Deep Learning Introduction

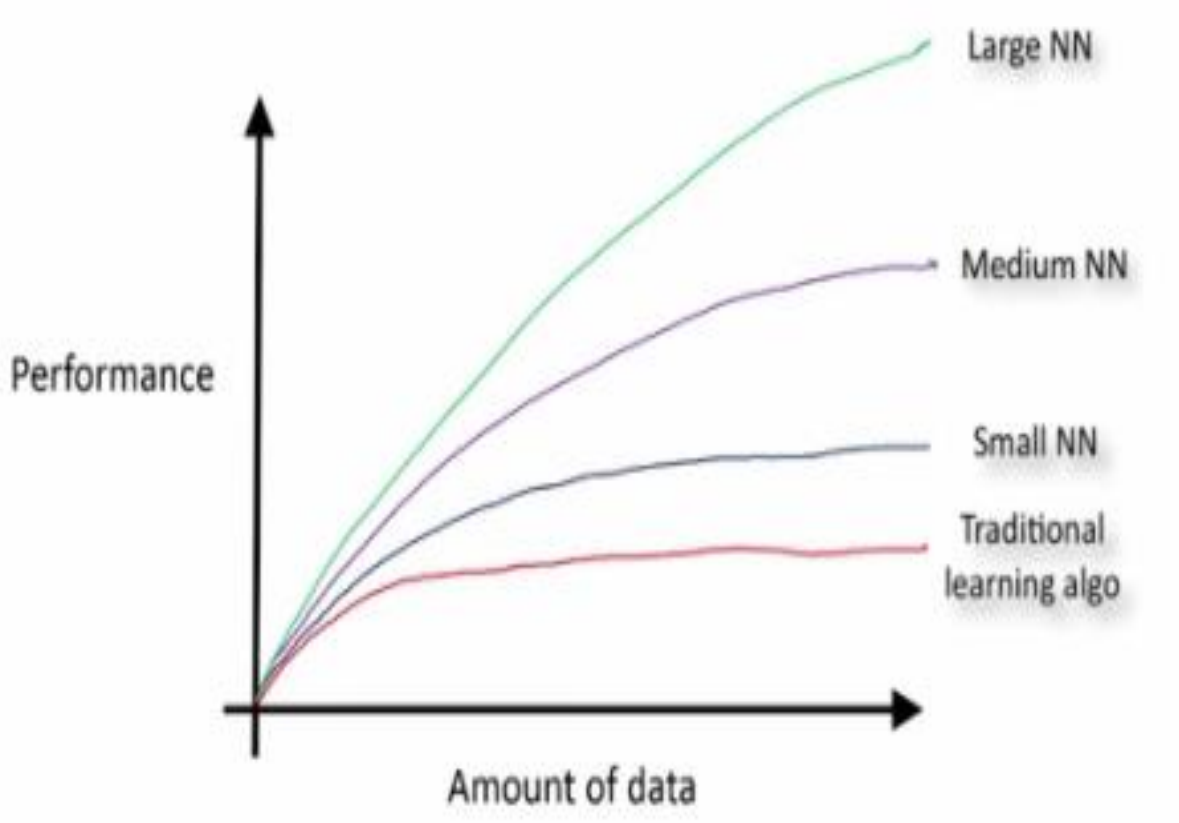
講者：Isaac

Outline

- Why Deep Learning
- What is Deep Learning
- Different kinds of Application
- TensorFlow Introduction

Why Deep Learning

Powerful of Deep Learning



Powerful of Deep Learning

- In the past
  - We need feature engineering (take lots of human labor)
- Deep learning
  - It learns suitable features for this task

Example

- Detect if this image is “zero” or “one”

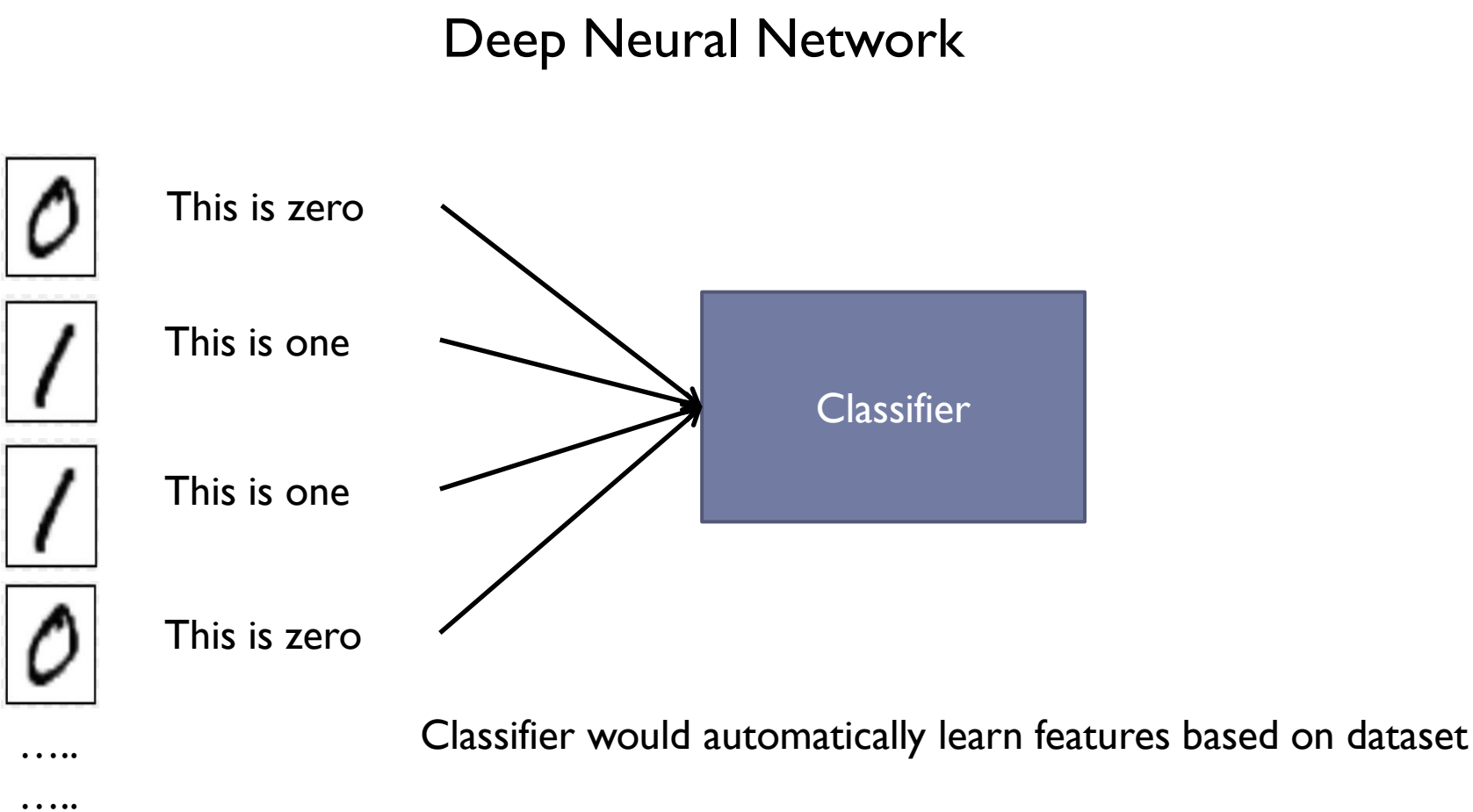
Example

Traditional method

Feature #1 = if black part is round
Feature #2 = ratio of black pixels in image
…..
…..
…..
Feature #N = center of image pixel is white

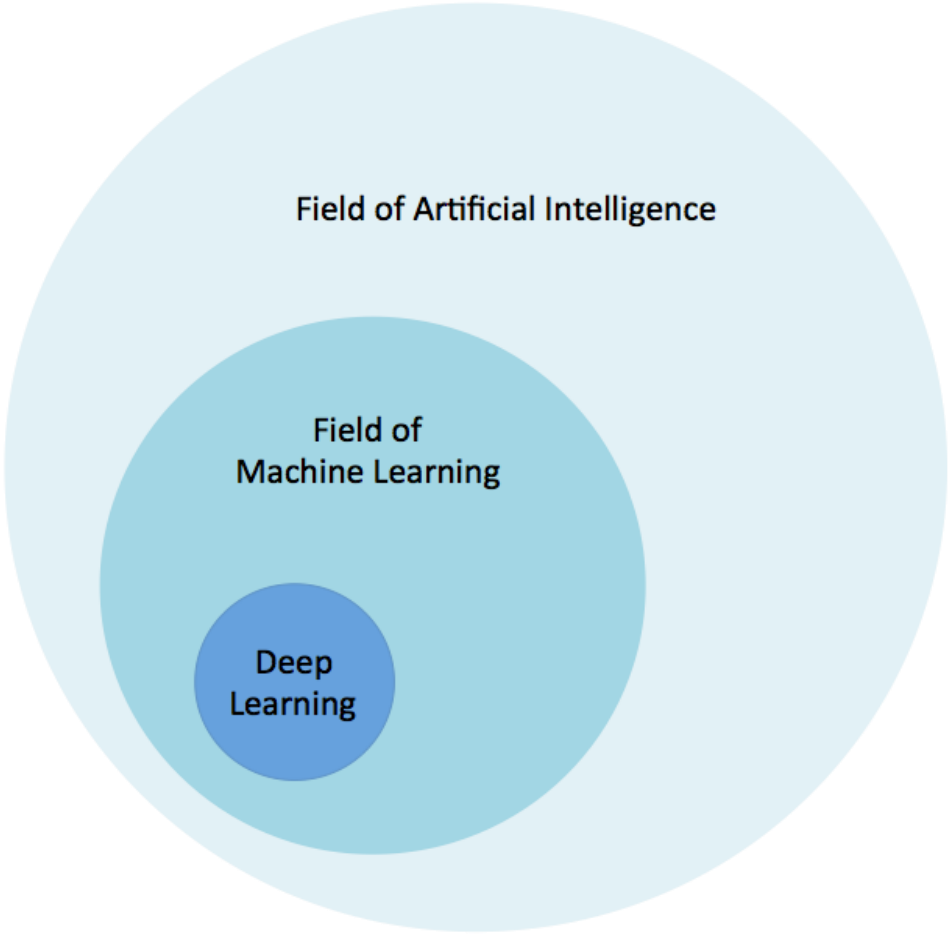
SVM
Logistic regression
…..
…..
…..

Example

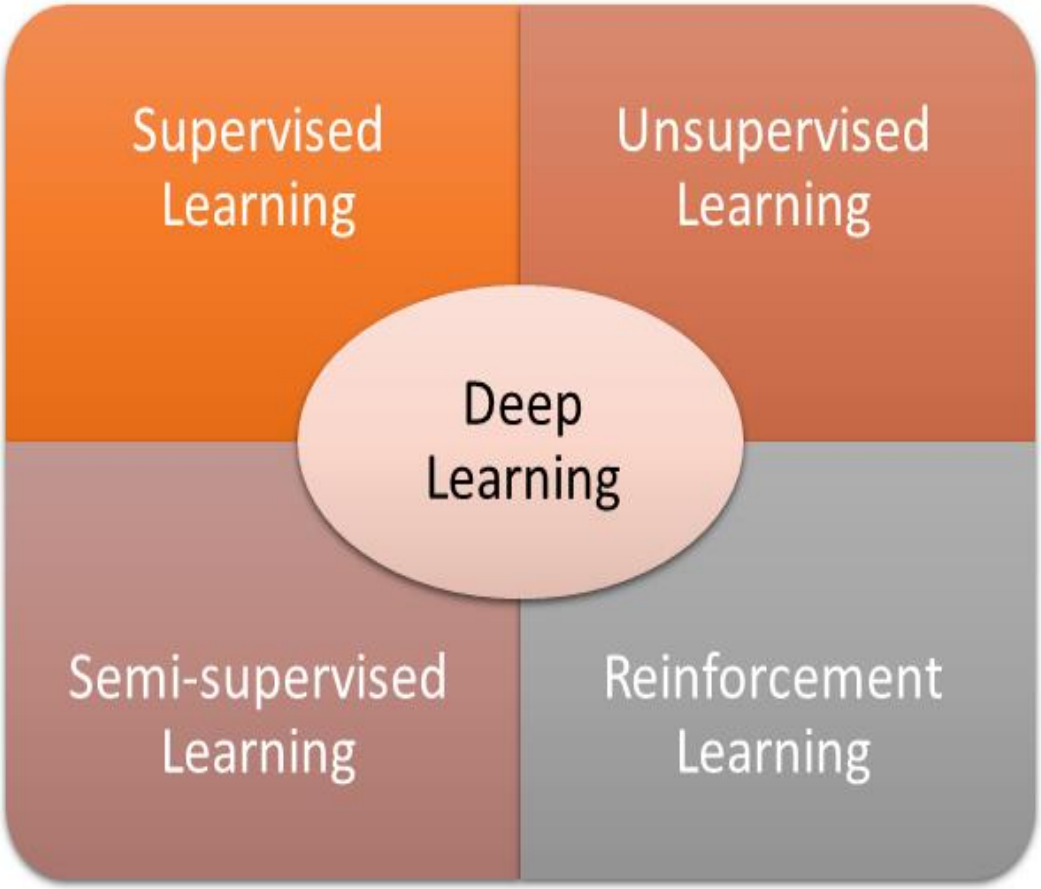

Deep Neural Network
This is zero
This is one
This is one
This is zero
Classifier
…..
…..
Classifier would automatically learn features based on dataset

What is Deep Learning

AI v.s. ML v.s. Deep Learning

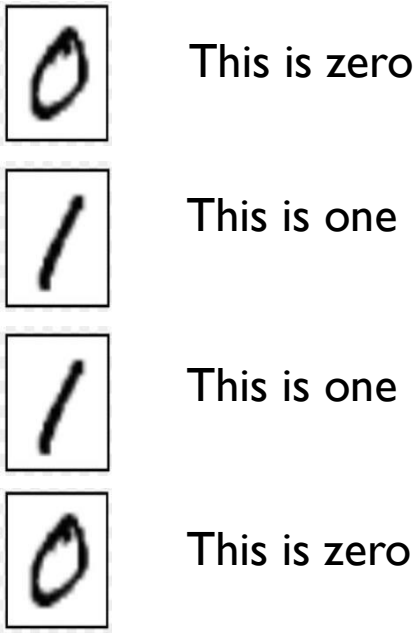


Different kind of Deep Learning



Different kind of Deep Learning

- Supervised Learning
  - Give machine data and corresponding label

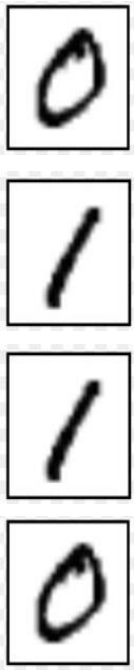


Different kind of Deep Learning

- Unsupervised Learning
  - Cluster unlabelled data

Different kind of Deep Learning

- Semi-supervised Learning
  - Some data are labelled but some are not



This is zero

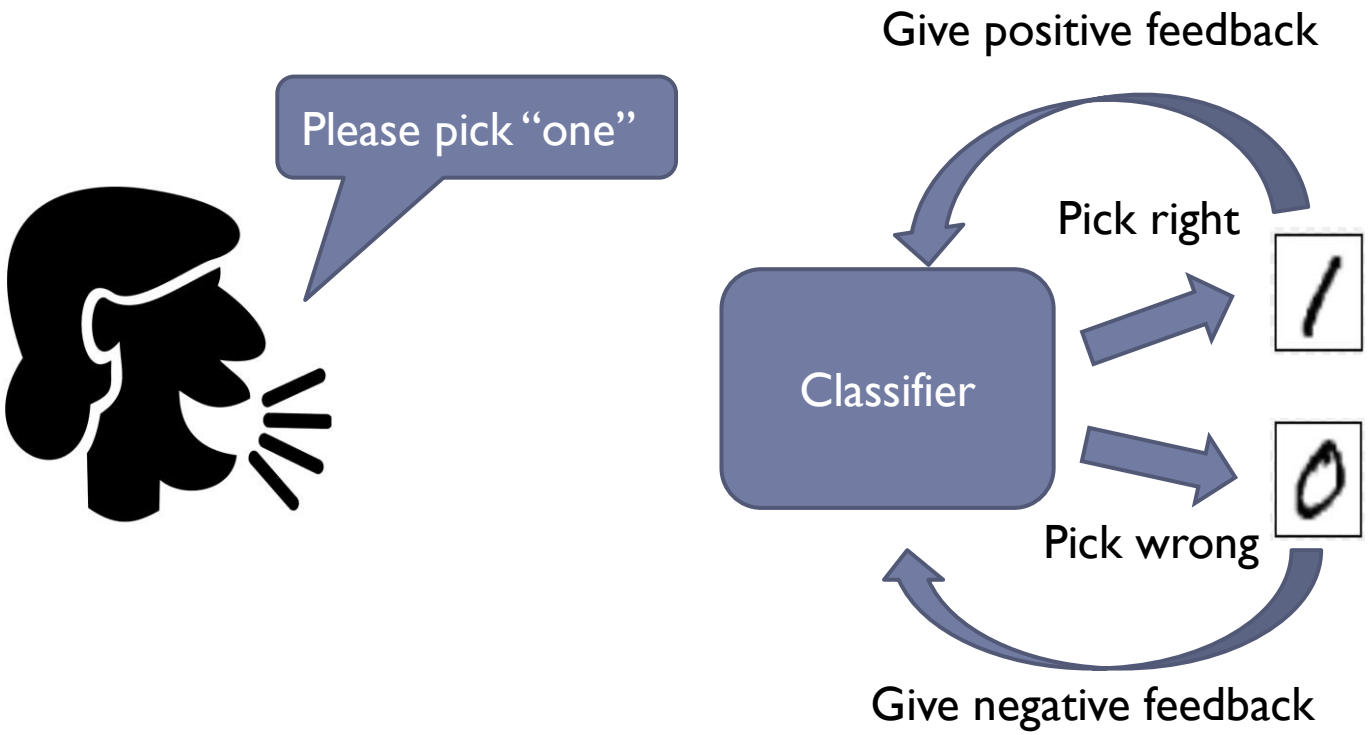
This is one

???

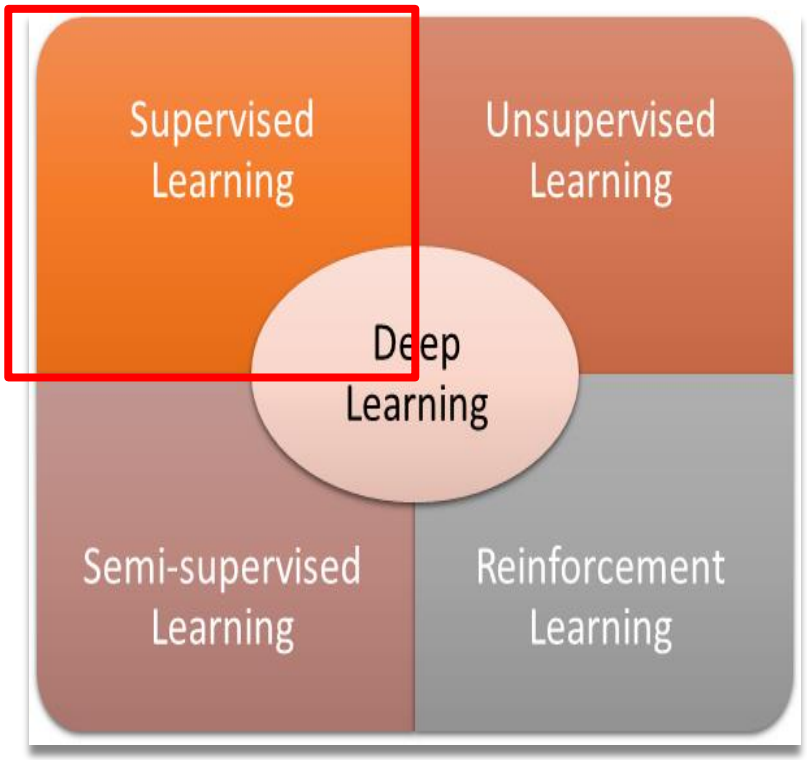
???

Different kind of Deep Learning

- Reinforcement Learning
  - Given unlabelled data, make machine self-learning



Different kind of Deep Learning



We will focus on supervised learning in this course !!!

What is Learning?

- We want to find a function such that……

$f(x)$

"hello"

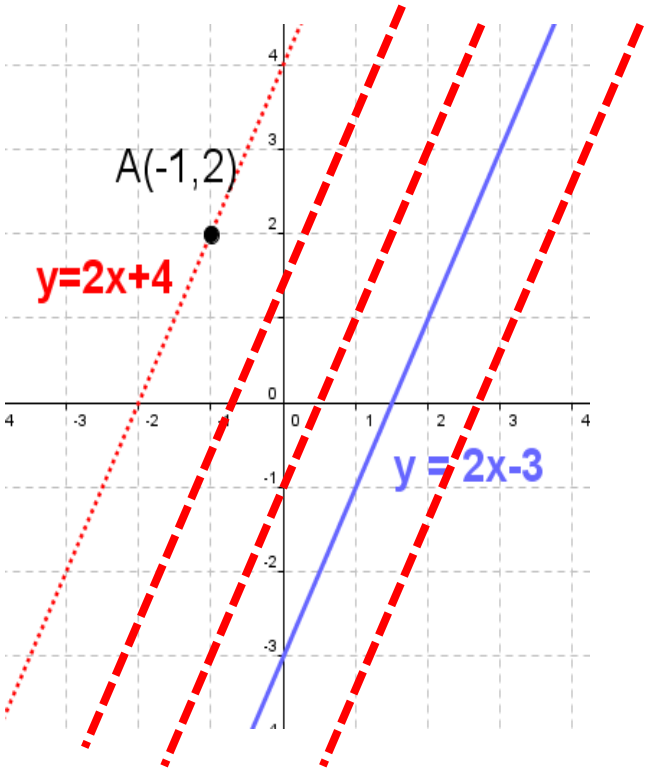
"2"

"Stock price today"

"Stock price tomorrow"

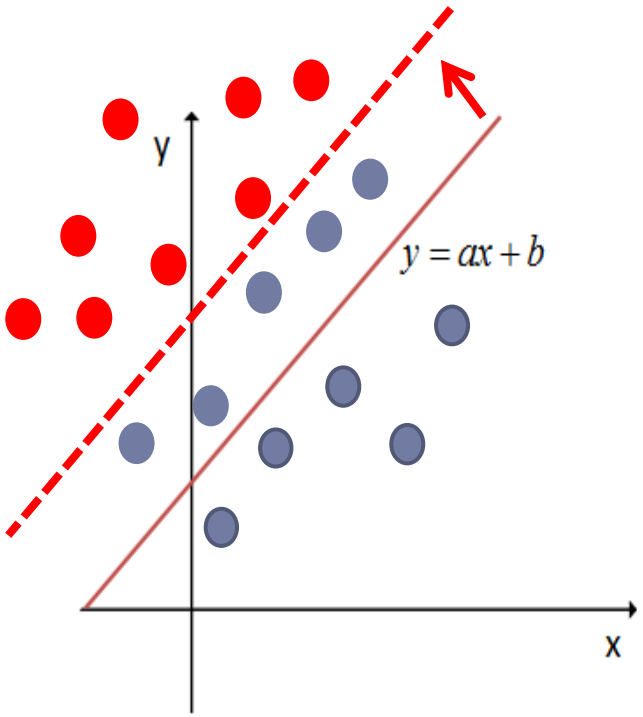
What is Learning?

- Define hypothesis function set f1, f2, …..
  - Y= ax + b, where "b" is a variable and "a" is a constant



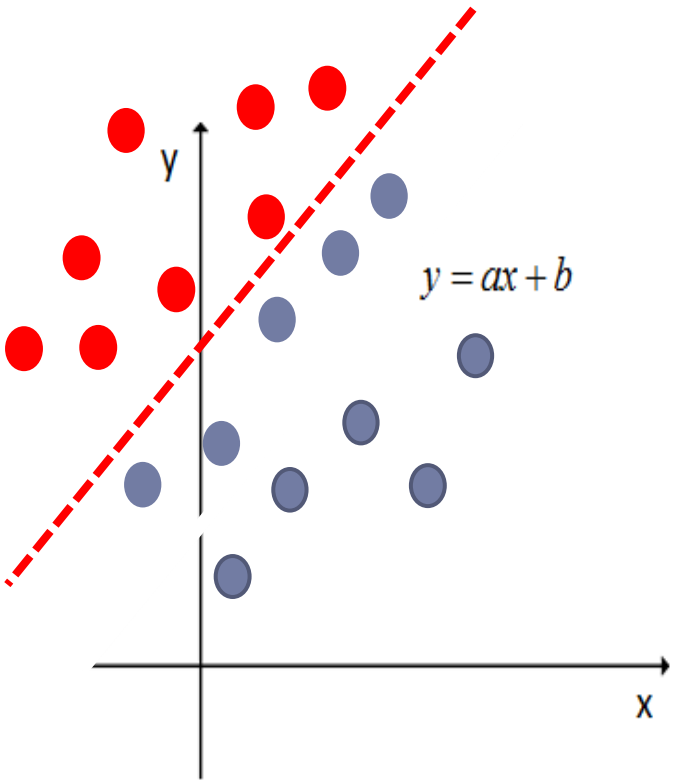
What is Learning?

- Feed training data to find the best function



What is Learning?

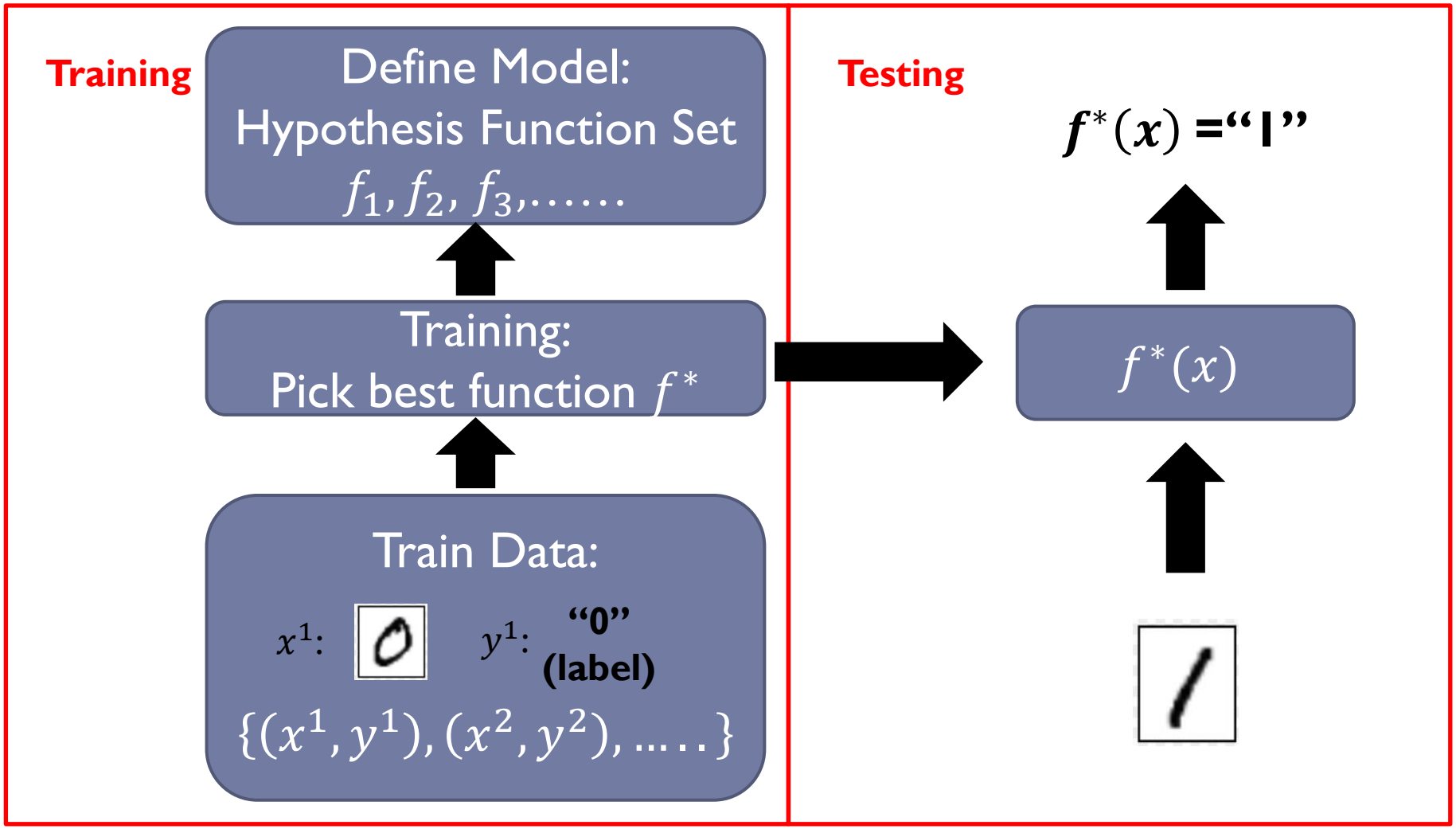
- Use this best function to predict future data



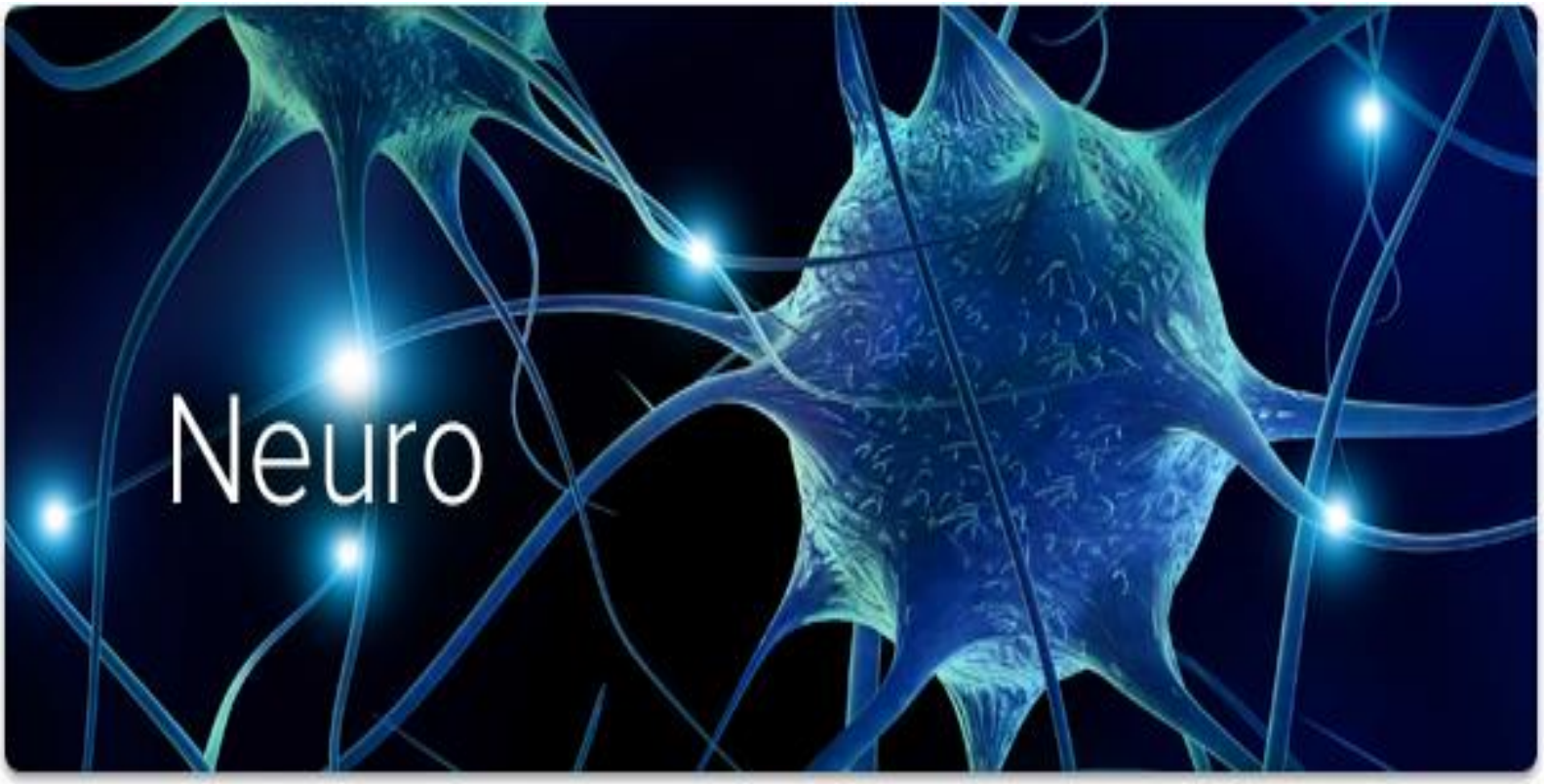
Use this new line to predict

Note:
In real word, most of work may be non-linear separable. So, Function set may be non-linear

What is Learning?

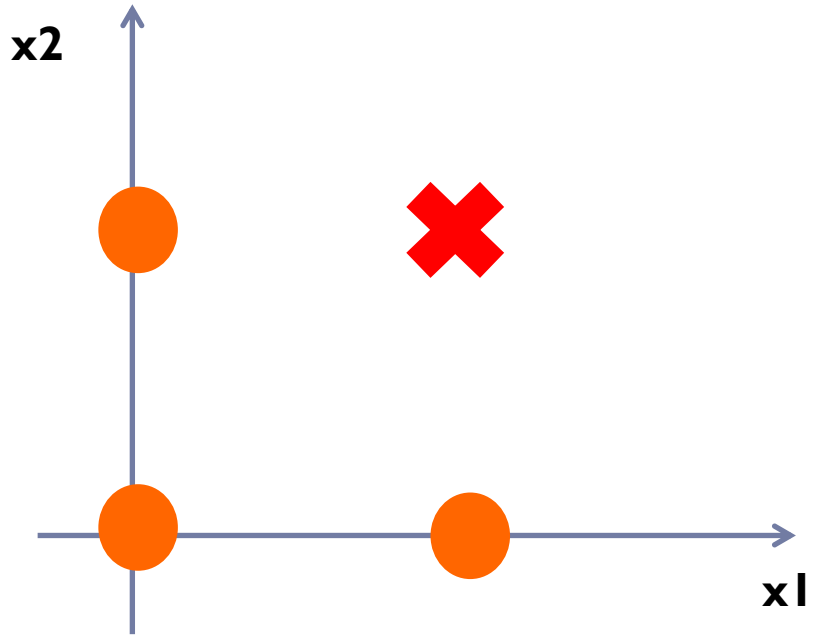


A Neuron



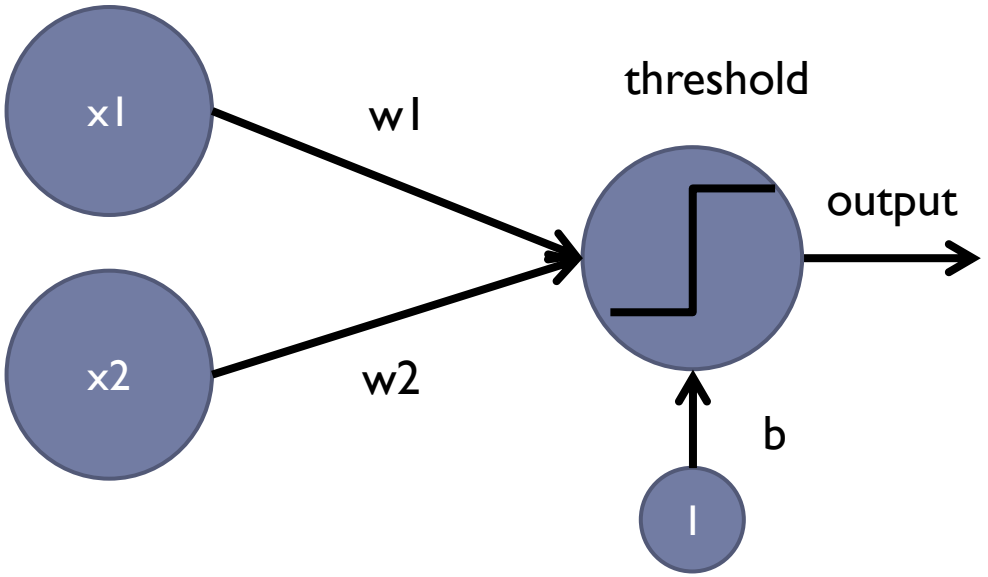
Example

NAND gate truth table		
x1	x2	output
0	0	1
0	1	1
1	0	1
1	1	0



Example

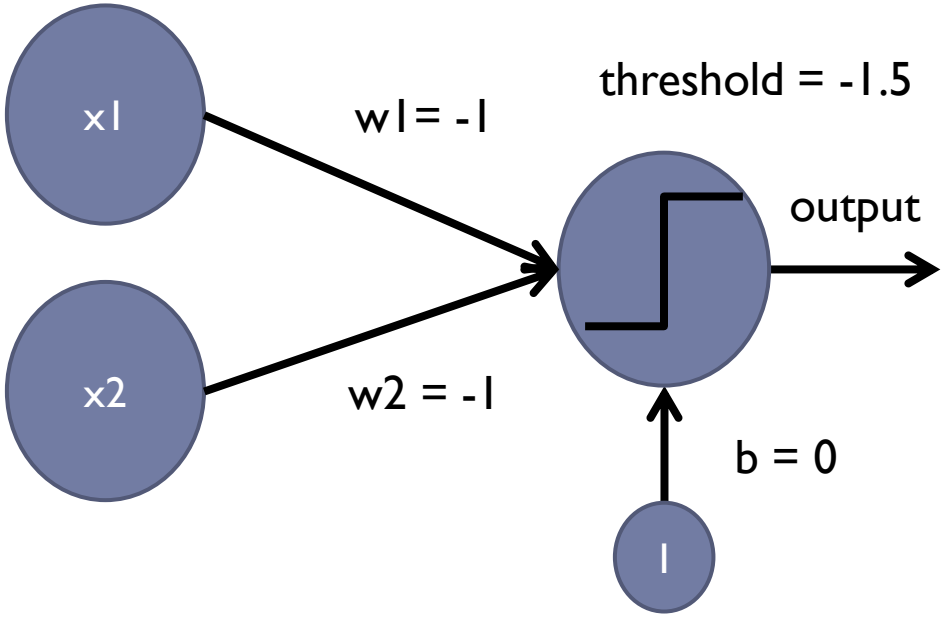
NAND gate truth table		
x1	x2	output
0	0	1
0	1	1
1	0	1
1	1	0



$$output = \begin{cases} 0 & if\ x1 * w1 + x2 * w2 + b \leq threshold \\ 1 & if\ x1 * w1 + x2 * w2 + b > threshold \end{cases}$$

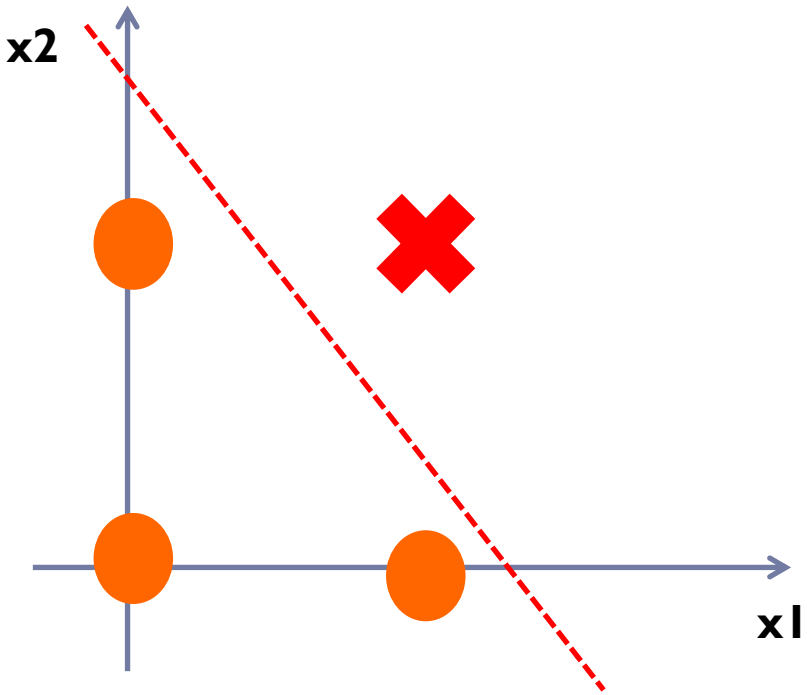
Example

NAND gate truth table		
x1	x2	output
0	0	1
0	1	1
1	0	1
1	1	0



$$output = \begin{cases} 0 & if\ x1 * w1 + x2 * w2 + b \leq threshold \\ 1 & if\ x1 * w1 + x2 * w2 + b > threshold \end{cases}$$

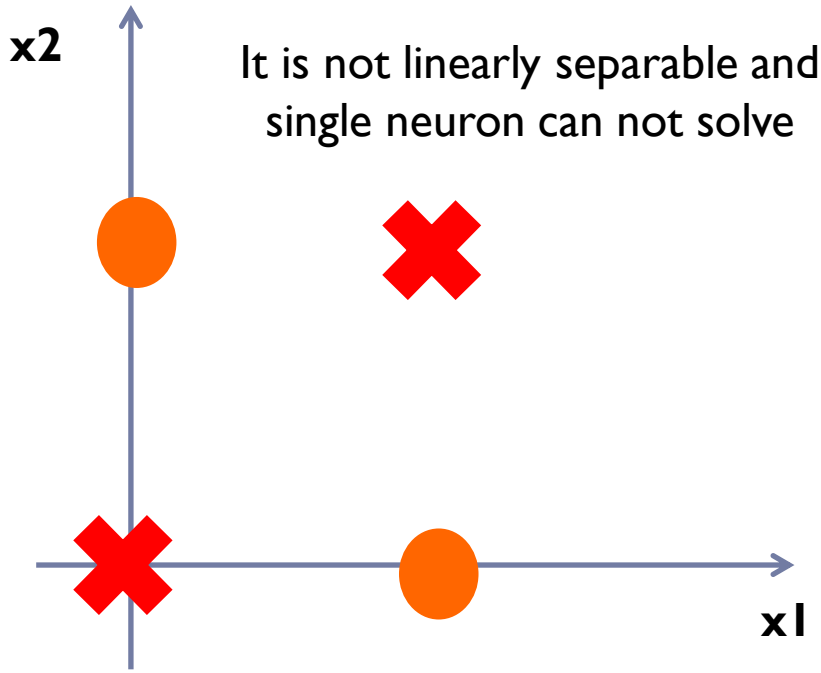
Example



Example

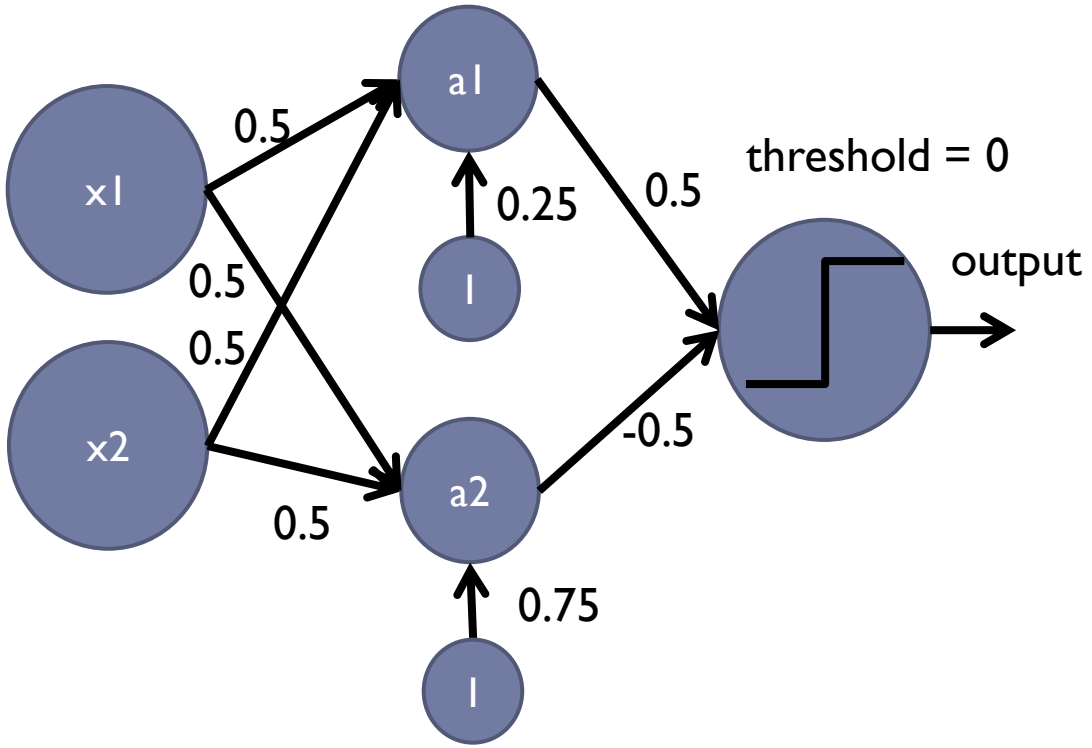
How about XOR ?

XOR gate truth table		
x1	x2	output
0	0	0
0	1	1
1	0	1
1	1	0

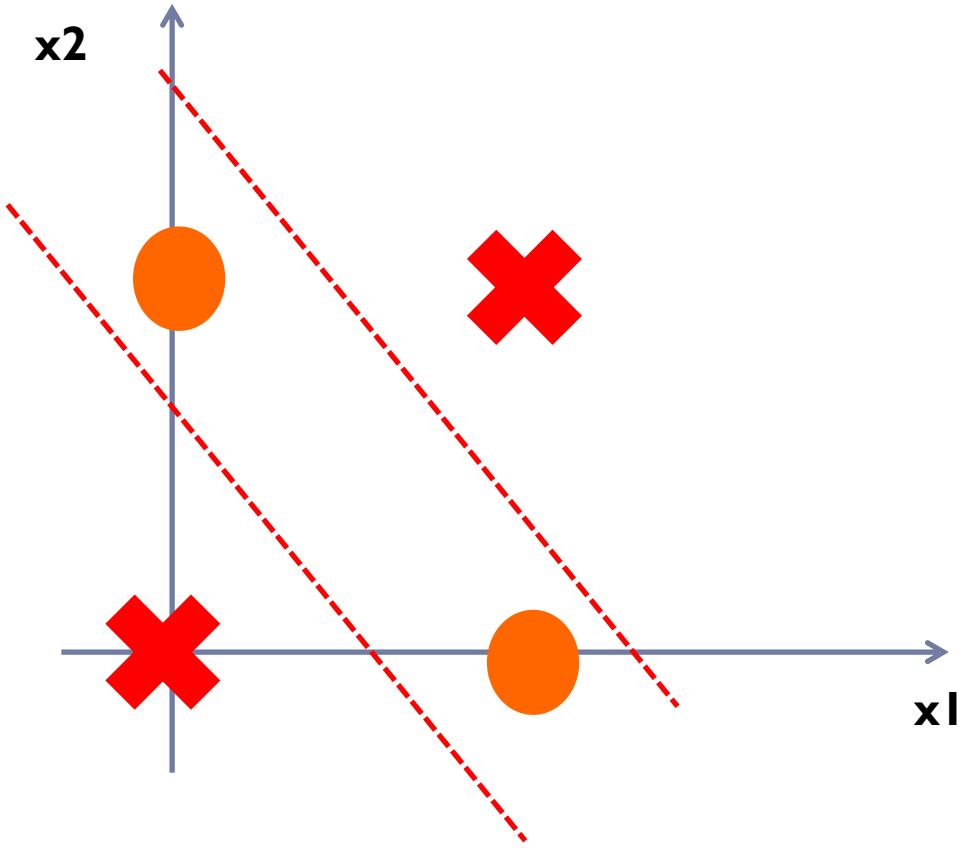


Example

XOR gate truth table		
x1	x2	output
0	0	0
0	1	1
1	0	1
1	1	0

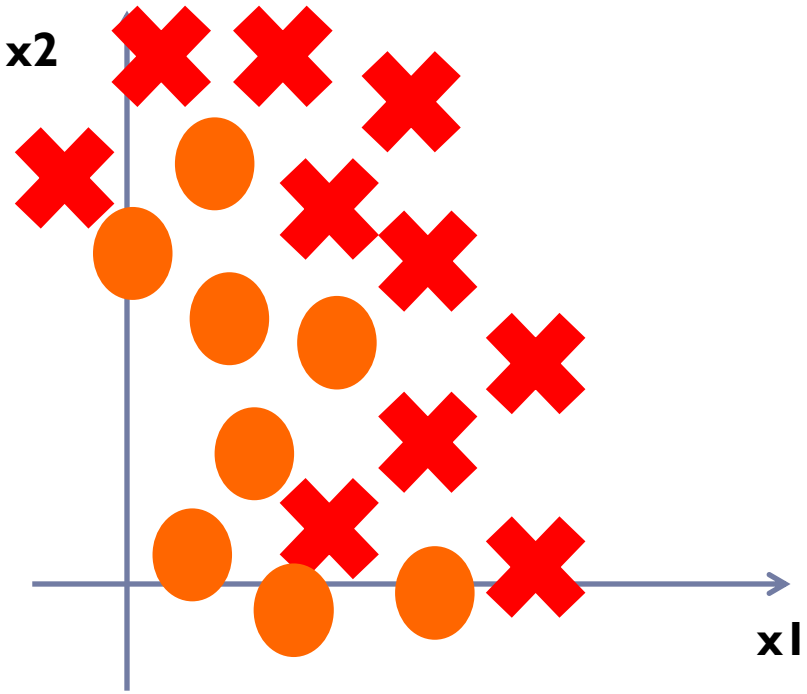


Example

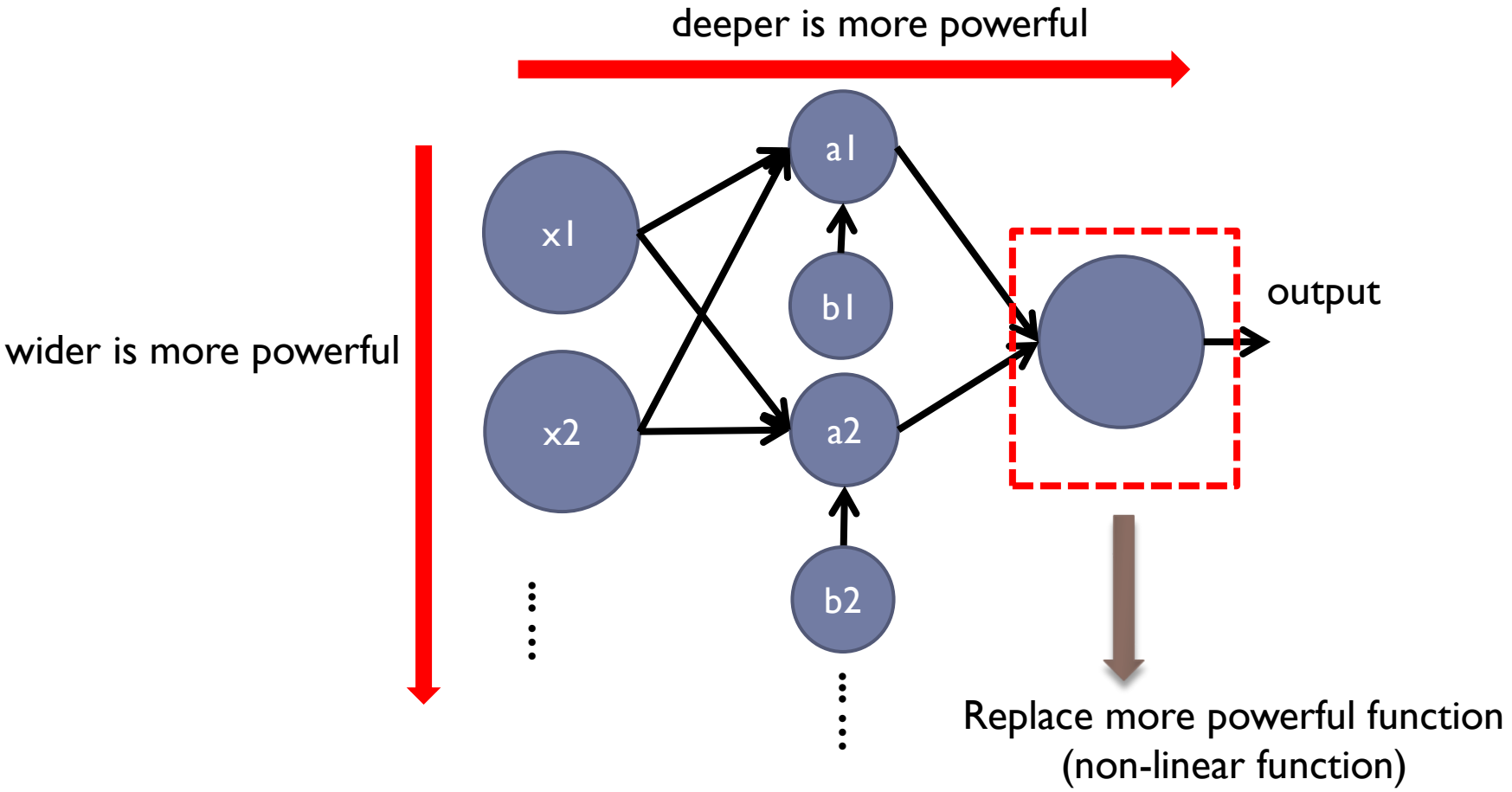


Example

How about more complex situation?



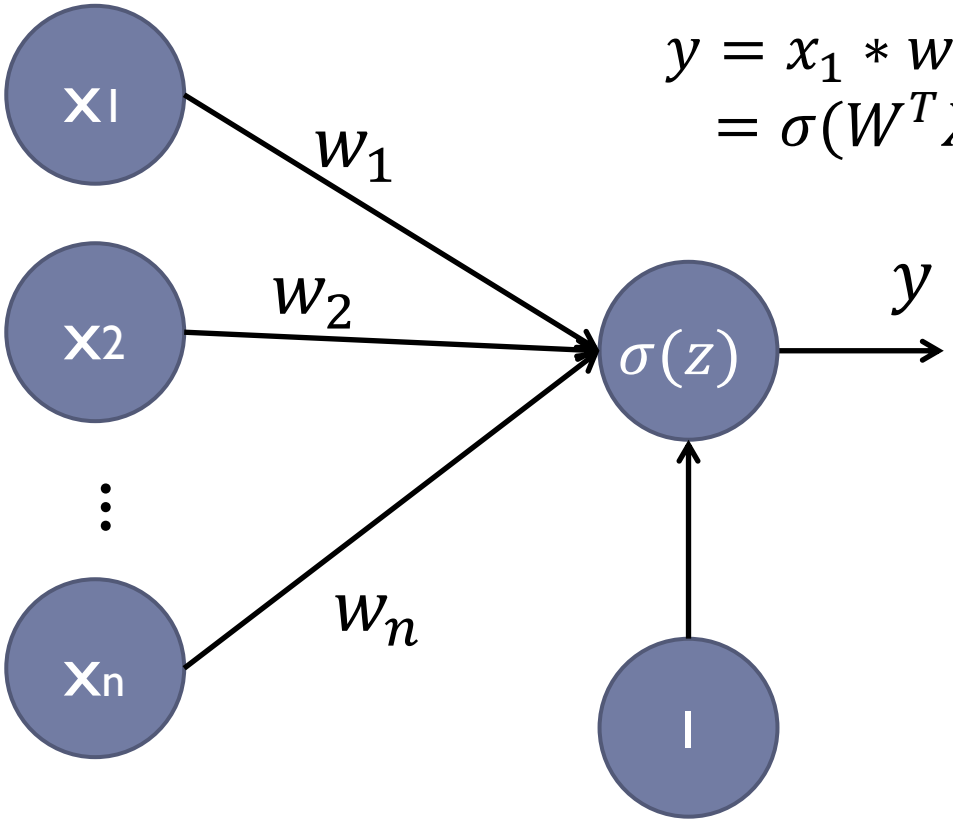
Example


deeper is more powerful
wider is more powerful
x1
x2
a1
a2
b1
b2
output
Replace more powerful function
(non-linear function)

From a Neuron to Deep Learning

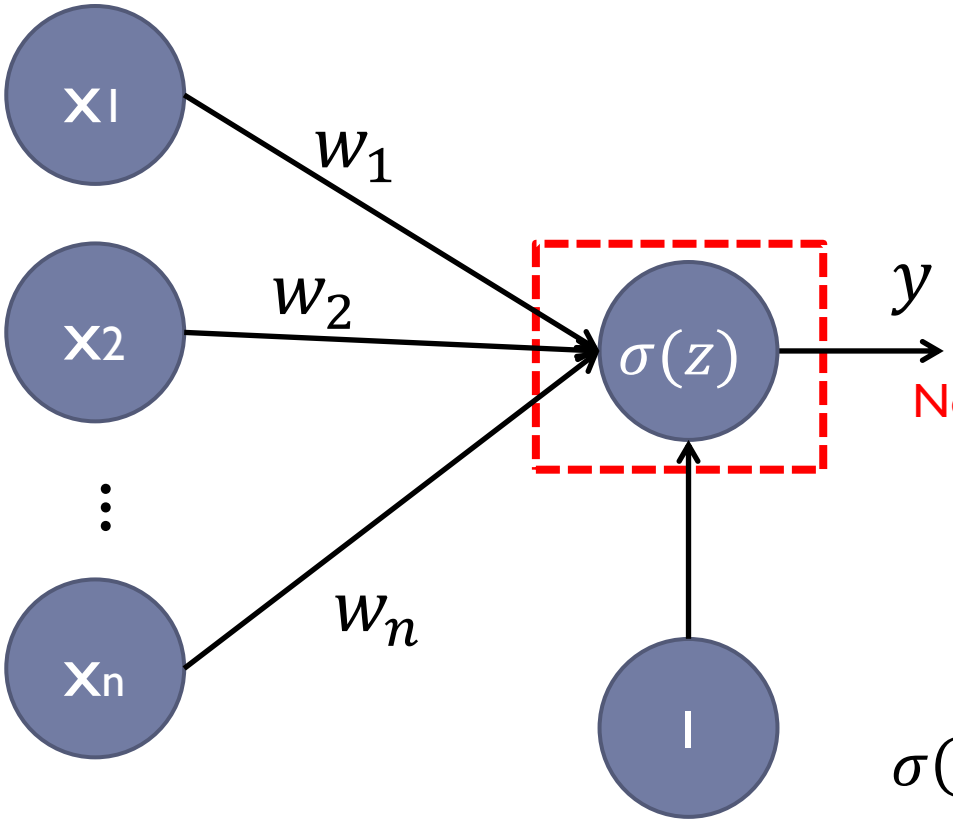
$$\boldsymbol{f}: \boldsymbol{R^N} \rightarrow \boldsymbol{R^1}$$

$$y = x_1 * w_1 + x_2 * w_2 + \cdots + x_n * w_n + b$$
$$= \sigma(W^T X + b)$$



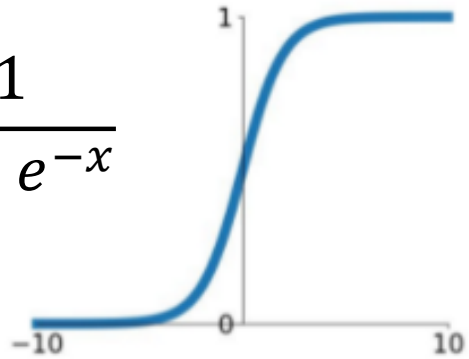
$$W = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ \vdots \\ w_n \end{bmatrix} \qquad \mathrm{X} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ \vdots \\ x_n \end{bmatrix}$$

From a Neuron to Deep Learning



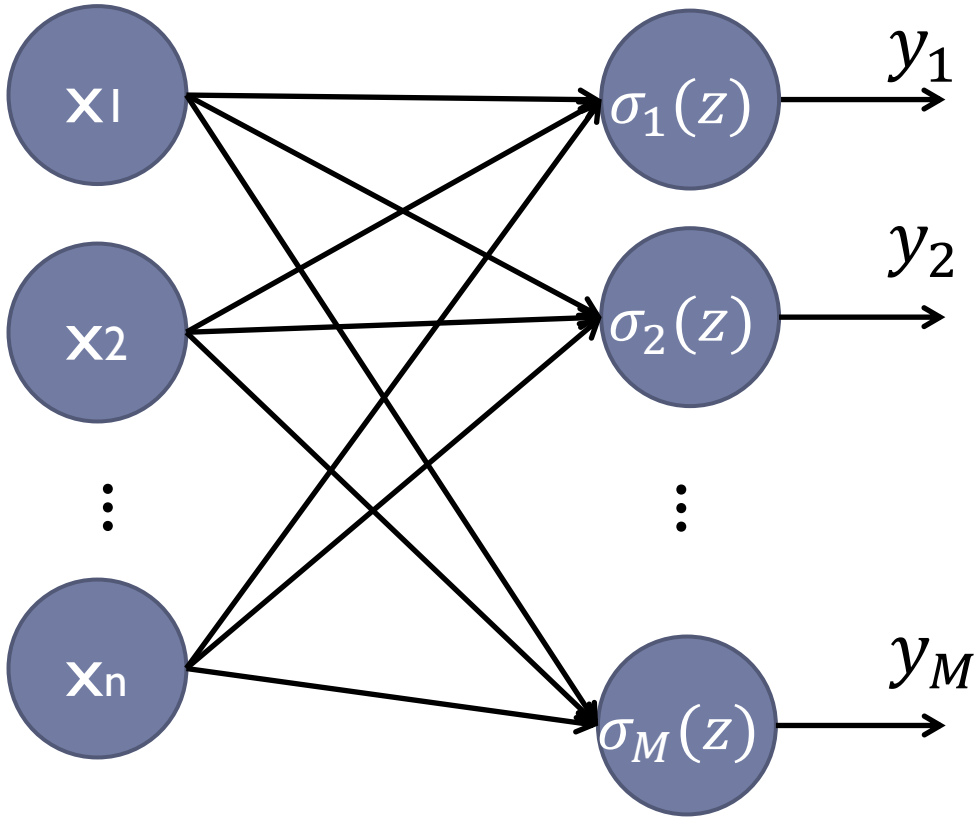
Non-linear function(activation function)

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



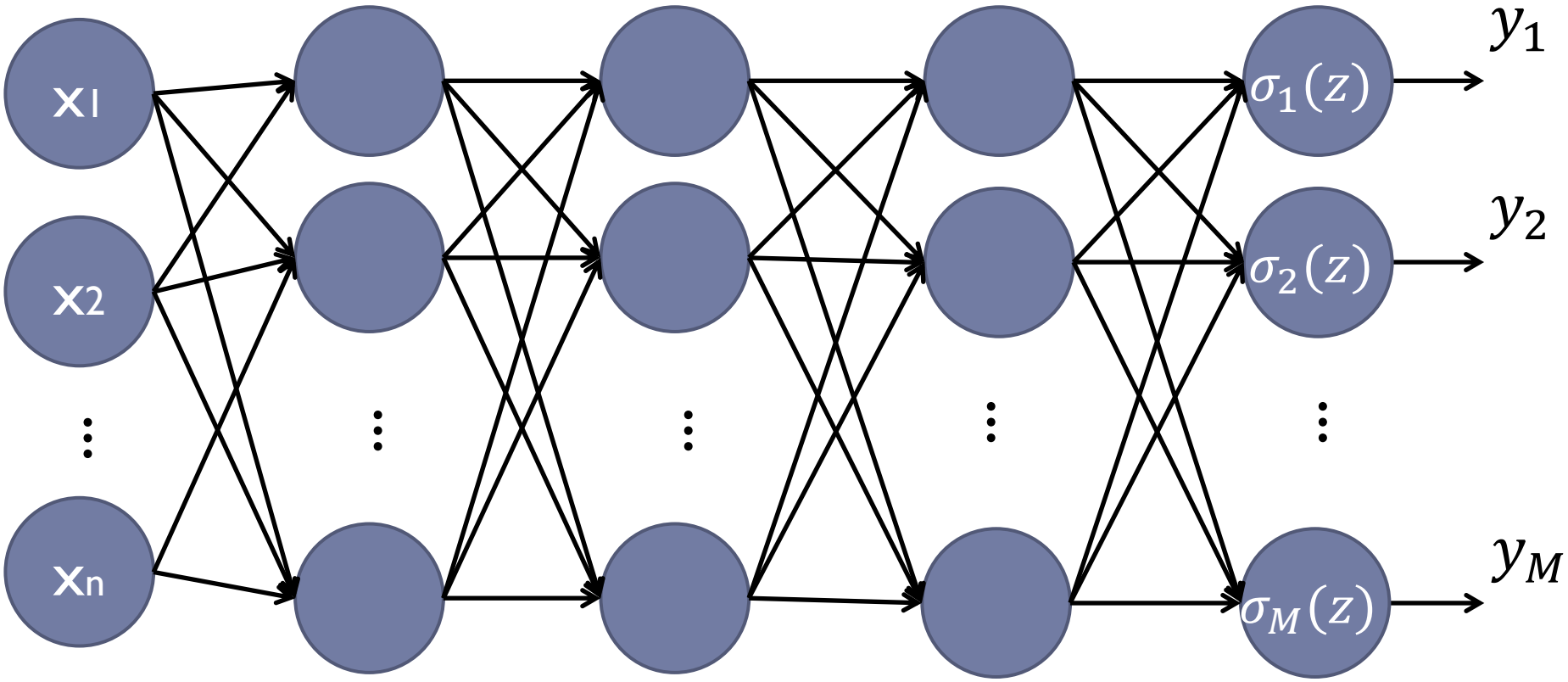
From a Neuron to Deep Learning

$$\boldsymbol{f}: \boldsymbol{R^N} \rightarrow \boldsymbol{R^M}$$



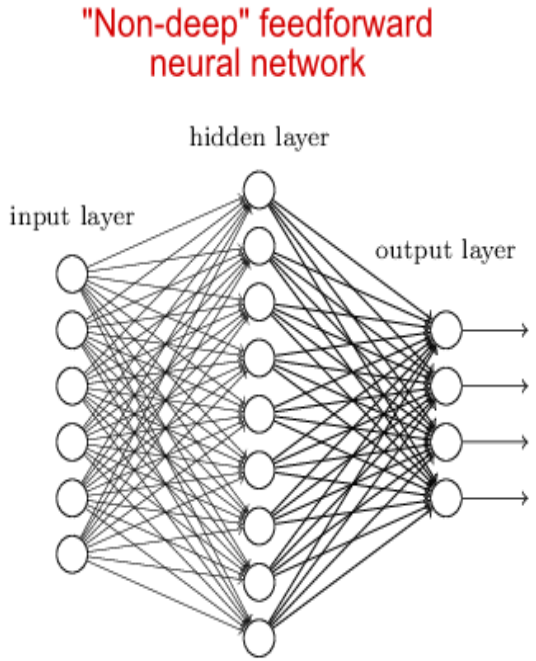
From a Neuron to Deep Learning

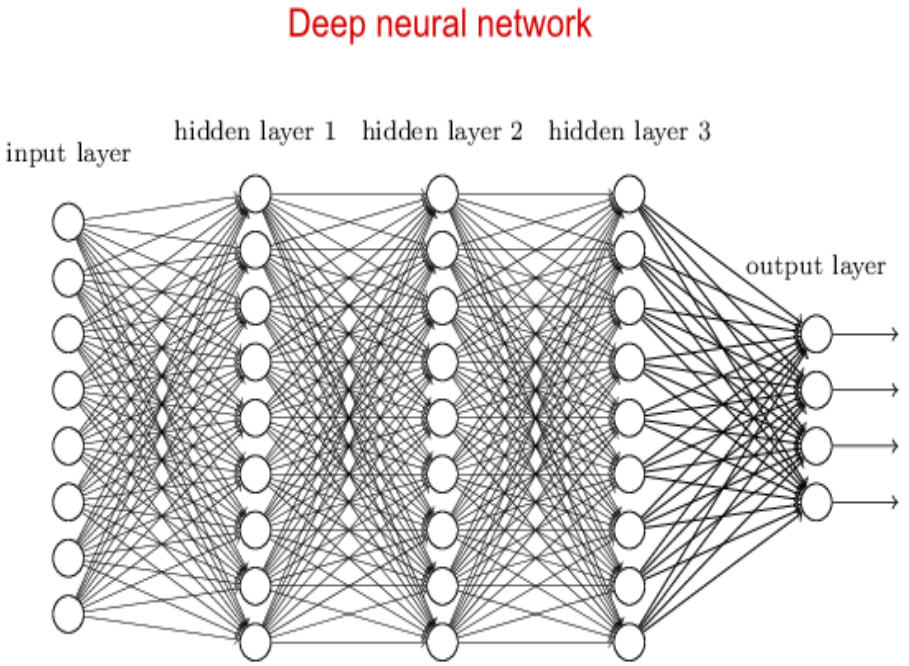
$$f: R^N \rightarrow R^M$$



From a Neuron to Deep Learning

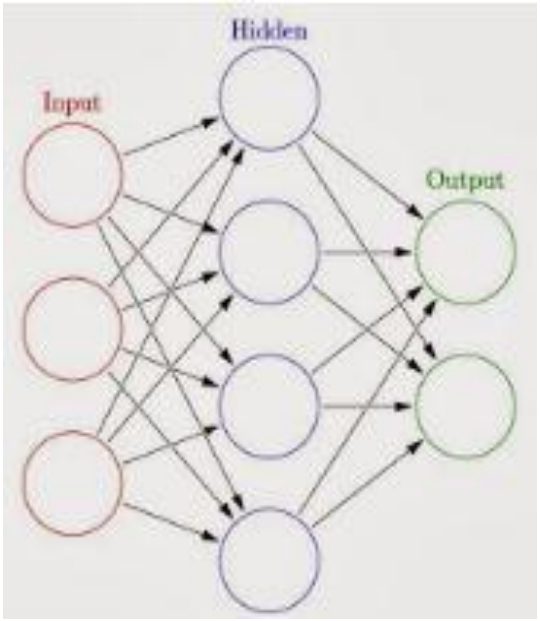
- Consist of input layer, hidden layer, and output layer
  - If # of hidden layer > 1, we call "deep" neural network



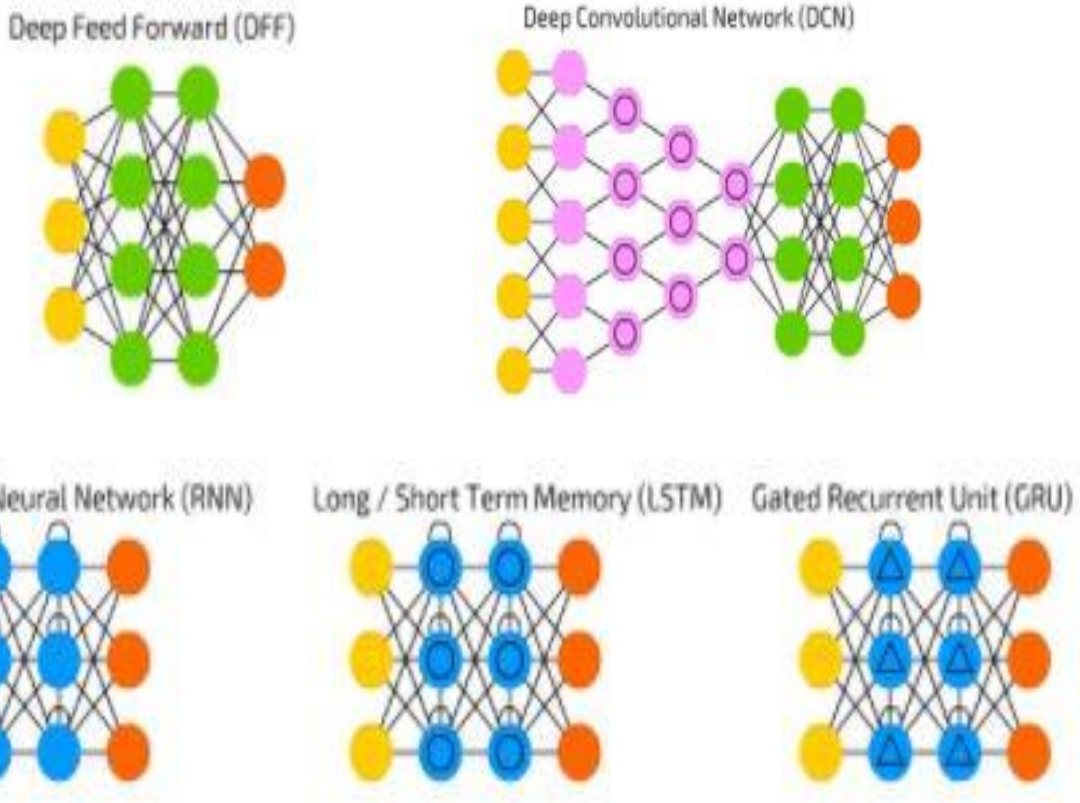


Is NN Enough?

- Think about logic gate
  - {AND, NOT }, {NAND, NOR }
  - functionally complete
- Universal approximation theorem
  - NN with single hidden layer can emulate any continuous functions.



Different kind of Neural Network



http://www.asimovinstitute.org/neural-network-zoo/

Different kinds of Application

Deep Learning Application

- Image recognition
  - Face recognition
  - Object category
- Speech recognition
  - Semantic analysis
  - Language translation
- Generate text/image/voice
- Play game

There are much more……

Image Recognition and Detection

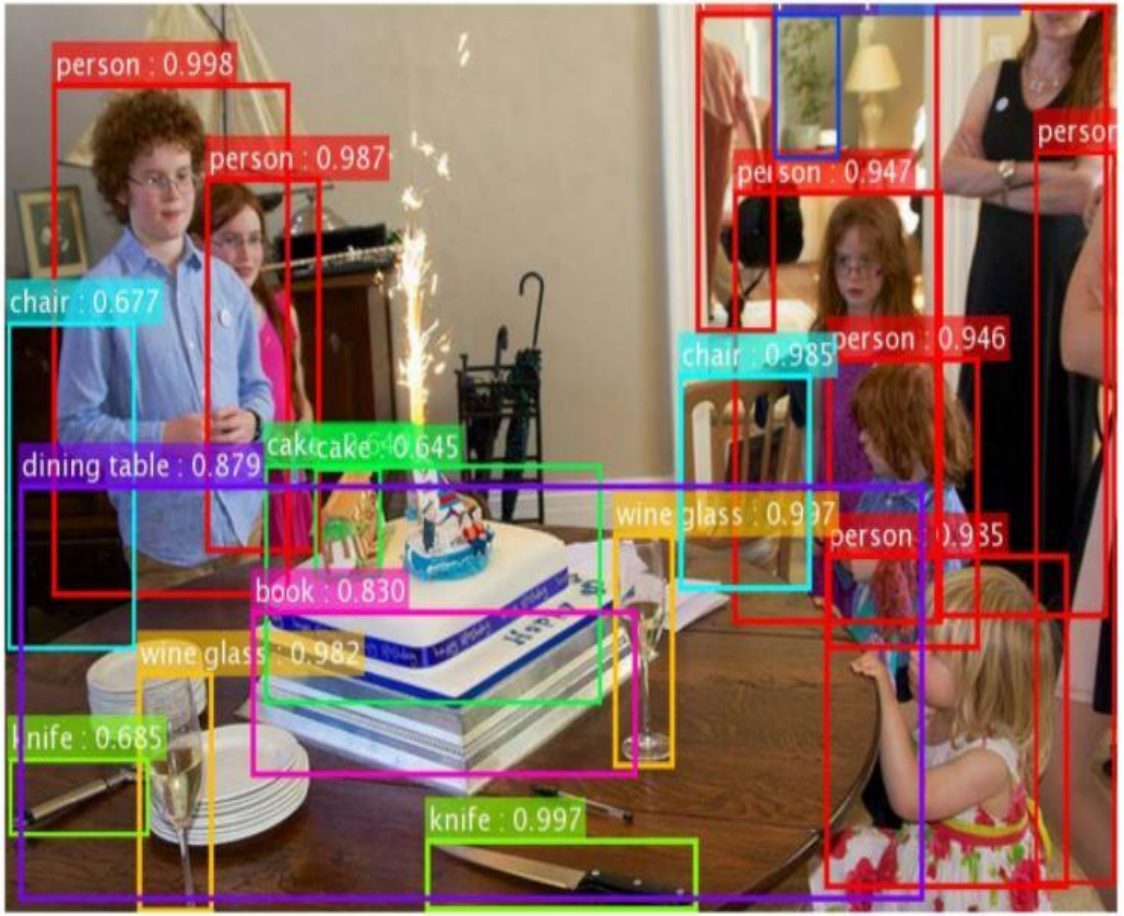


Image Caption

A woman is throwing a frisbee in a park.

A dog is standing on a hardwood floor.

A stop sign is on a road with a mountain in the background.

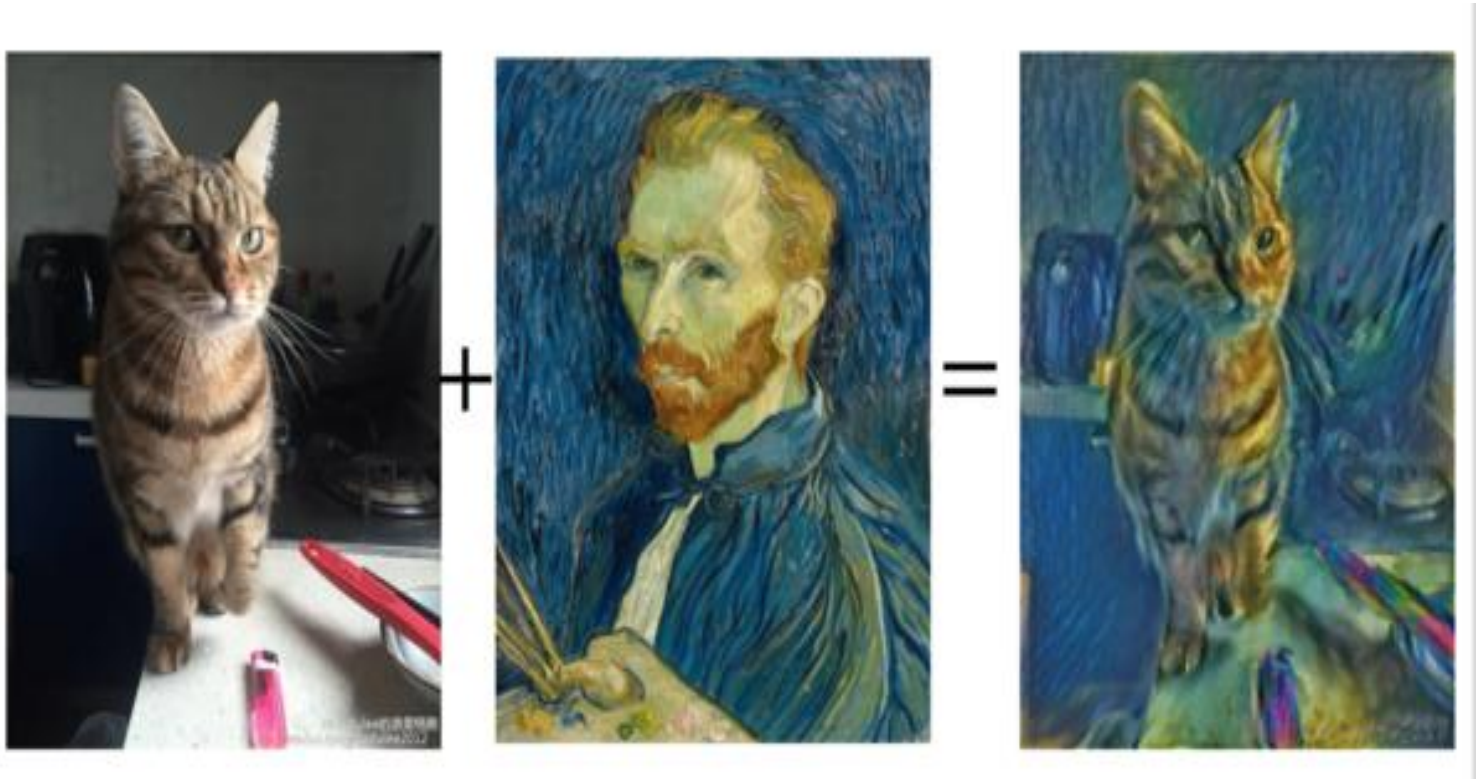
A little girl sitting on a bed with a teddy bear.

A group of people sitting on a boat in the water.

A giraffe standing in a forest with trees in the background.

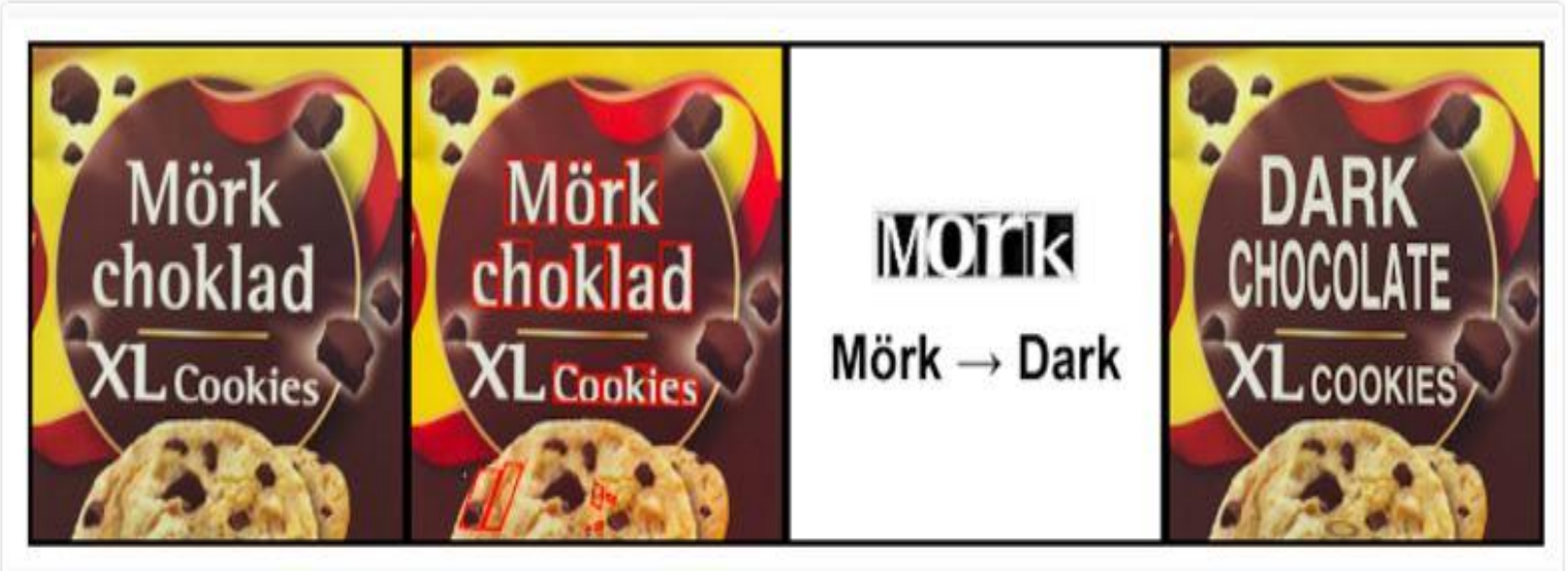
http://www.iro.umontreal.ca/~bengioy/papers/2015-lecun-bengio-hinton-nature.pdf

Image Style Transfer



https://no2147483647.wordpress.com/2015/12/21/deep-learning-for-hackers-with-mxnet-2/

Automatic Machine Translation

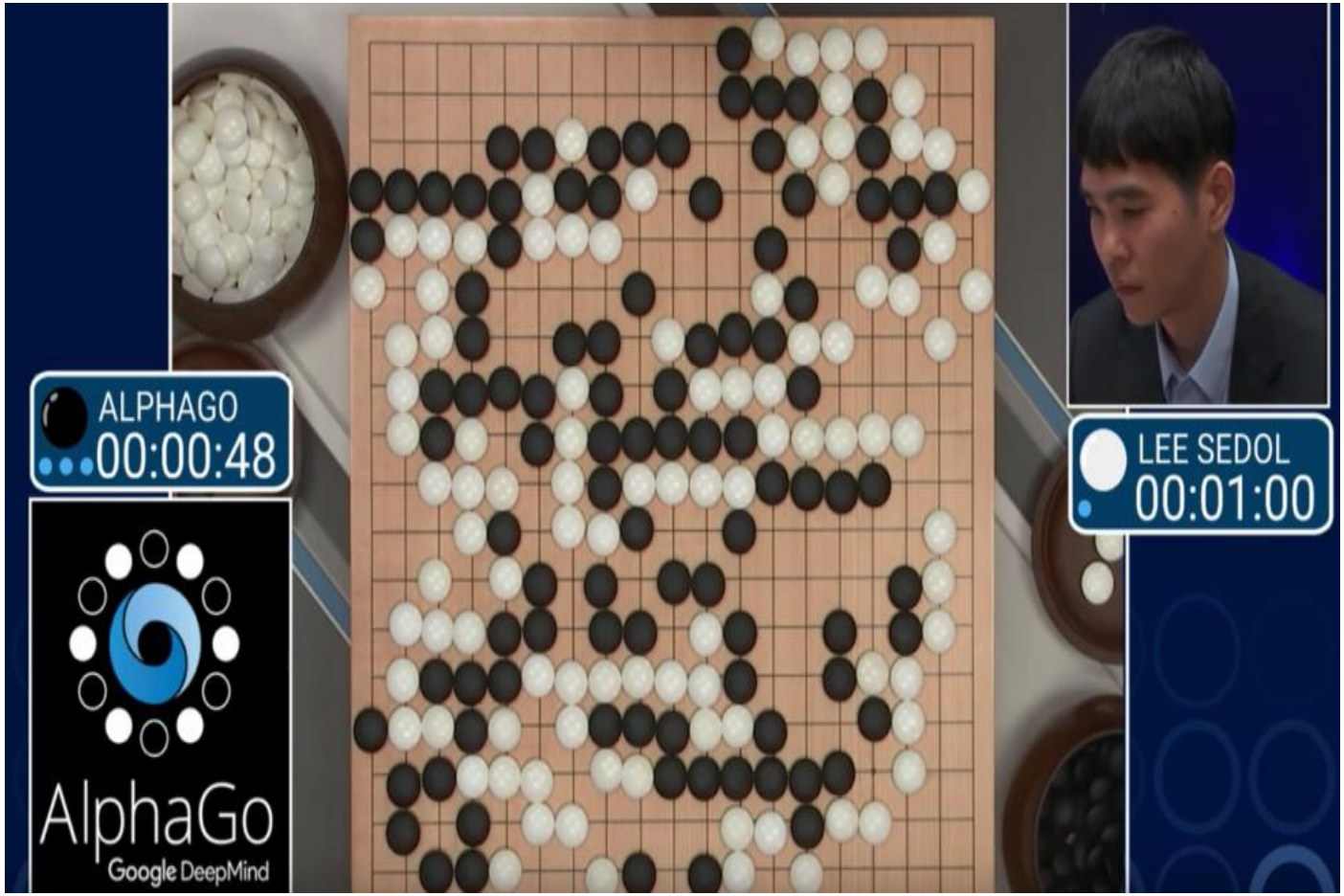


http://machinelearningmastery.com/inspirational-applications-deep-learning/

Text Generator

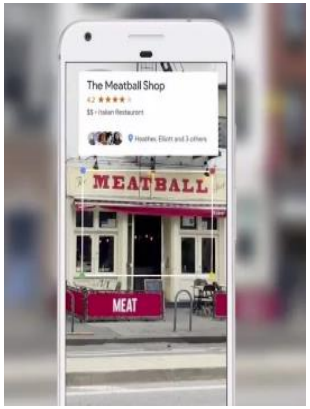
```
PANDARUS:
Alas, I think he shall be come approached and the day
When little srain would be attain'd into being never fed,
And who is but a chain and subjects of his death,
I should not sleep.

Second Senator:
They are away this miseries, produced upon my soul,
Breaking and strongly should be buried, when I perish
The earth and thoughts of many states.

DUKE VINCENTIO:
Well, your wit is in the care of side and that.

Second Lord:
They would be ruled after this chamber, and
my fair nues begun out of the fact, to be conveyed,
Whose noble souls I'll have the heart of the wars.

Clown:
Come, sir, I will make did behold your worship.

VIOLA:
I'll drink it.
```

AlphaGo



Google Lens

- An App that understand the world around you through your smartphone camera
  - Display relevant content on your screen
- Interesting function include
  - Restaurant rating, species of flowers, Wi-Fi hotspot login, prominent building in a city, ticket info on concert poster , etc……



Amazon echo

Apple Siri

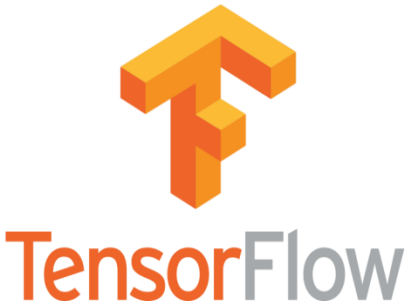

Siri
3G
9:41 AM
“ On May 19 remind me it’s dad’s birthday ”
Here’s your reminder for May 19, 2012 at 9 am:
19
Saturday
May 2012
Dad’s birthday
5/19/12
Cancel
Confirm

TensorFlow Introduction

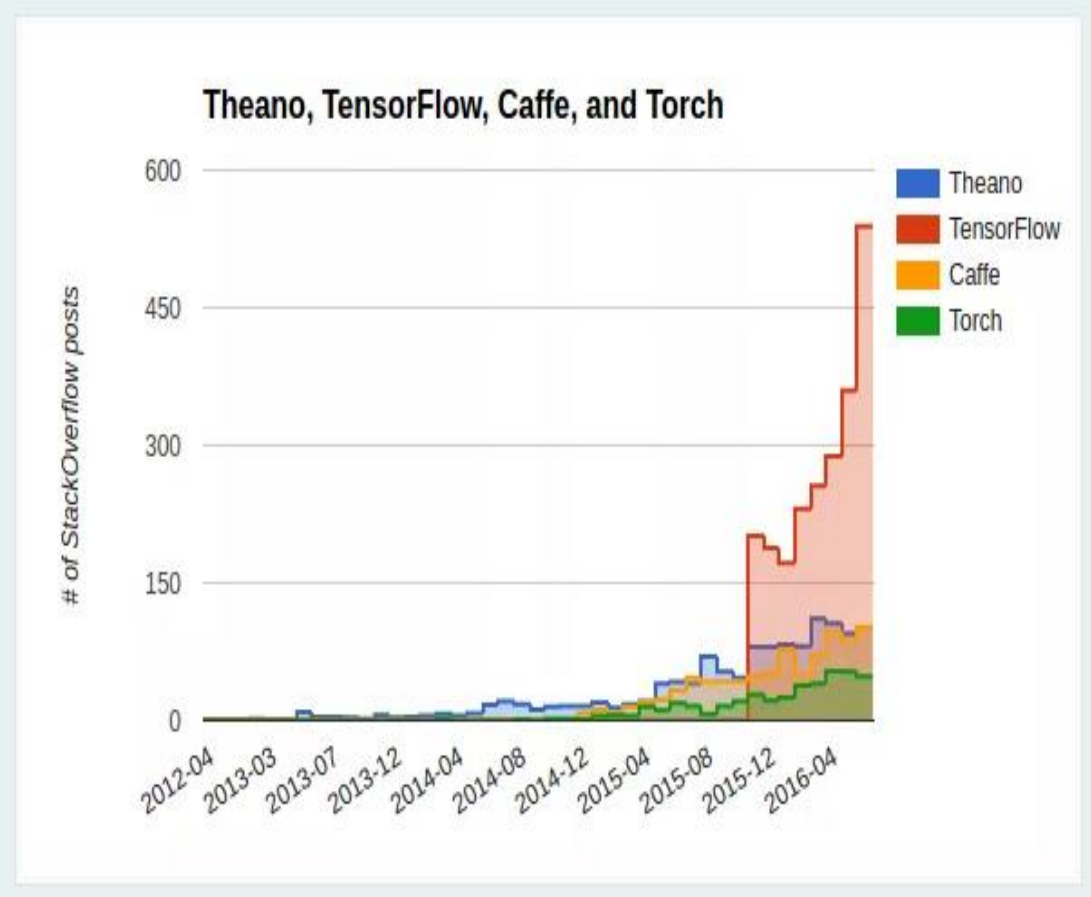
Different Framework

TensorFlow

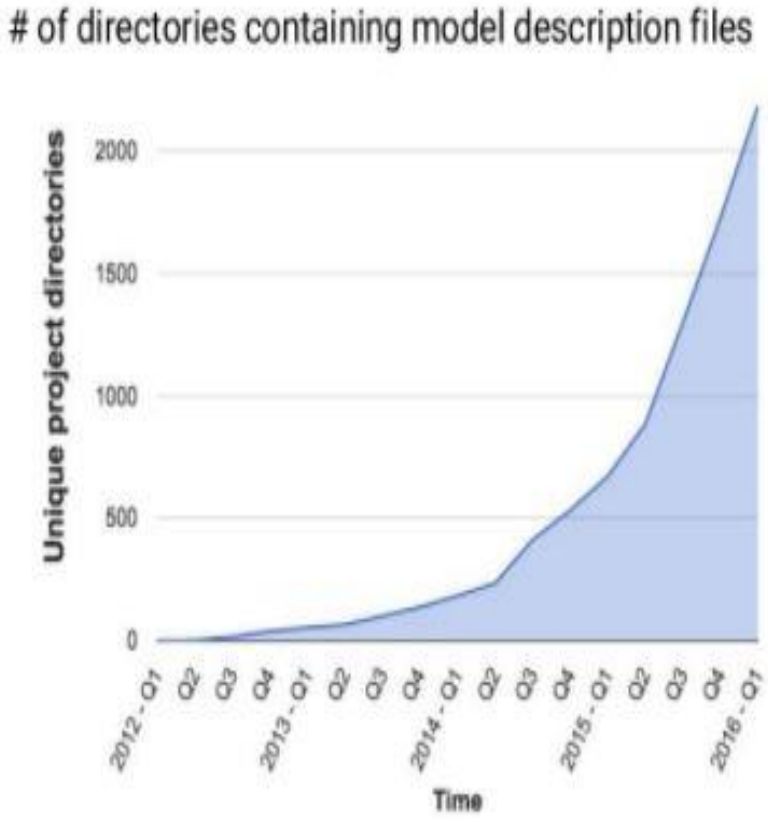
- An open source software library for machine intelligence
  - Developed by the Google Brain team and released in November 2015
  - Version 1.0.0 was launched in February 2017
  - https://github.com/tensorflow/tensorflow
- Support many useful tool
  - tensorboard, tfrecord,
- Support multi-GPU and distributed environment



Popularity of TensorFlow



Growing Use of Deep Learning in Google



Across many products/areas:

Android
Apps
drug discovery
Gmail
Image understanding
Maps
Natural language understanding
Photos
Robotics research
Speech
Translation
YouTube
... many others ...

https://www.slideshare.net/JenAman/large-scale-deep-learning-with-tensorflow

TensorFlow v.s. Numpy

Numpy	TensorFlow
`a = np.zeros((2,2)); b = np.ones((2,2))`	`a = tf.zeros((2,2)), b = tf.ones((2,2))`
`np.sum(b, axis=1)`	`tf.reduce_sum(a,reduction_indices=[1])`
`a.shape`	`a.get_shape()`
`np.reshape(a, (1,4))`	`tf.reshape(a, (1,4))`
`b * 5 + 1`	`b * 5 + 1`
`np.dot(a,b)`	`tf.matmul(a, b)`
`a[0,0], a[:,0], a[0,:]`	`a[0,0], a[:,0], a[0,:]`

https://cs224d.stanford.edu/lectures/CS224d-Lecture7.pdf

What is “Tensor”

Formally, tensors are multilinear maps from vector spaces to the real numbers (V vector space, and V^* dual space)

$$f : \underbrace{V^* \times \cdots V^*}_{p \text{ copies}} \times \underbrace{V \times \cdots V}_{q \text{ copies}} \to \mathbb{R}$$

A scalar is a tensor ($f : \mathbb{R} \to \mathbb{R},\ f(e_1) = c$)

A vector is a tensor ($f : \mathbb{R}^n \to \mathbb{R},\ f(e_i) = v_i$)

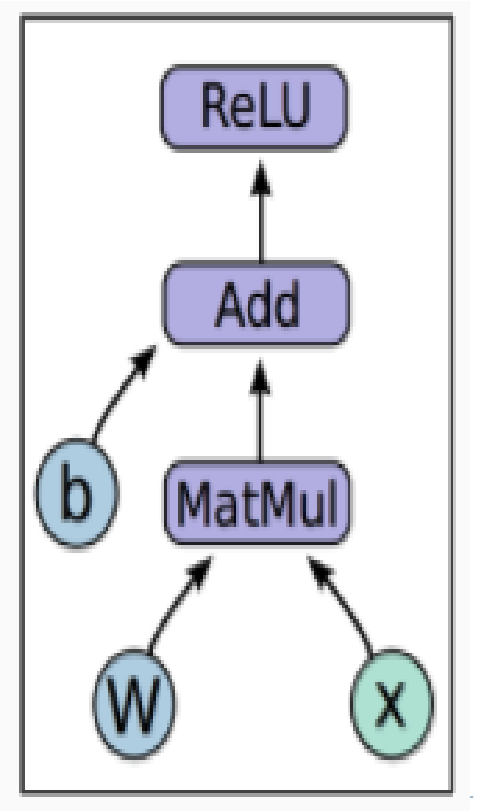
A matrix is a tensor ($f : \mathbb{R}^n \times \mathbb{R}^m \to \mathbb{R},\ f(e_i, e_j) = A_{ij}$)

Common to have fixed basis, **so a tensor can be represented as a multidimensional array of numbers.**

https://cs224d.stanford.edu/lectures/CS224d-Lecture7.pdf

What is “Flow”

- Computation can be regarded as directed graph(computation graph)
  - Each node represent a operation
  - Each edge represent a status(variable)



TensorFlow Summary

Programming Model	• Dataflow-like model
Language	• Python • C++
Deployment	• Code once, Run everywhere
Computing Resource	• CPU • GPU
Distribution Process	• Local Implementation • Distributed Implementation
Math Expressions	• Math Graph Expression • Auto Differentiation
Optimization	• Auto Elimination • Kernel Optimization • Communication Optimization • Support model, data parallelism • ...