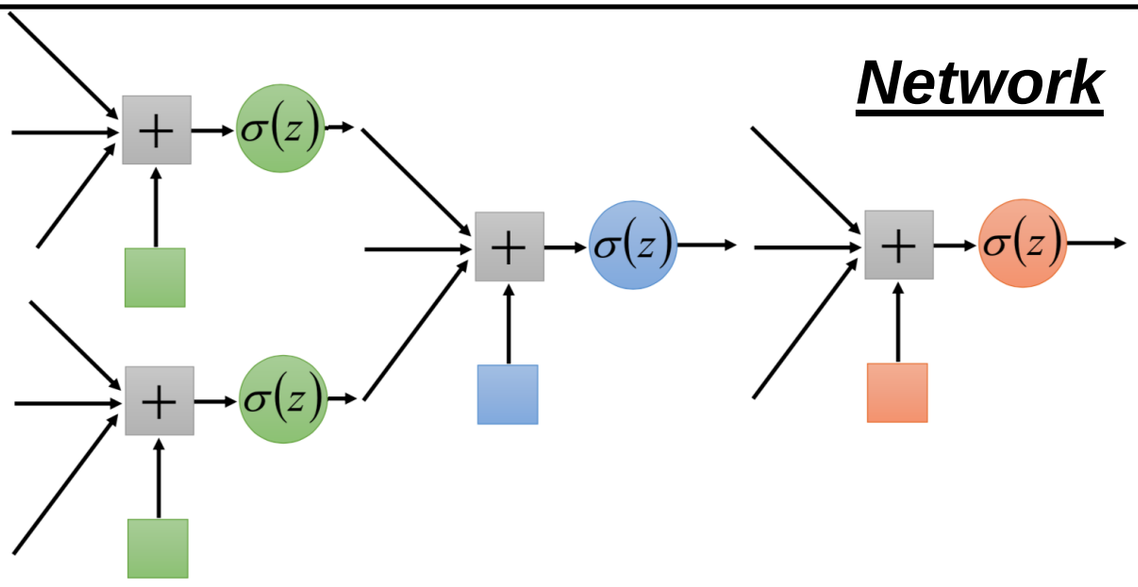
$$\sigma(z) = \frac{1}{1+e^{-z}}$$

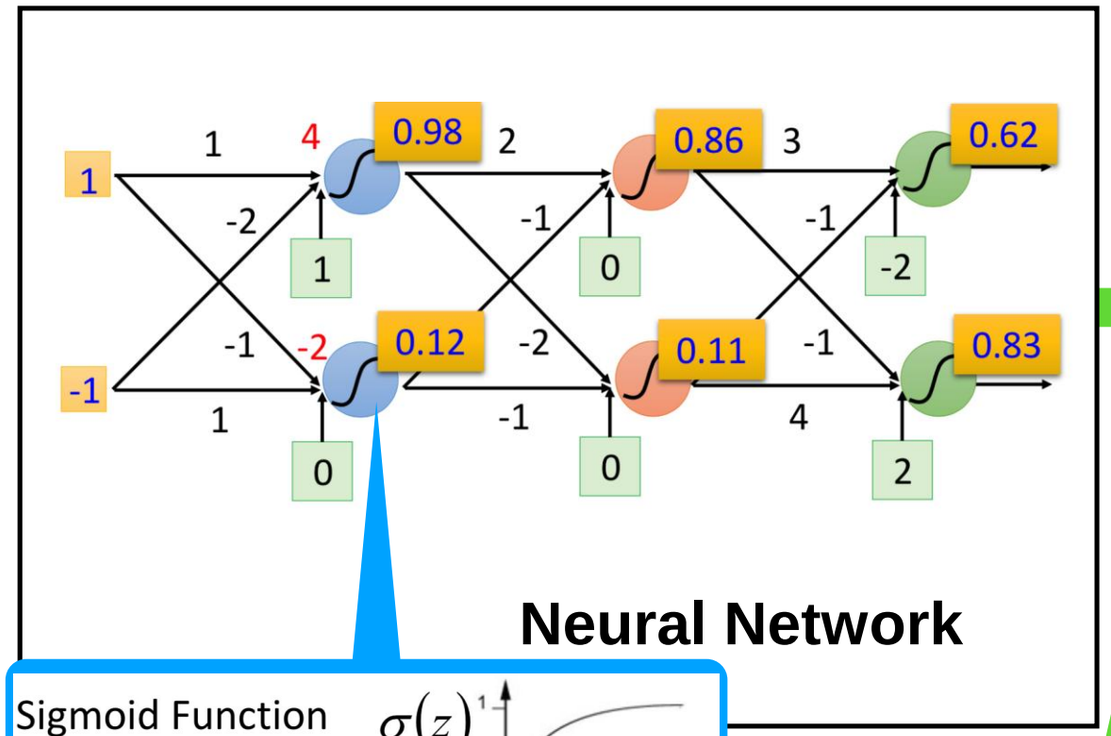


z = 2 * 1 + -1 * -2 + 1 * -1 + 1
= 4



Network

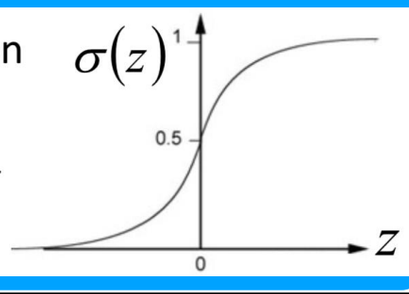


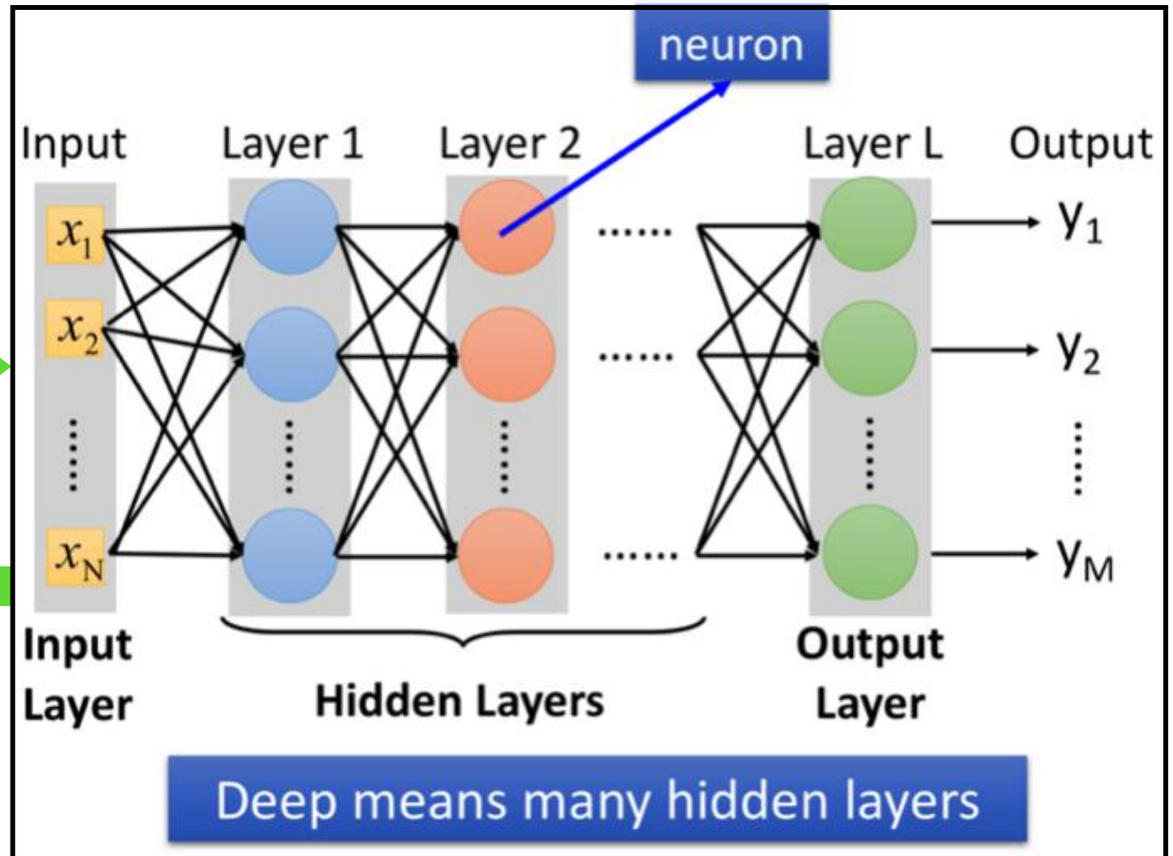


Neural Network

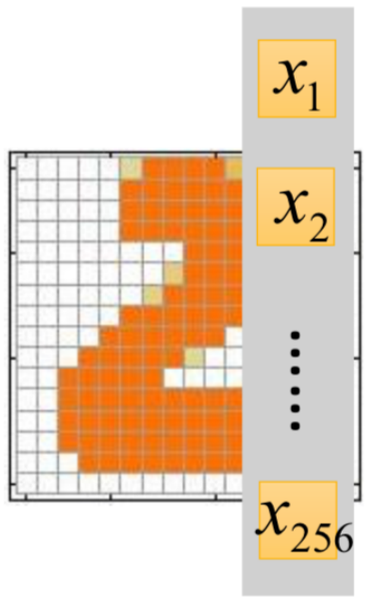
Sigmoid Function

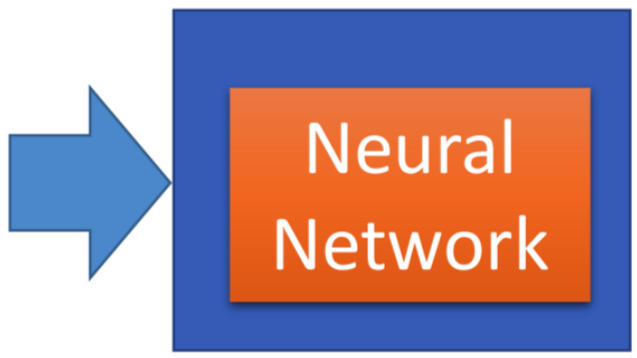
$$\sigma(z)=\frac{1}{1+e^{-z}}$$



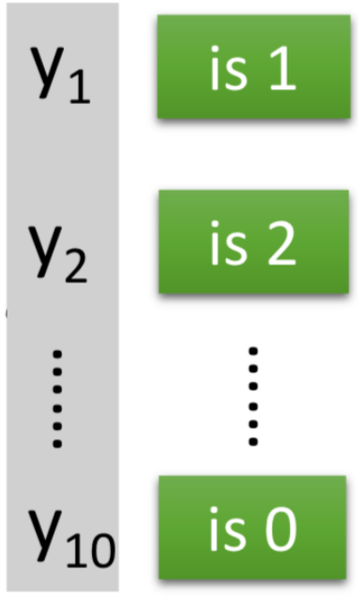


Fully Connected Feedforward Network



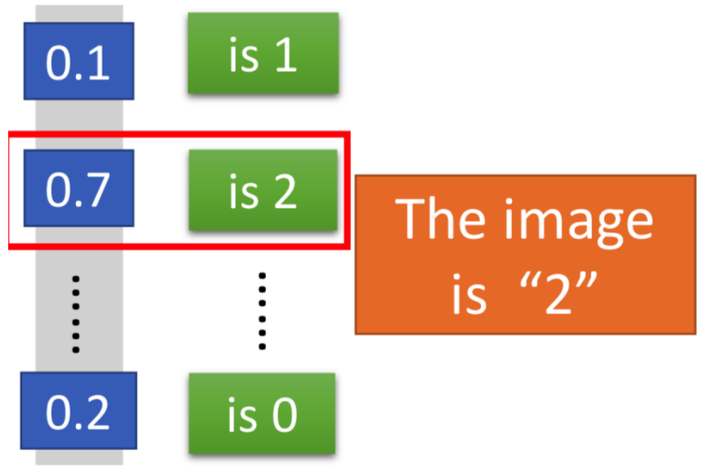


What is needed is a function ……



Input:
256-dim vector

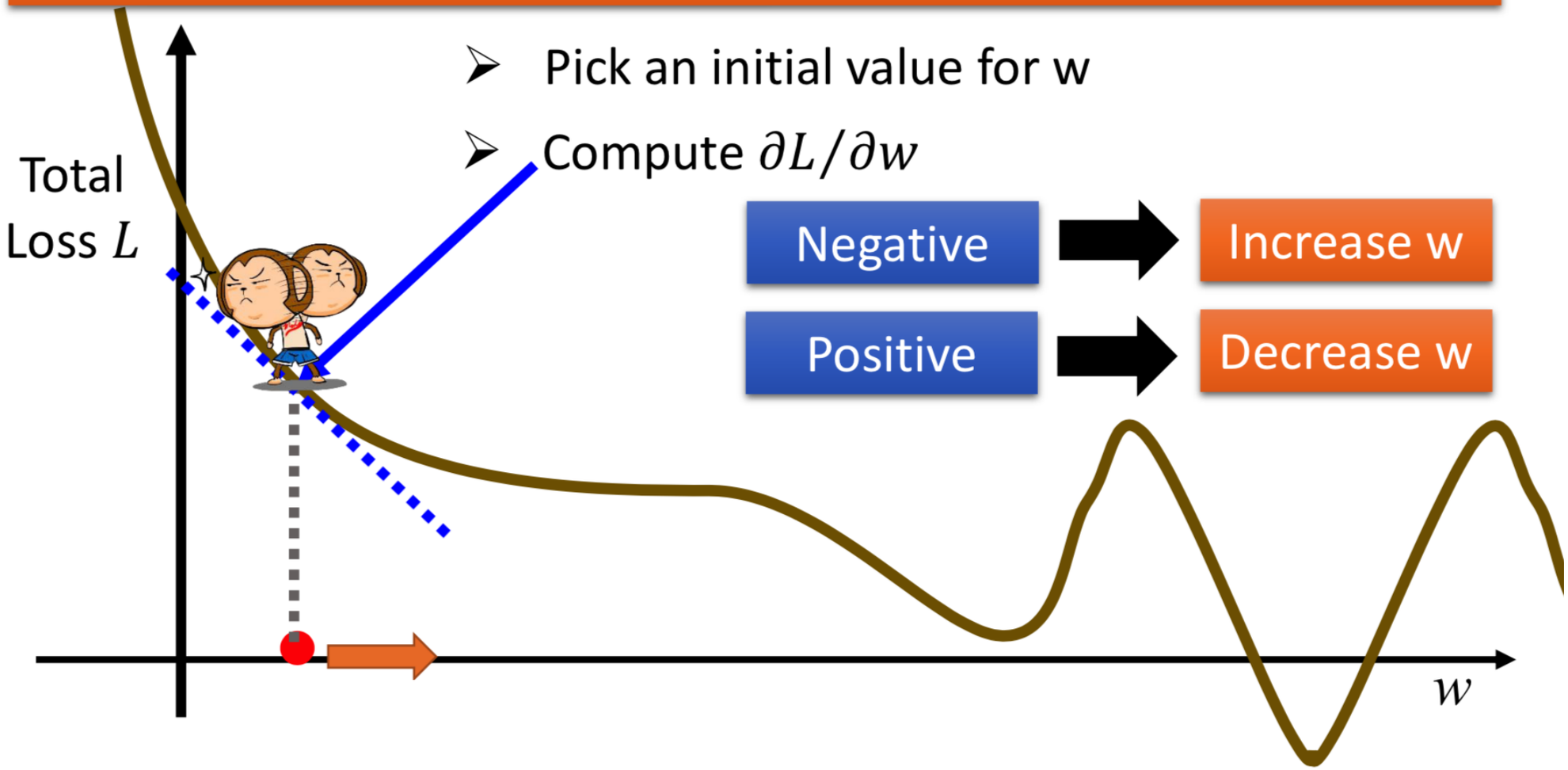
output:
10-dim vector



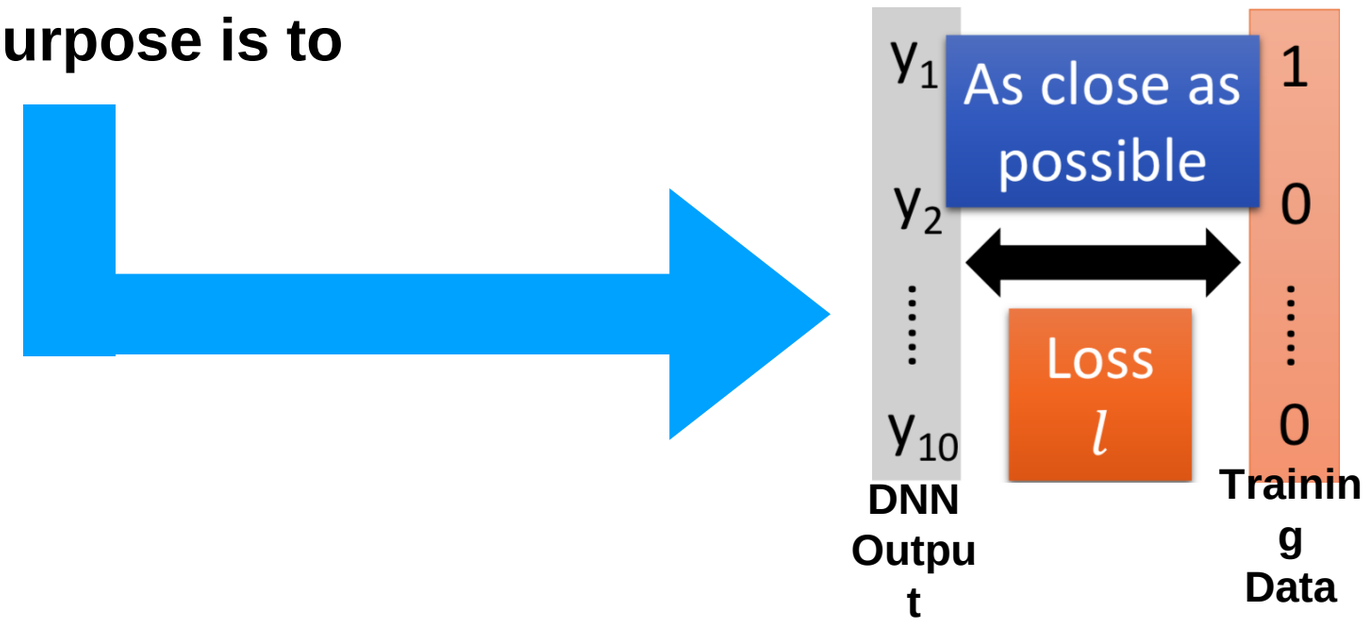
Output Example

Network parameters $\theta = \{w, w, \cdots, b, b, \cdots\}$

Find ***network parameters*** θ^* that minimize total loss L

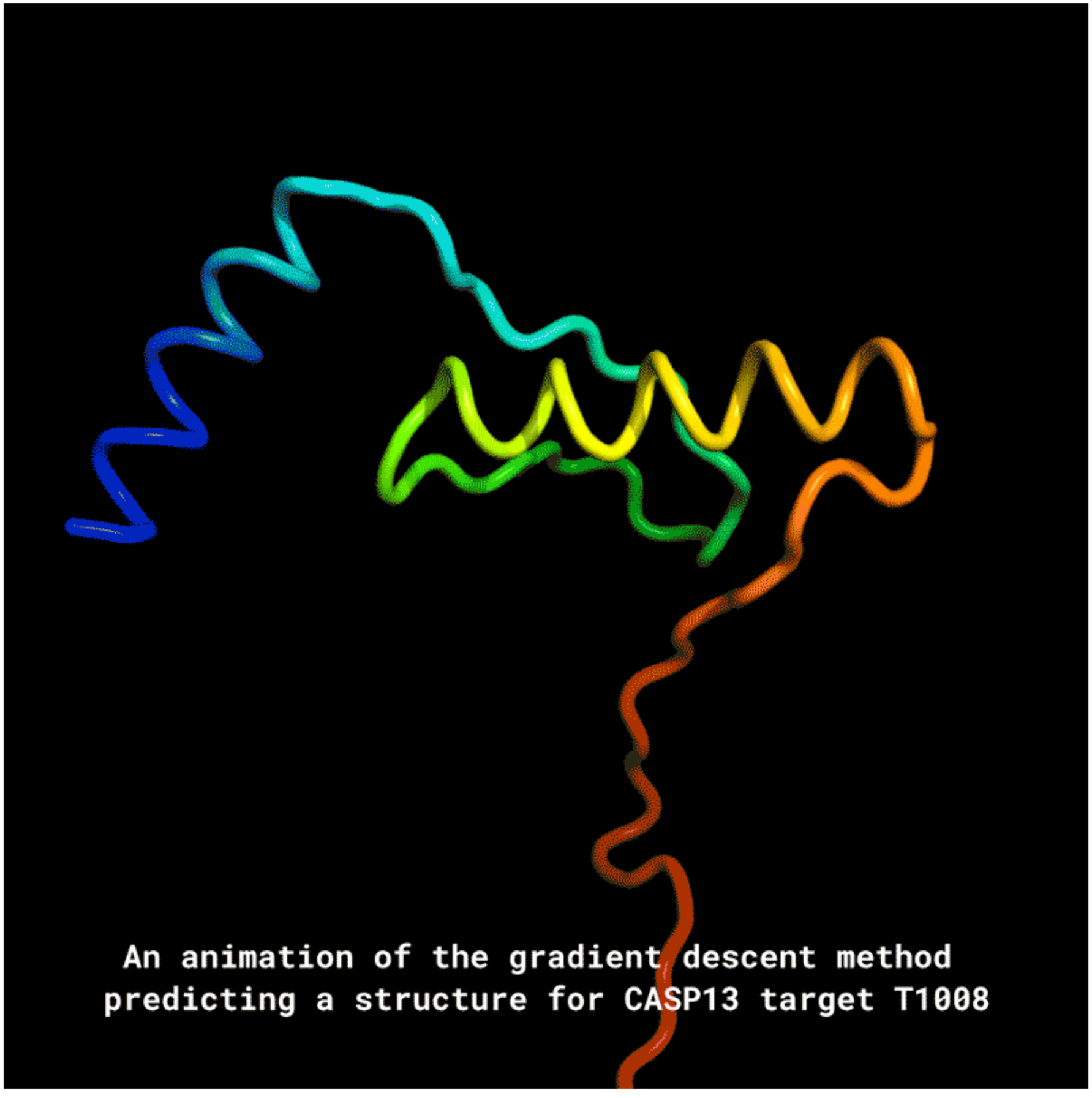


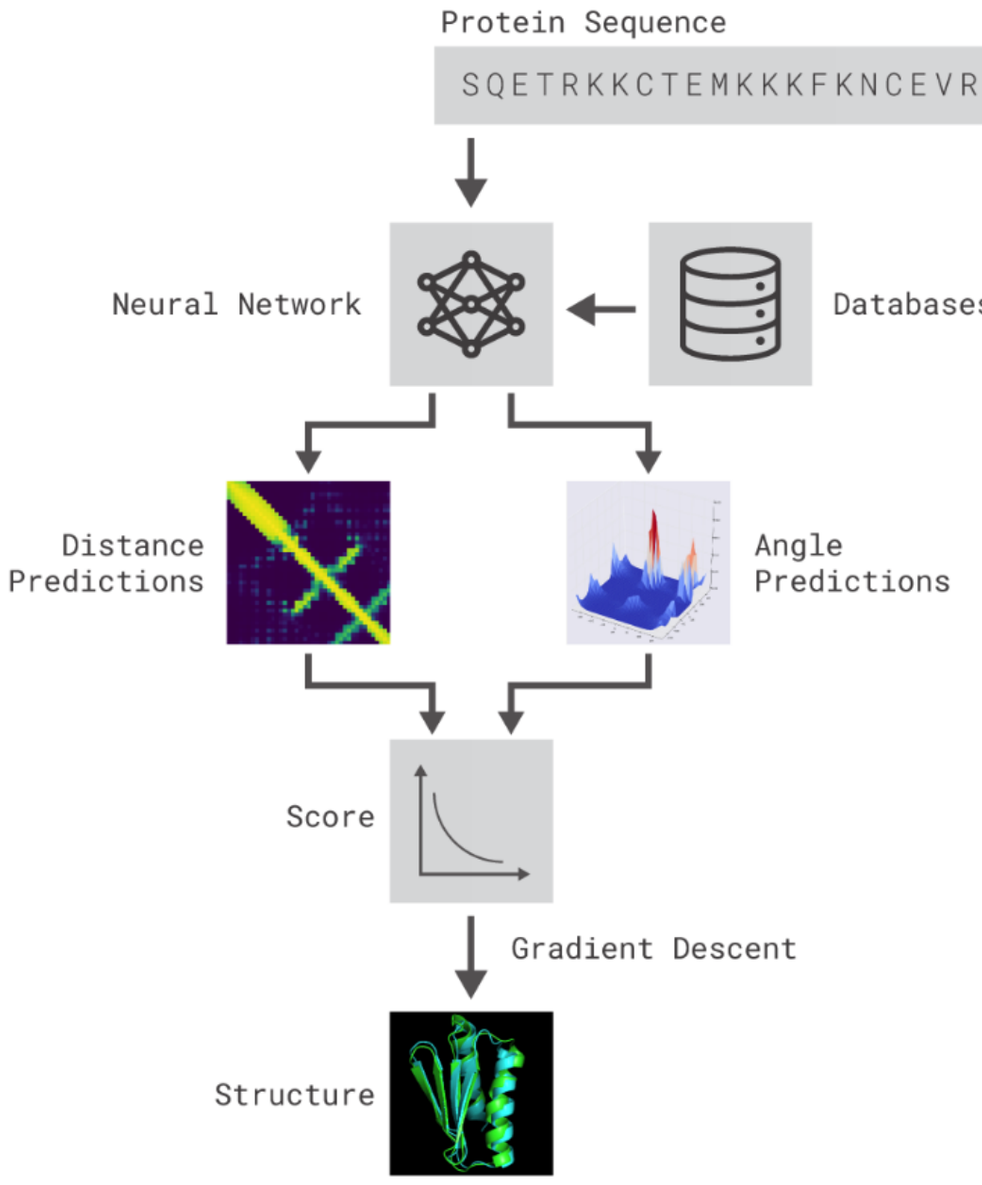
The purpose is to



Find the best θ to find the best function

AlphaFold: Using AI to protein folding problem


An animation of the gradient descent method
predicting a structure for CASP13 target T1008

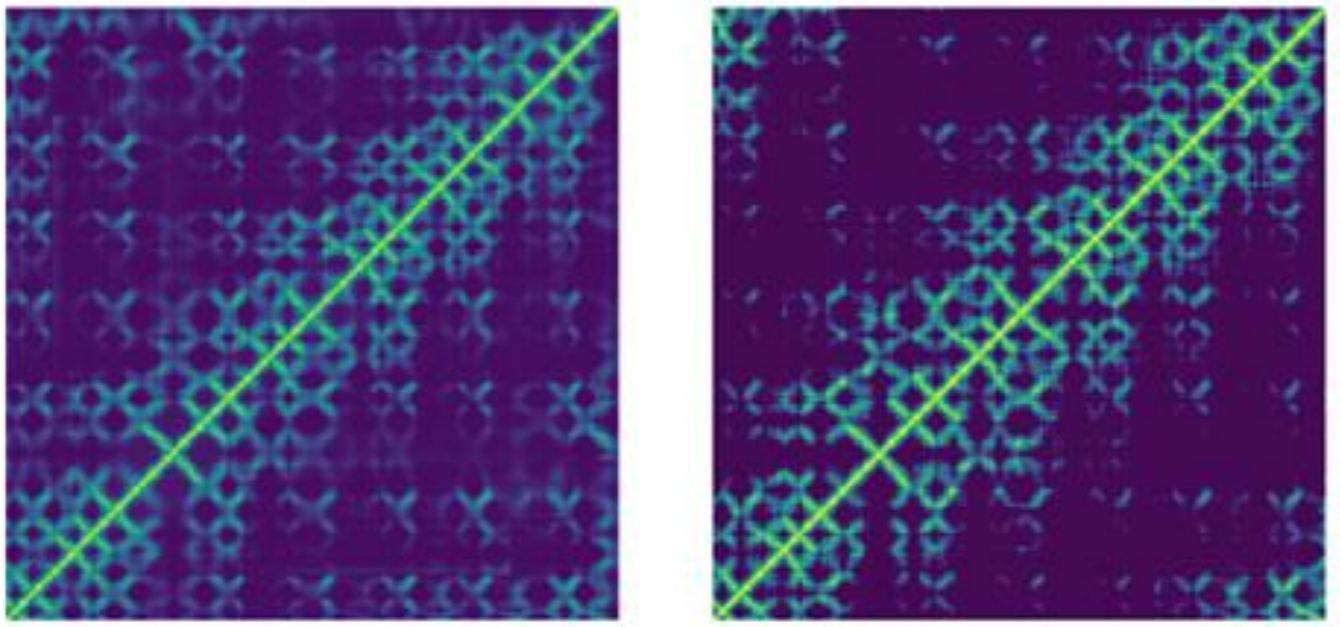


Used two parameters

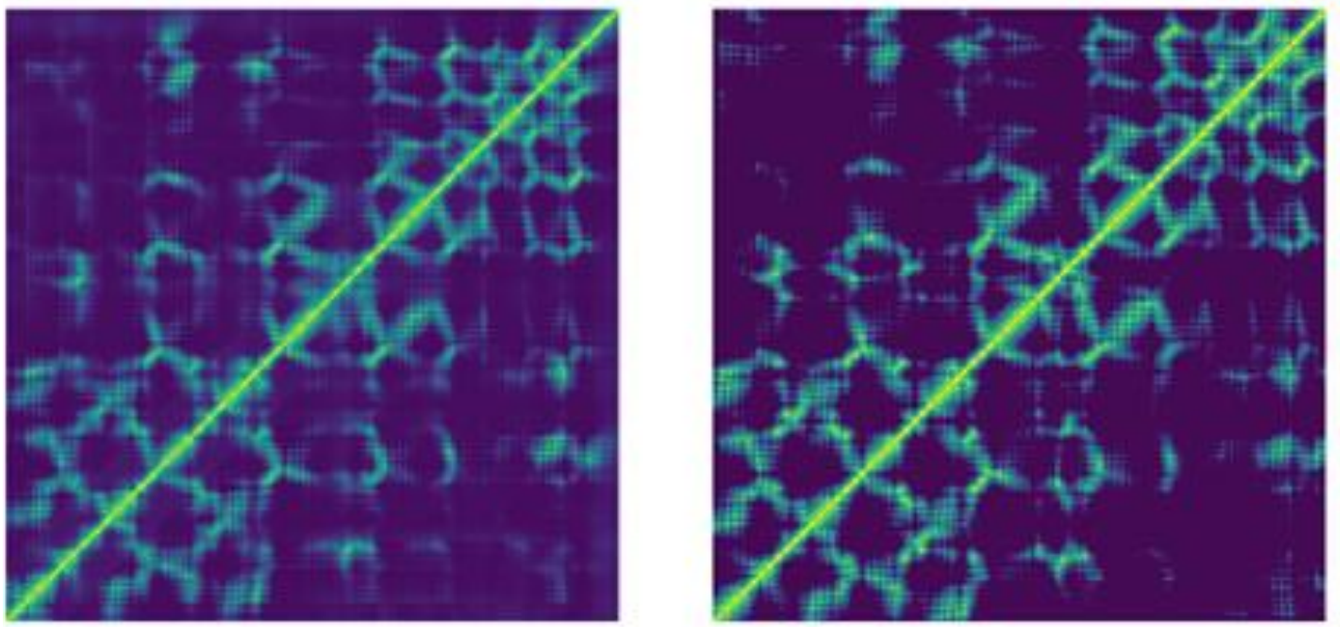
(a)the distances between pairs of amino acids
(b)the angles between chemical bonds that connect those amino acids.

Average predicted distance

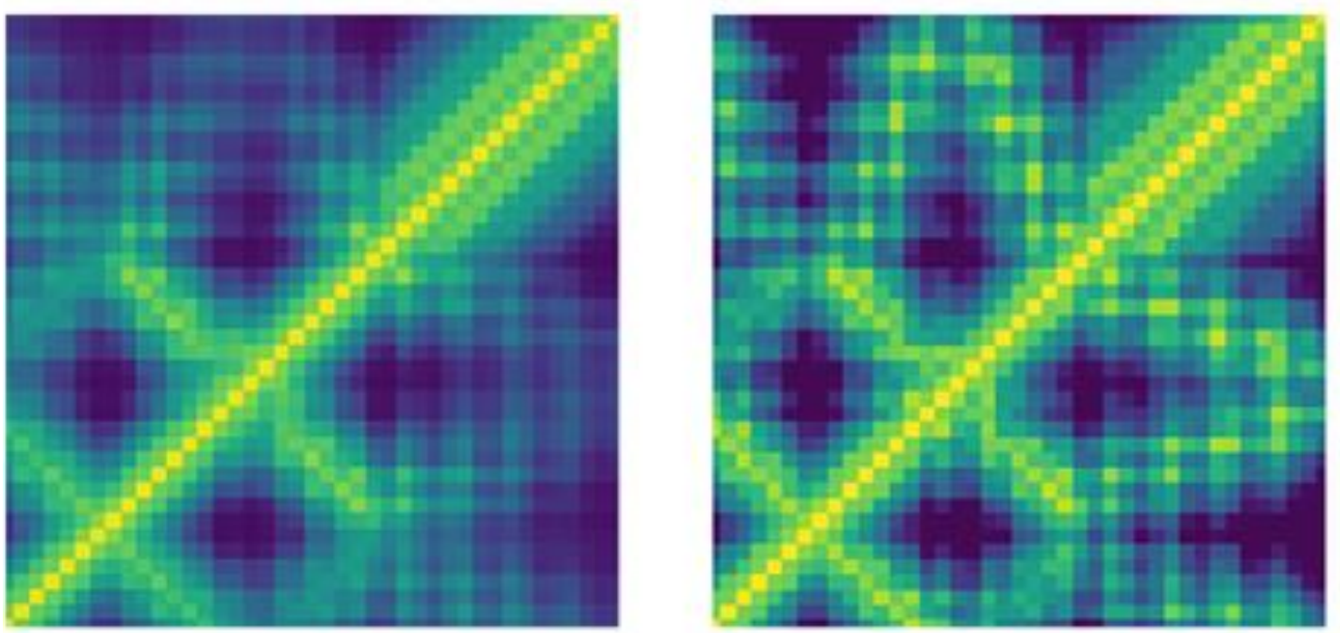
Ground truth



T0954 / 6CVZ



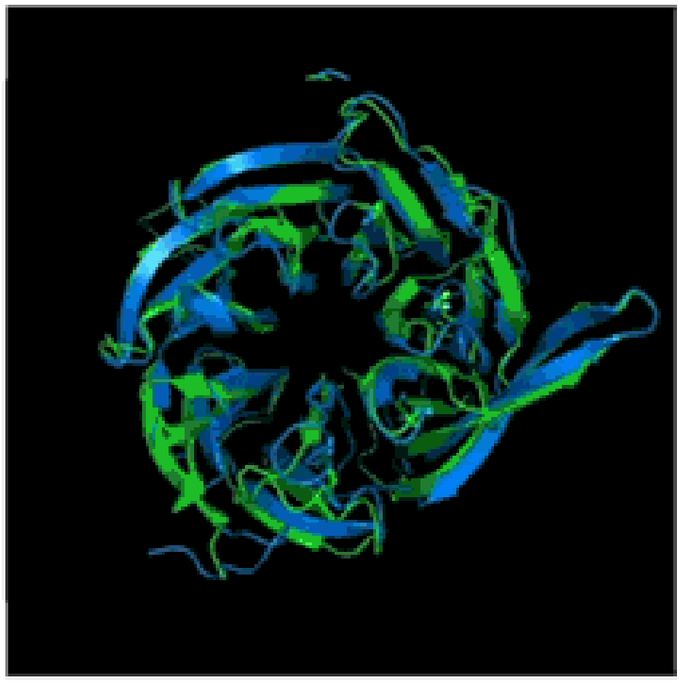
T0965 / 6D2V



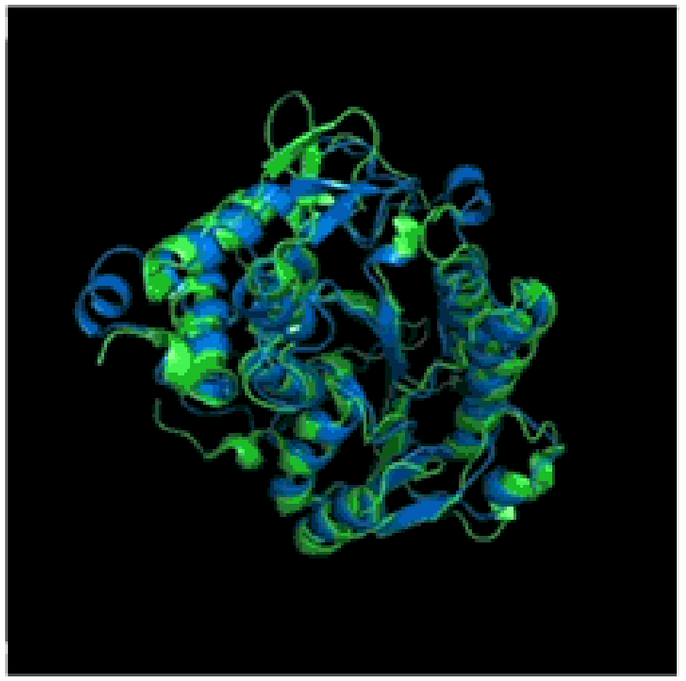
T0955 / 5W9F

Structures:
Ground truth (green)
Predicted (blue)

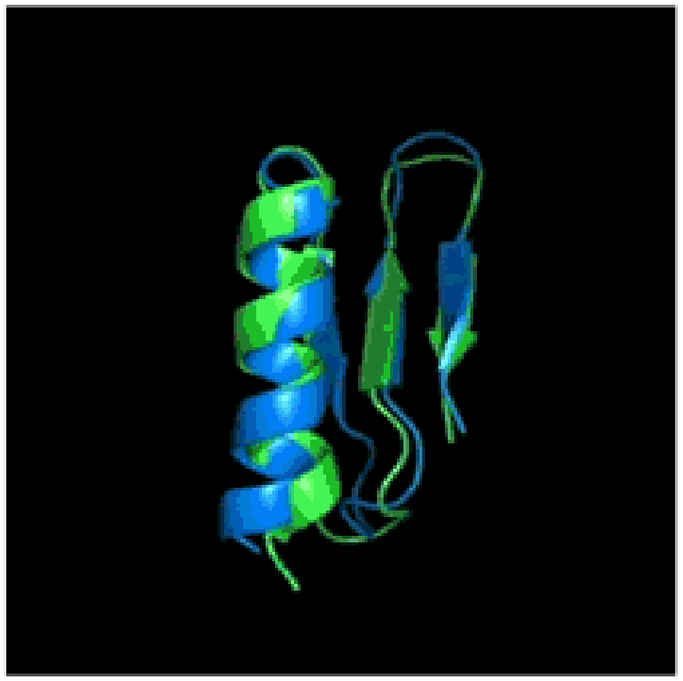
T0954 / 6CVZ



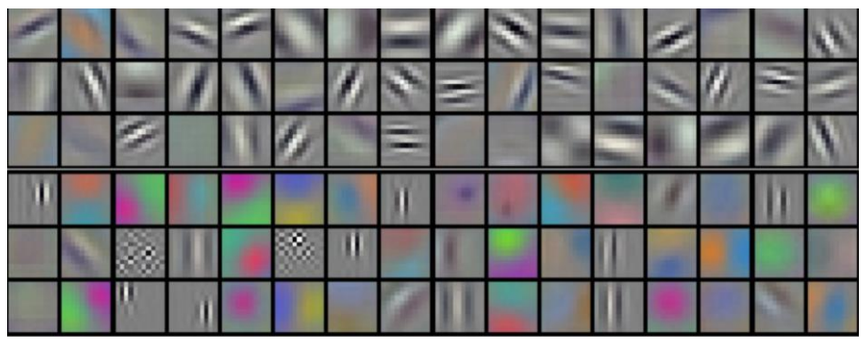
T0965 / 6D2V



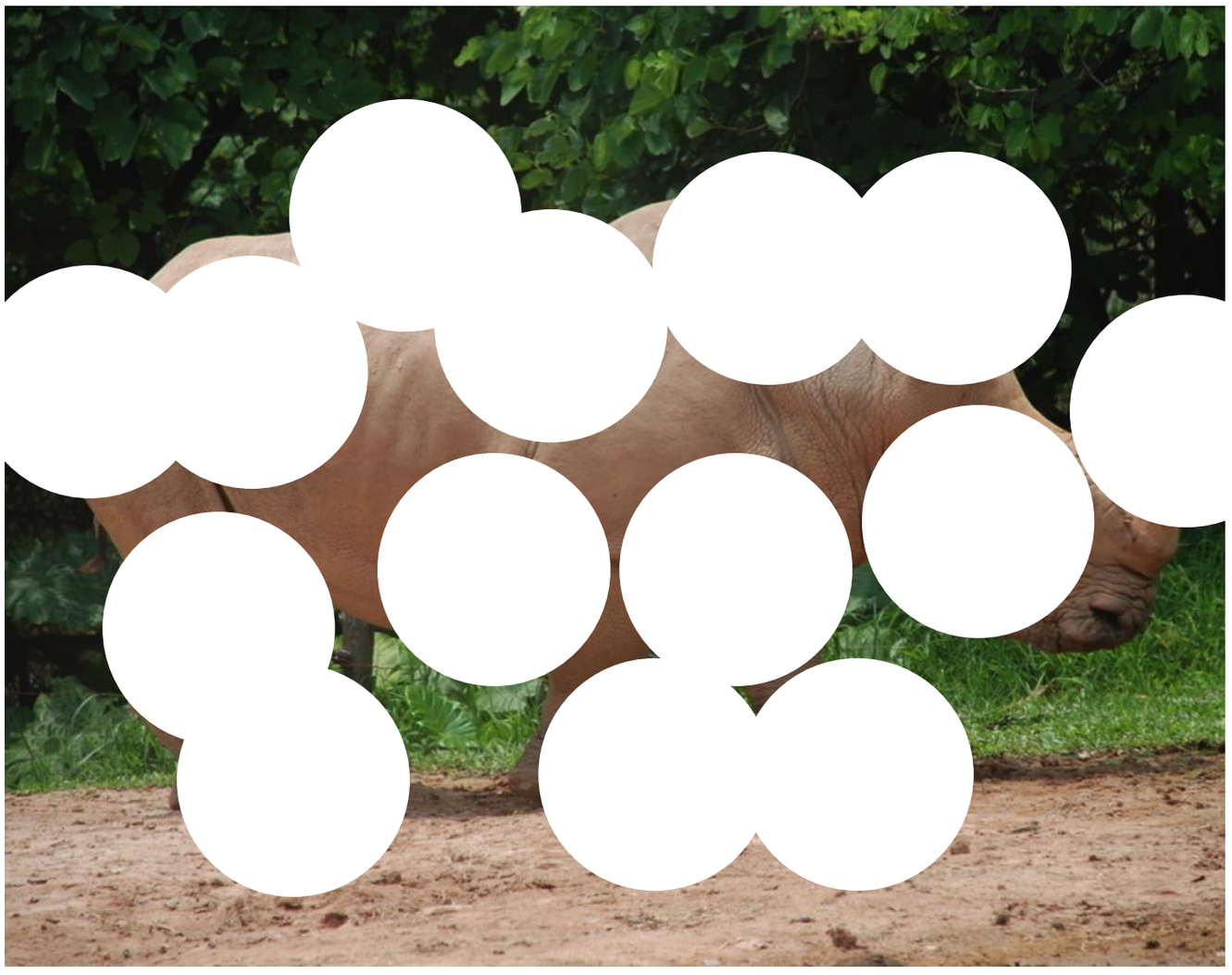
T0955 / 5W9F

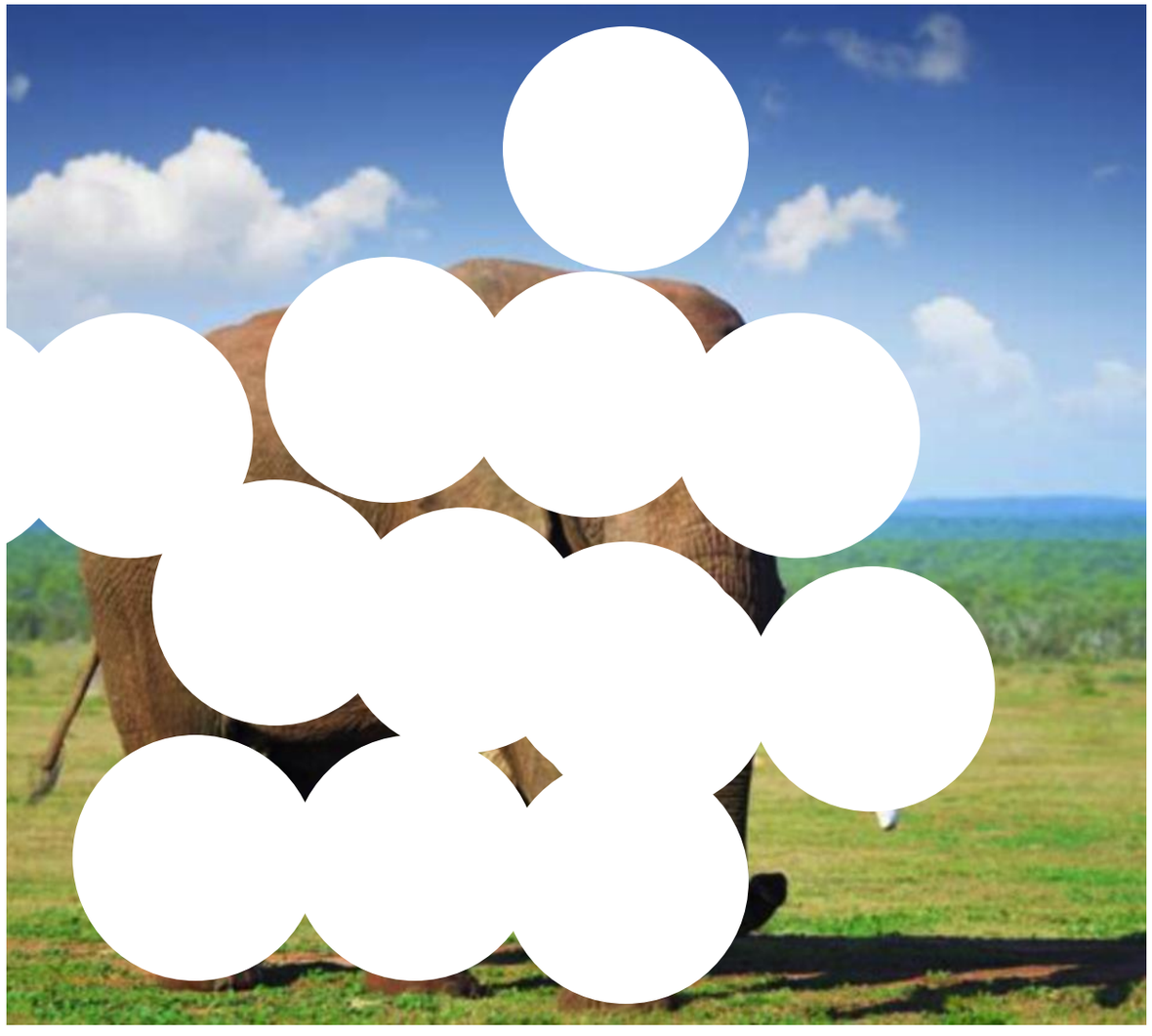


Convolutional Neural Networks(CNNs)



How to identify rhinos and elephants?





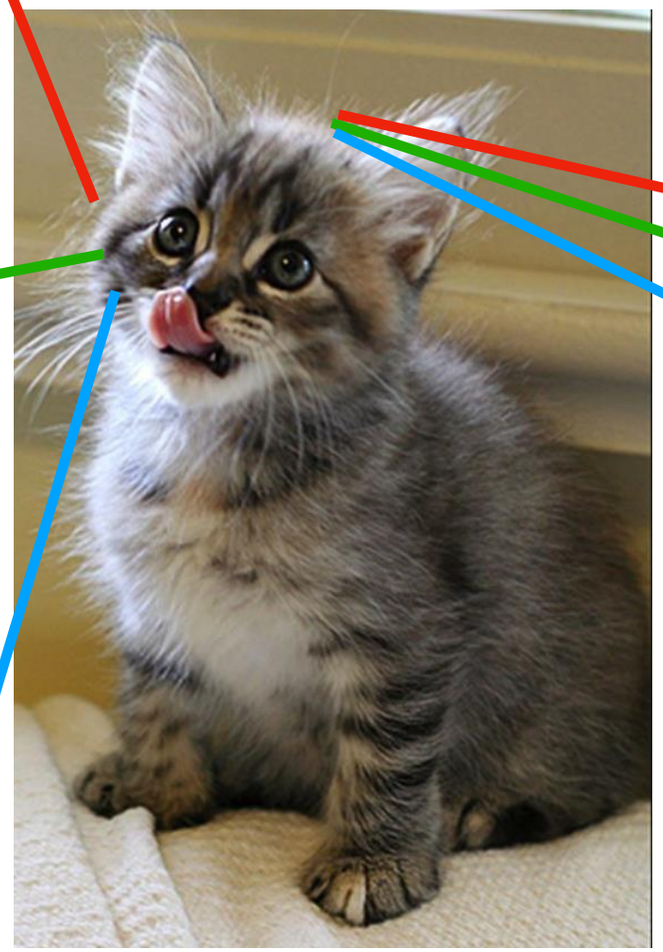
CNNs and Cat

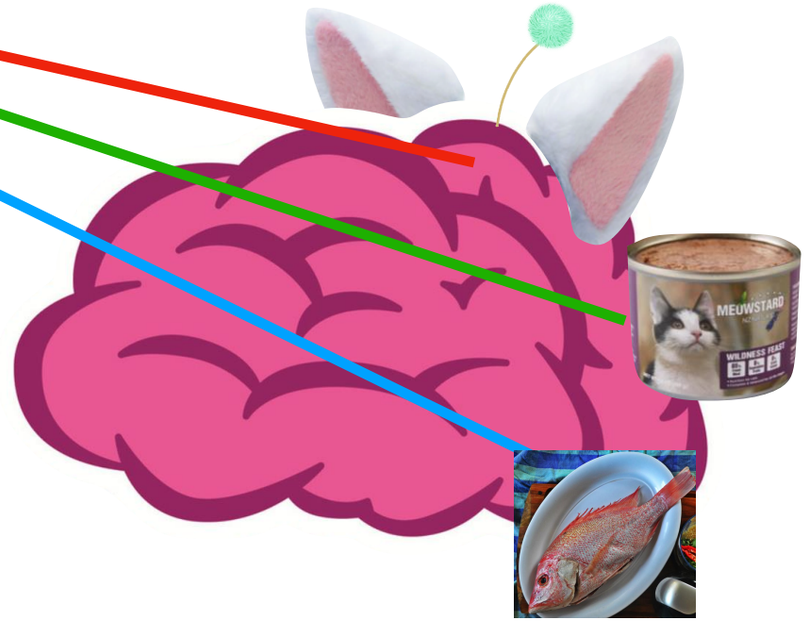

MEOWSTARD
NZ NATURE
WILDNESS FEAST
85% Fresh Meat
8% Vegetables Fruits
6% Fish Oils


MEOWSTARD

CNNs and Cat

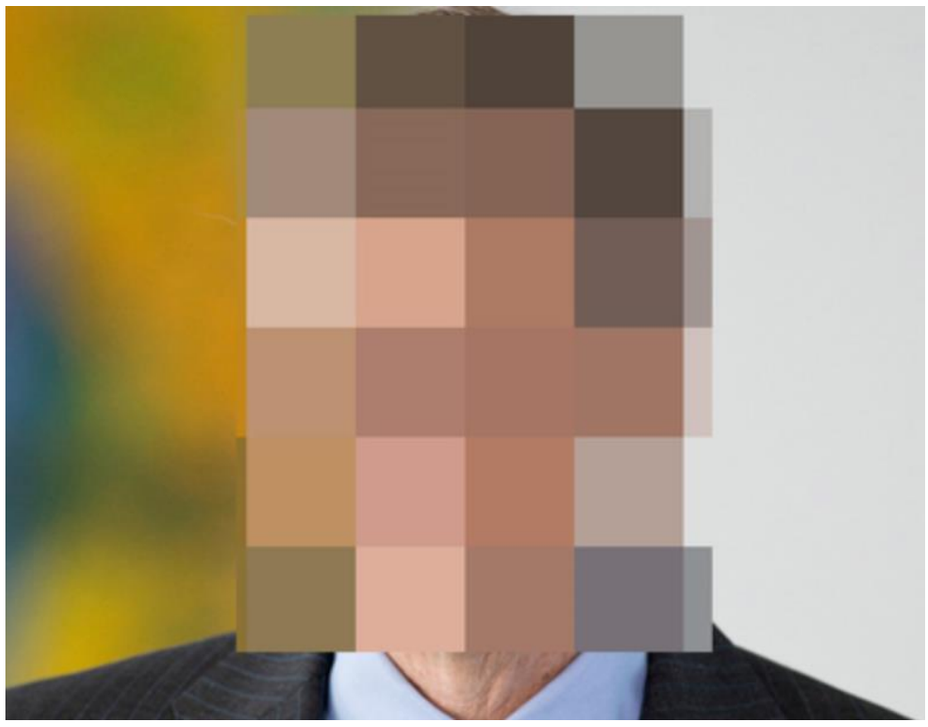

MEOWSTARD
NZ NATURE
WILDNESS FEAST




MEOWSTARD
WILDNESS FEAST

Before Start
Let's talk about two questions

- What is Matrix? And how to do Matrix Operations
- How to make a mosaic



Matrix

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ a_{31} & a_{32} & \cdots & a_{3n} \\ \cdots & \cdots & & \cdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

Matrix Multiply with a number：

$$2 \cdot \begin{bmatrix} 1 & 8 & -3 \\ 4 & -2 & 5 \end{bmatrix} = \begin{bmatrix} 2 \cdot 1 & 2 \cdot 8 & 2 \cdot (-3) \\ 2 \cdot 4 & 2 \cdot (-2) & 2 \cdot 5 \end{bmatrix} = \begin{bmatrix} 2 & 16 & -6 \\ 8 & -4 & 10 \end{bmatrix}$$

Make a mosaic

Display color is some numbers, mixed by Red,Green and Blue,
every single color have 256 level.
such as 000:000:000 is black, 255:000:000 is red.

The picture is a pixel matrix. Mosaic is to add the pixel RGB values in the range,
then divide by the number of pixels

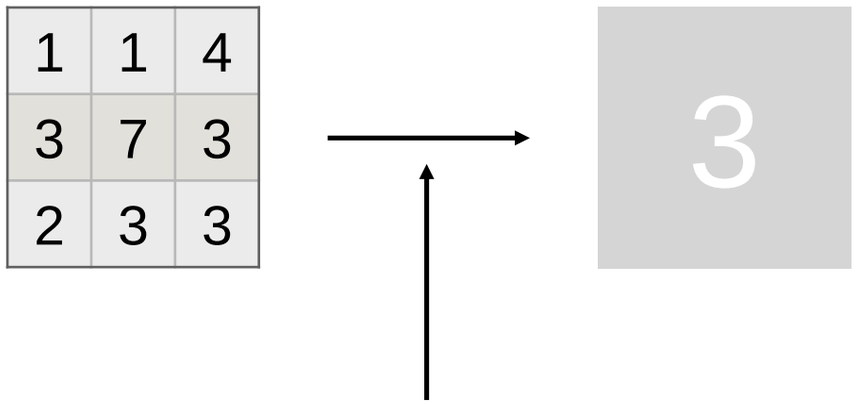
1	1	4
3	7	3
2	3	3

3

$$\frac{1+1+4+3+7+3+2+3+3}{9} = 3$$

Where is the connection between mosaic and CNN?

- CNN： A classifier that can identify some features through training



For mosaic, have a middle process
W is a filter.

$$W = \frac{1}{9} * \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

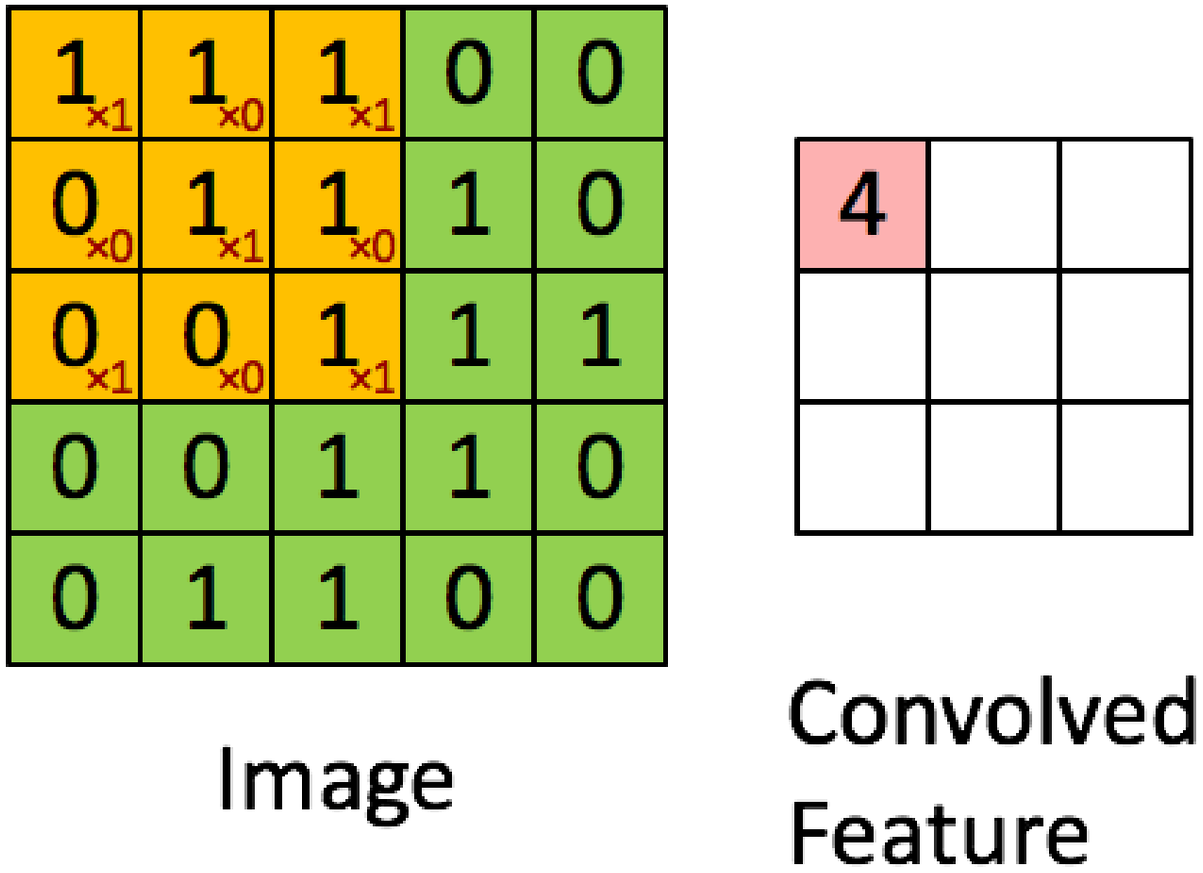
For this process, Using filter W,
Multiply the same position number
Output a mosaic(low-pass filtering)

$$\frac{1*1 + 1*1 + 4*1 + 3*1 + 7*1 + 3*1 + 2*1 + 3*1 + 3*1}{9} = 3$$

a matrix, the convolution of the filter is used to identify the similarity between the matrix ar

This is convolutional

Here is an example:



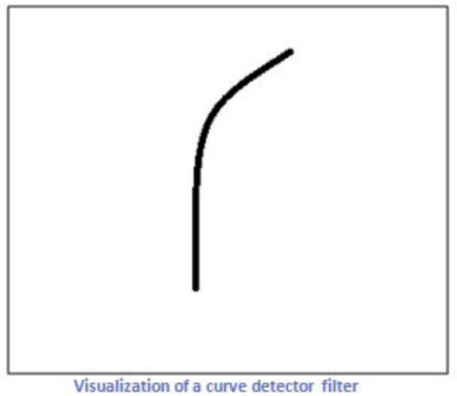
How to use filters to identify pictures?

Original image

picture

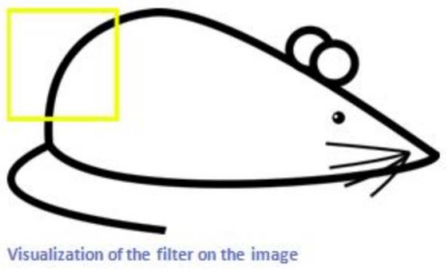
0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter



Visualization of a curve detector filter

Designed filter



Visualization of the filter on the image

Visualization of the receptive field

0	0	0	0	0	0	30
0	0	0	0	50	50	50
0	0	0	20	50	0	0
0	0	0	50	50	0	0
0	0	0	50	50	0	0
0	0	0	50	50	0	0
0	0	0	50	50	0	0

Pixel representation of the receptive field

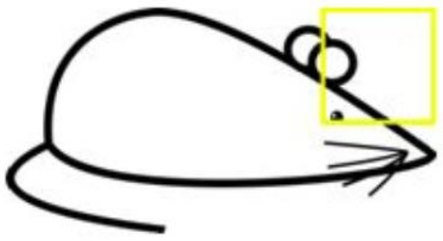
*

0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter

out put Y

Multiplication and Summation = (50*30)+(50*30)+(50*30)+(20*30)+(50*30) = 6600 (A large number!)



Visualization of the filter on the image

0	0	0	0	0	0	0
0	40	0	0	0	0	0
40	0	40	0	0	0	0
40	20	0	0	0	0	0
0	50	0	0	0	0	0
0	0	50	0	0	0	0
25	25	0	50	0	0	0

Pixel representation of receptive field

*

0	0	0	0	0	30	0
0	0	0	0	30	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	30	0	0	0
0	0	0	0	0	0	0

Pixel representation of filter

out put N

Multiplication and Summation = 0

How to training CNN

aining starts. According to the training result to adjust the filter value, this process needs t

This is a filter training process in a single-layer neural network

step 1

1	1	1	1	9
1	1	1	9	1
1	1	9	1	1
1	1	9	1	1
1	1	9	1	1

input matrix

3	5	2	5	7
1	2	3	4	8
4	7	2	3	4
2	3	6	1	4
1	2	4	5	1

random filter

convolution

3	5	2	5	63
1	2	3	36	8
4	7	18	3	4
2	3	54	3	4
1	2	36	5	1

sum: 237

limit = 9

Raise the identified(>=9) point

reduce the unrecognized(<9) point

max = 8
min = 1
every step change 1

2	4	1	4	8
1	1	2	5	7
3	6	3	2	3
1	2	7	1	3
1	1	8	1	2

step 1 output filter

step 2

1	1	1	1	9
1	1	1	9	1
1	1	9	1	1
1	1	9	1	1
1	1	9	1	1

input matrix

2	4	1	4	8
1	1	2	5	7
3	6	3	2	3
1	2	7	1	3
1	1	5	4	1

step 1 output filter

convolution

2	4	1	4	72
1	1	2	45	7
3	6	27	2	3
1	2	63	1	3
1	1	45	4	1

sum: 302

.
.
.

step n

. . .

sum: 425

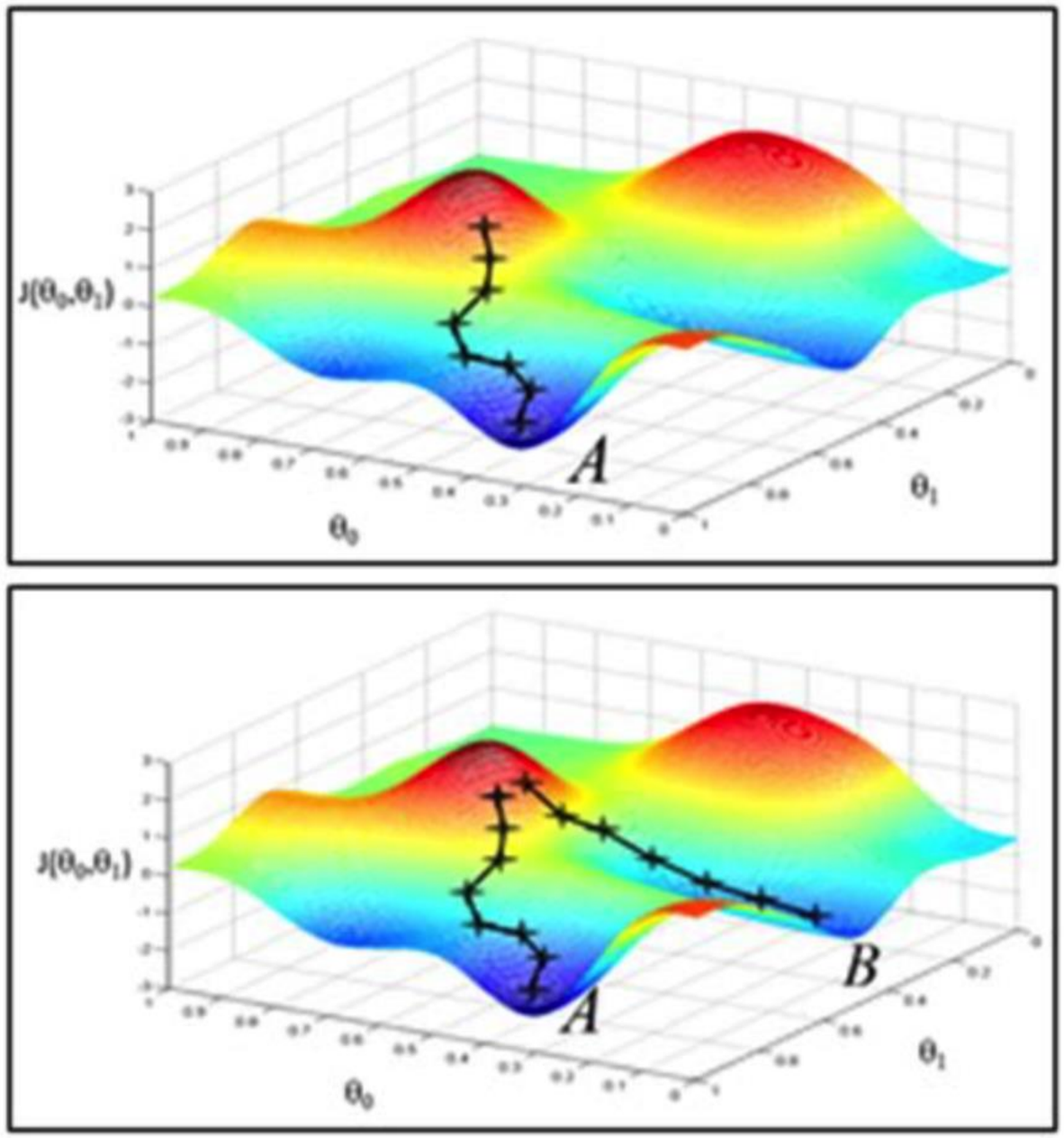
1	1	1	1	9
1	1	1	9	1
1	1	9	1	1
1	1	9	1	1
1	1	9	1	1

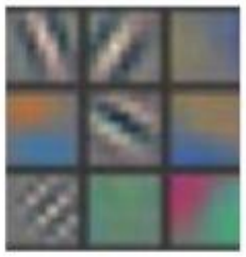
Loss function

The goal is to minimize the distance between the training data and the filter.

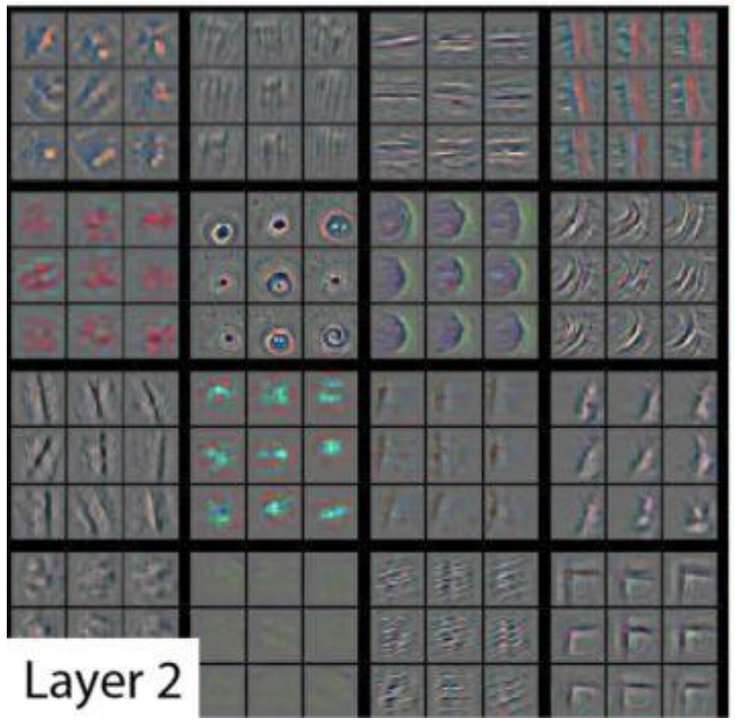
training-completed filter
Maximize the probability of identifying the input matrix

Gradient Descent

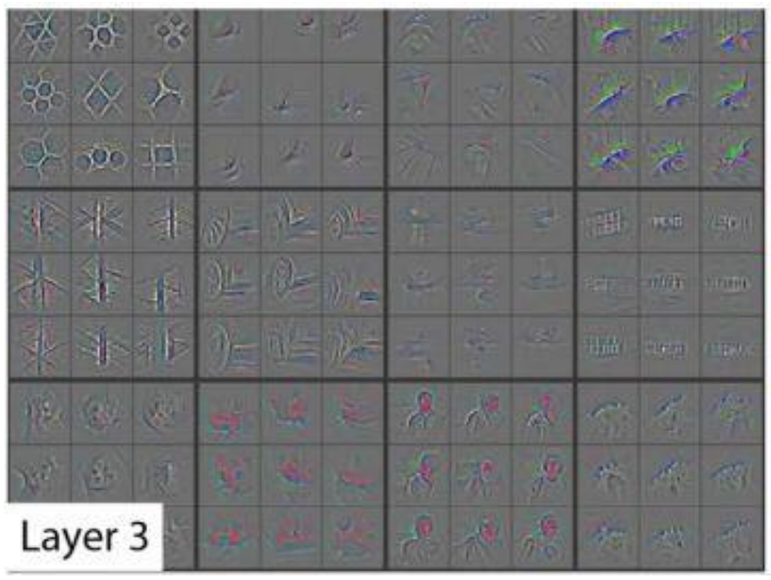




Layer 1



Layer 2



Layer 3

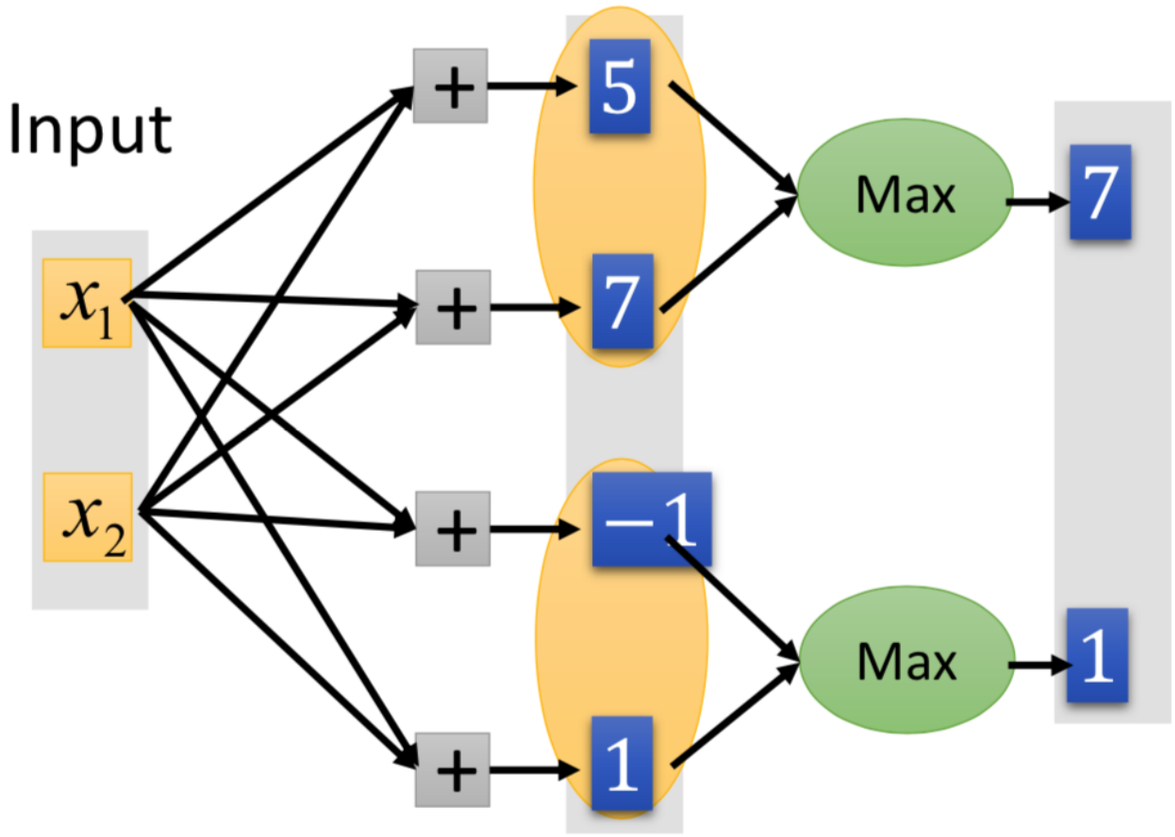
.

.

.

Training-completed image recognition convolutional neural network

Identify



1	0	0	0	0	1
0	1	0	0	1	0
0	0	1	1	0	0
1	0	0	0	1	0
0	1	0	0	1	0
0	0	1	0	1	0

image

1	-1	-1
-1	1	-1
-1	-1	1

-1	1	-1
-1	1	-1
-1	1	-1

convolution

-1	-1	-1	-1
-1	-1	-2	1
-1	-1	-2	1
-1	0	-4	3

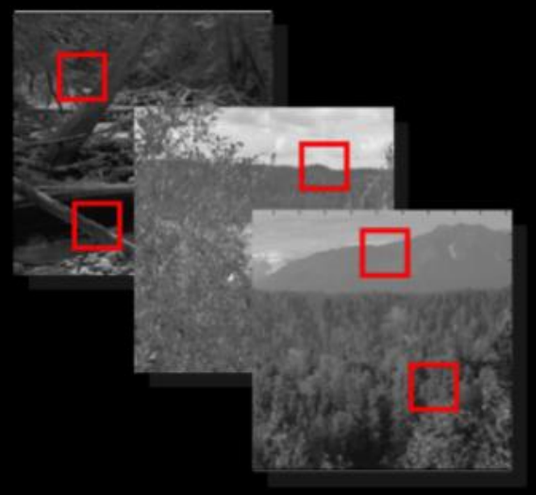
Max pooling

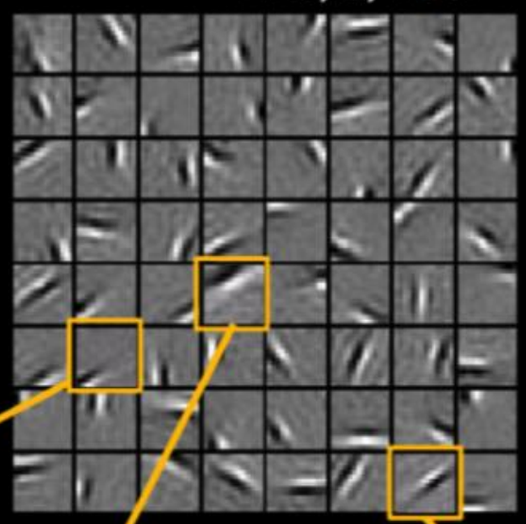
-1	1
0	3

Demo

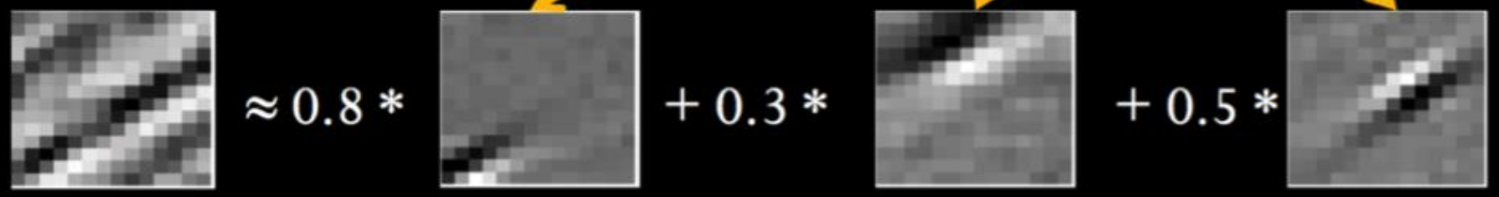
Natural images

Learned bases (ϕ_1, ..., ϕ_{64}): "Edges"





Test example



$x \approx 0.8 * \phi_{36} + 0.3 * \phi_{42} + 0.5 * \phi_{63}$

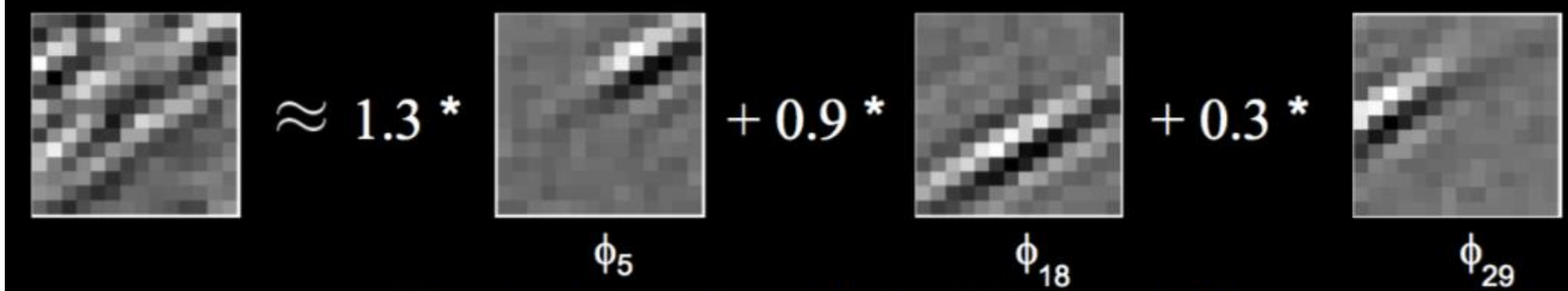
$[a_1, ..., a_{64}] = [0, 0, ..., 0, \mathbf{0.8}, 0, ..., 0, \mathbf{0.3}, 0, ..., 0, \mathbf{0.5}, 0]$

(feature representation)

More succinct, higher-level, representation.

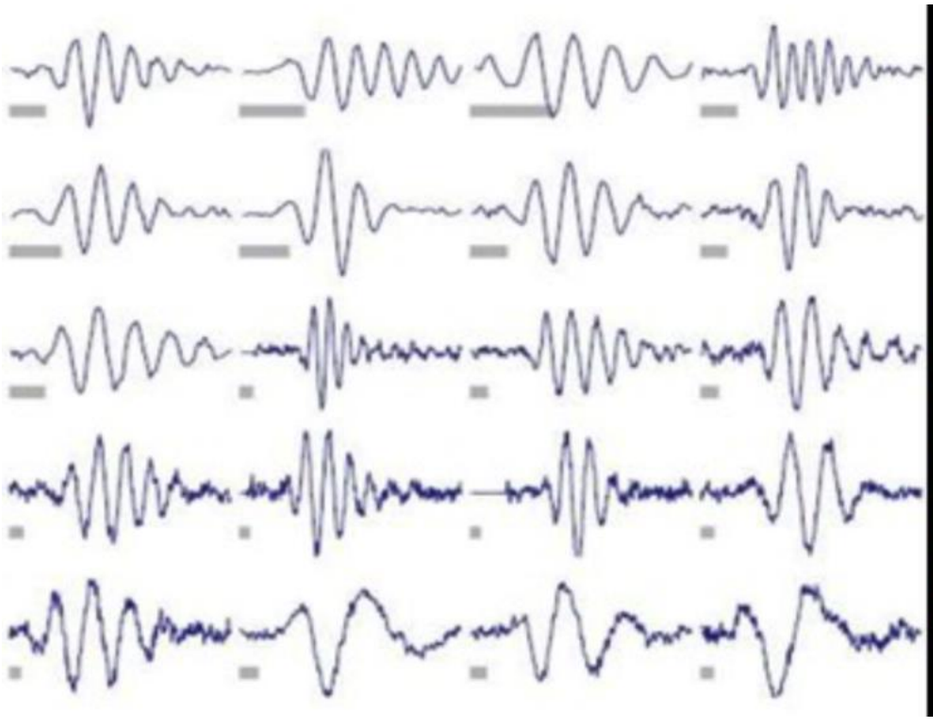
$\approx 0.6 * \phi_{15} + 0.8 * \phi_{28} + 0.4 * \phi_{37}$

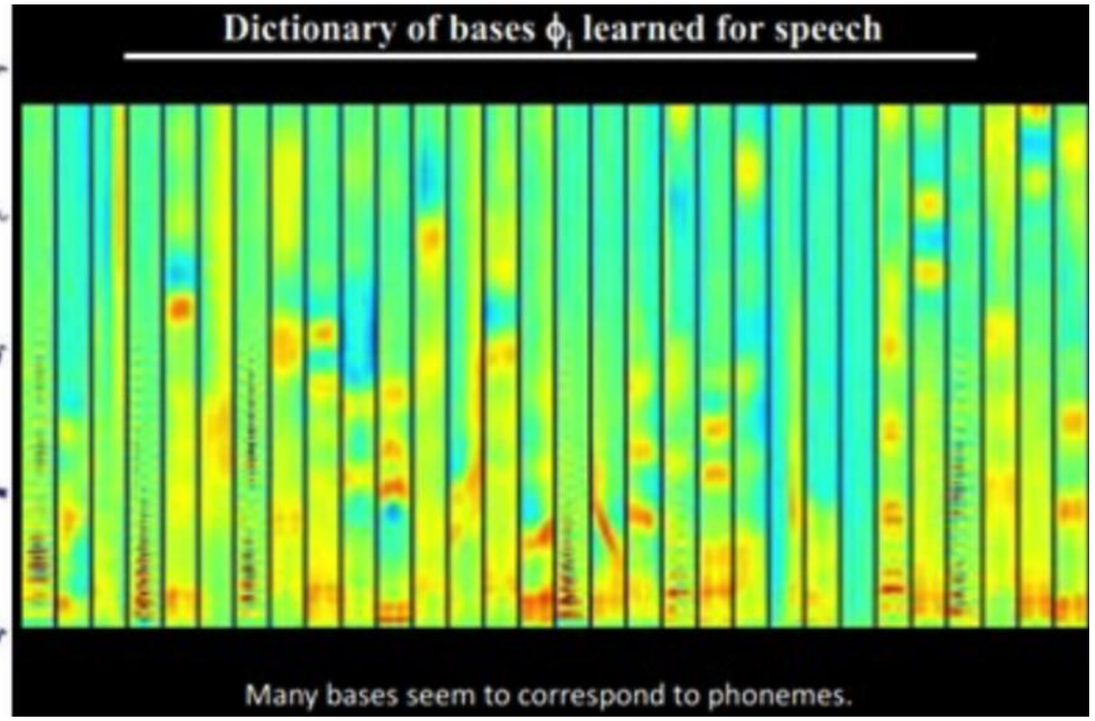
Represent as: $[a_{15}=0.6, a_{28}=0.8, a_{37} = 0.4]$.

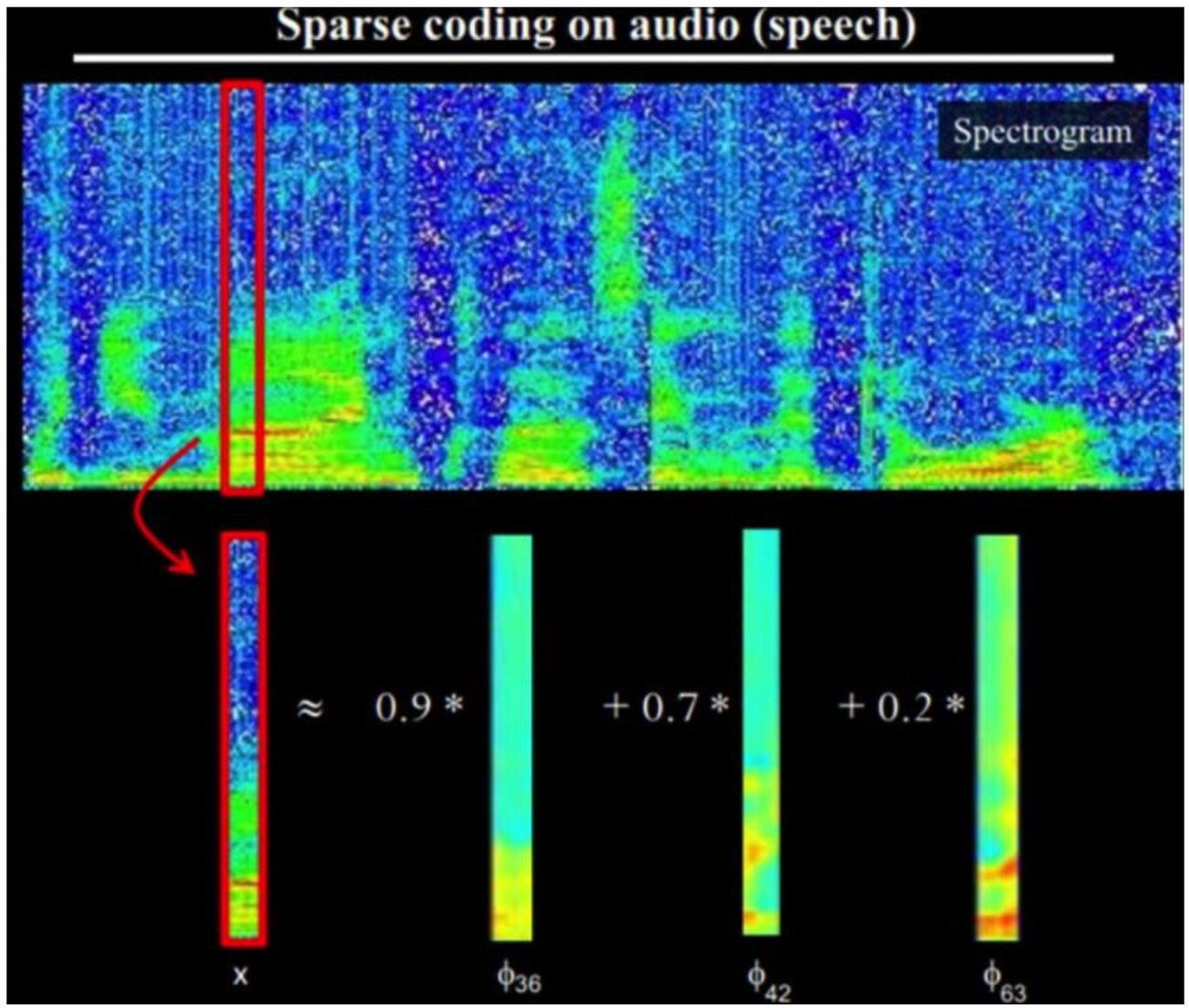


$\approx 1.3 * \phi_5 + 0.9 * \phi_{18} + 0.3 * \phi_{29}$

Represent as: $[a_5=1.3, a_{18}=0.9, a_{29} = 0.3]$.




Dictionary of bases ϕ_i learned for speech
Many bases seem to correspond to phonemes.


Sparse coding on audio (speech)
Spectrogram
≈ 0.9 * + 0.7 * + 0.2 *
x
ϕ_{36}
ϕ_{42}
ϕ_{63}

TensorFlow

torch

theano

Caffe

Microsoft CNTK

Chainer

- MIT 6.034, Fall 2010, Artificial Intelligence, Patrick H. Winston
- Stanford, CS229 Machine Learning by Andrew Ng
- Deep Learning Tutorial, 李宏毅Hung-yi Lee
- Deep Learning, Yann LeCun, Yoshua Bengio & Geoffrey Hinton Nature 521, 436–444 (28 May 2015) doi:10.1038/nature14539
- https://deepmind.com/blog/alphafold/
- https://www.bilibili.com/video/av38195397?p=19

Thank you!