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Deep Learning Workshop:

Concepts & Experiments

MSBD 5001 Fall 2019

Outline

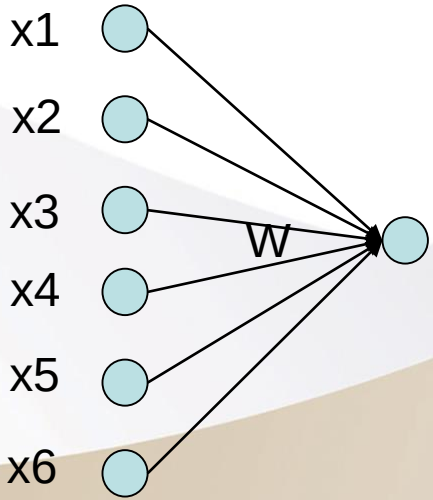
- The basics of fully connected neural network
- The basics of convolutional neural network
- The basics of deep learning
- The tutorial of Tensorflow 2.0.
- Use Tensorflow 2.0 beta to train, validate and test your own deep learning model

Install Tensorflow 2.0

- pip install -U gast==0.2.2
- pip install tensorflow==2.0.0-beta0
- pip install pillow
- Open python and run the following codes:
  - from tensorflow import keras
  - keras.datasets.mnist.load_data()
  - keras.applications.VGG16(input_shape=(224,224,3), weights='imagenet',include_top=False)

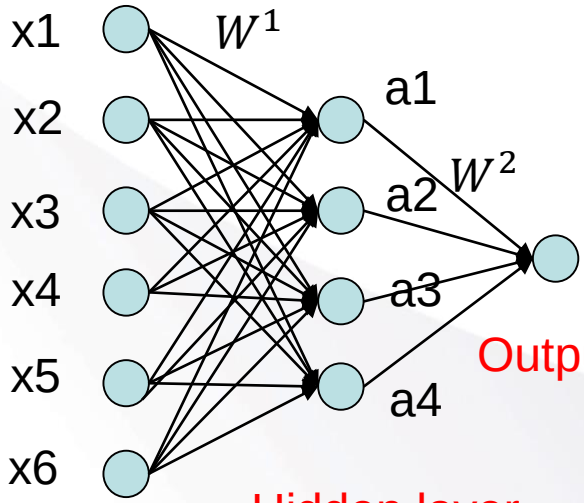
Logistic Regression

- $L = \sum(Error(y,\ \sigma(x^T w))$ #make a swap of x/w.
- Apply a non-linear function (E.g. sigmoid) on $(x^T w)$ to fit the target value.
- We can use graph to represent the process.



$$output = \sigma(x_1 * w_1 + x_2 * w_2 + x_3 * w_3 + x_4 * w_4 + x_5 * w_5 + x_6 * w_6)$$

A Simple Fully Connected Feedforward Neural Network



W^1 : 6*4 matrix.

W^2 : 4*1 matrix. (So transposition is not needed)

W_{ij}^1: The weight connecting x_i and a_j.

$$a = \sigma(xW^1)$$

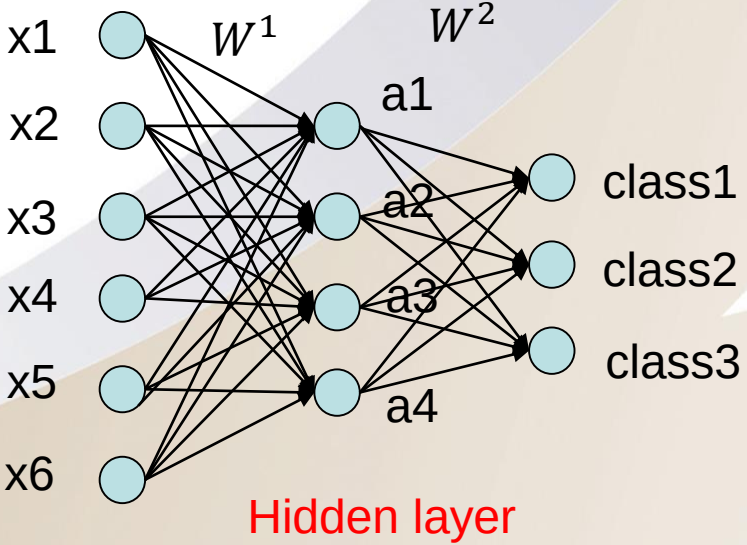
$$output = \mathrm{a}W^2 = \sigma(xW^1)W^2$$

More complex neural networks could be extended based on this with more hidden layers.

Softmax: Classfication

- N output nodes to represent the probability distribution over n different classes.
- W^2 : 4*3 matrix.
- $output = softmax(\mathrm{aW}^2) = softmax(\sigma(xW^1)\mathrm{W}^2)$
- Like logistic regression, use a non-linear function to transform output from $(-\infty, +\infty)$ to [0,1].
- Softmax is similar with sigmoid, supporting multiple outputs.

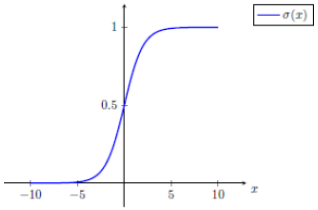
$$\mathrm{softmax}(\boldsymbol{z})_i = \frac{\exp(z_i)}{\sum_j \exp(z_j)}$$



Activation

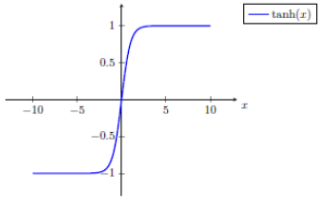
- Activation function is to transform the input signal into an output signal to model complex non-linear patterns.
- Without activation function, stacking linear layers is equivalent to a single linear layer.
- We can replace the sigmoid function in hidden layer with other non-linear functions!

Sigmoid



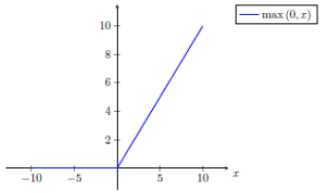
$$\sigma(x) = \frac{1}{1+\exp(-x)}$$

tanh



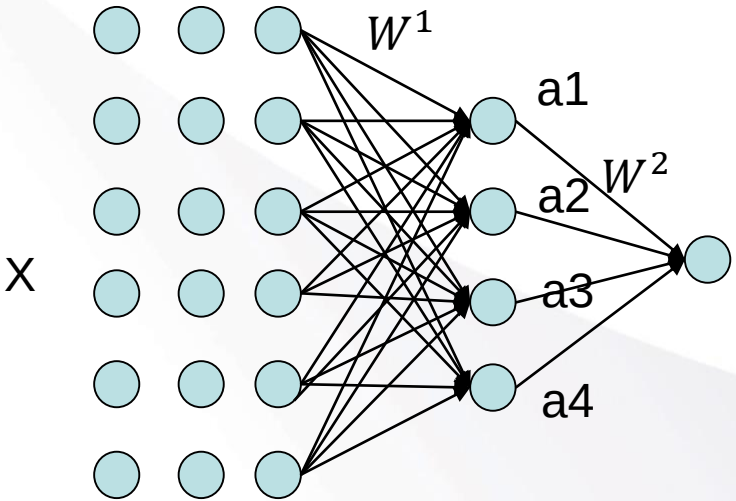
$$\tanh(x) = \frac{\exp(x)-\exp(-x)}{\exp(x)+\exp(-x)}$$

ReLu



$$\text{ReLu}(x) = \max(0, x)$$

Batch Forwarding



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Batch size: 3

W^1 : 6*4 matrix.

W^2 : 4*1 matrix.

W_{ij}^1: The weight connecting x_i and a_j.

X: 3*6 feature matrix (generally a row represents a sample)

X_{ij}: The j-th feature of the i-th sample.

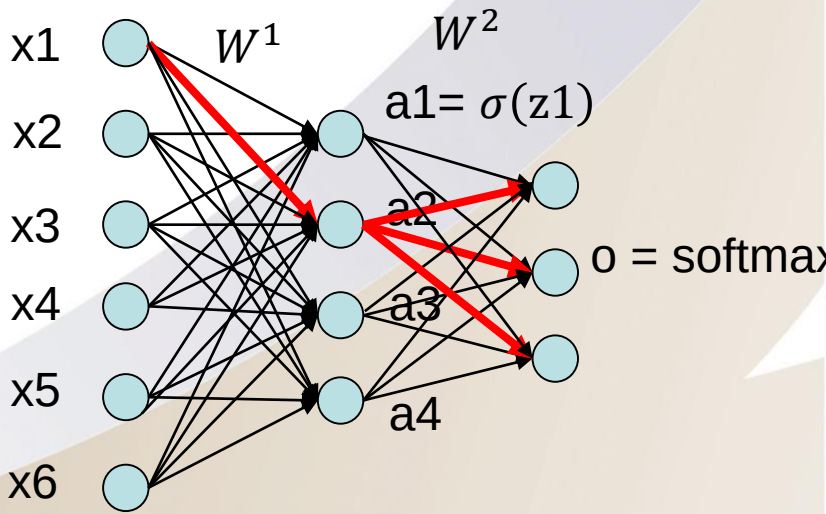
$$A = \sigma(XW^1)$$

$$output = A\mathrm{W}^2 = \sigma(XW^1)\mathrm{W}^2$$

Output: 3*1 matrix.

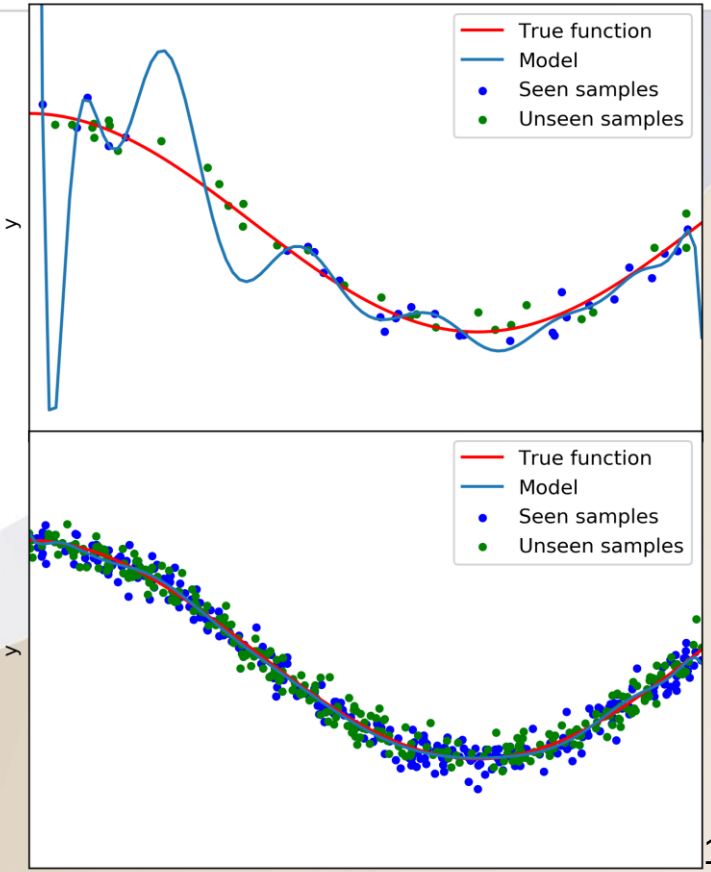
Back-propagation

- Chain Rule of Calculus:
- $z = f(g_1(x) + g_2(x))$
- $\frac{\partial z}{\partial x} = \frac{\partial z}{\partial g_1}\frac{\partial g_1}{\partial x} + \frac{\partial z}{\partial g_2}\frac{\partial g_2}{\partial x}$
- $loss = L(softmax(aW^2)$
- $= L(softmax(\sigma(xW^1)W^2))$
- For W_{12}^1, $\frac{\partial L}{\partial W_{12}^1} = \Sigma_k \frac{\partial L}{\partial o_k}(\frac{\partial o_k}{\partial s_k}\frac{\partial s_k}{\partial a_2}\frac{\partial a_2}{\partial z_2}\frac{\partial z_2}{\partial W_{12}^1})$
- Accelerated by matrix multiplication.



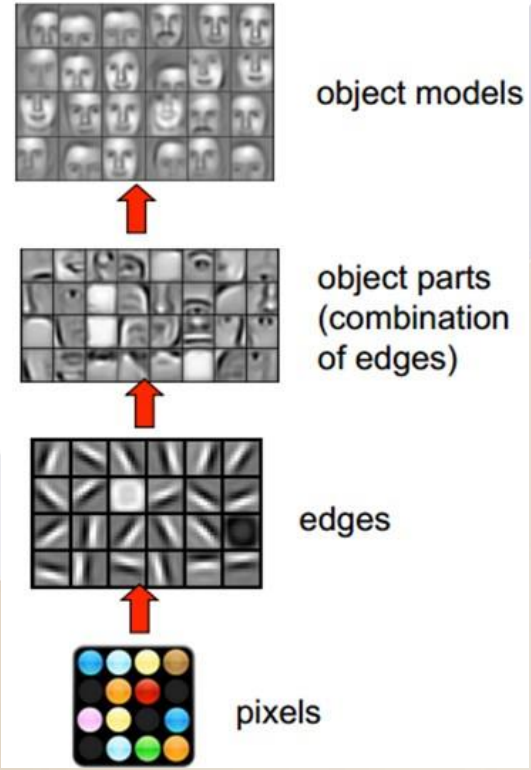
Why deep learning?

- Why neural network?
  - **Universal approximation theorem** (Hornik et al.,1989 Cybenko 1989) states that a feedforward network with a linear output layer and at least one hidden layer can approximate almost any function, given enough hidden units.
  - Huge amount of data lowers the possibility of overfitting.



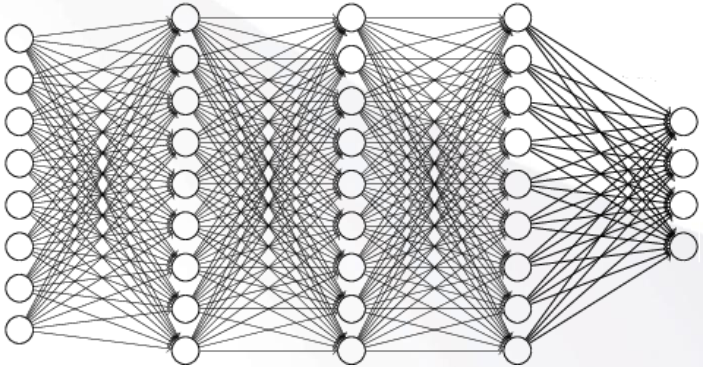
Why deep learning?

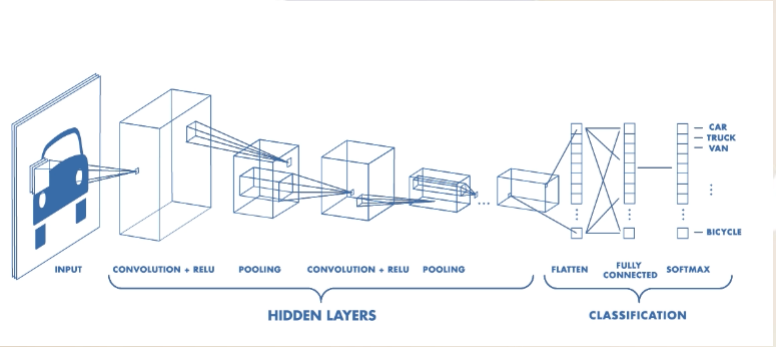
- Why deep?
  - Deeper models reduce the number of units required to represent the function involving composition of simpler functions.



ConVnet for Image Feature Extraction

- Convolutional neural network for images





Source: https://www.mathworks.com/videos/introduction-to-deep -learning-what-are-convolutional-neural-networks--1489512765771.html

ConVnet for Image Feature Extraction

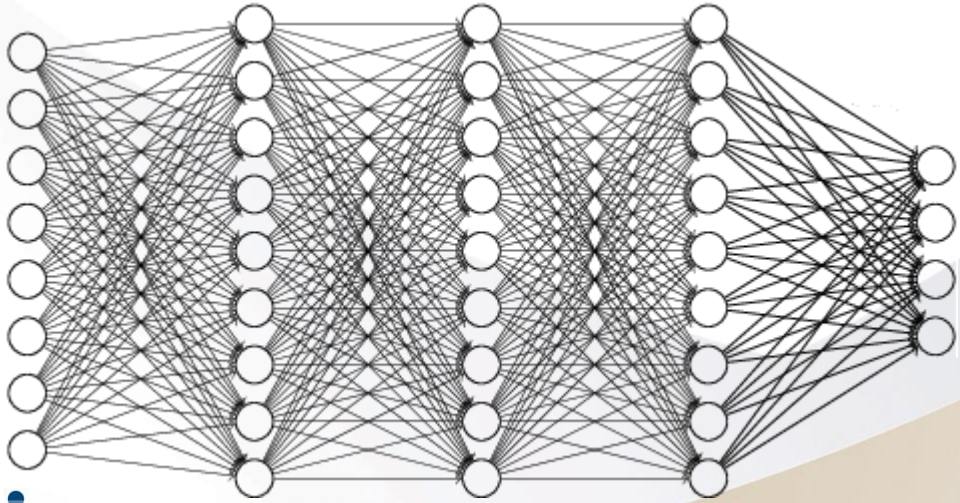
- What makes image different with other machine learning training data?

64*64=4096 pixels
4096*3=12288 dimensions

1000*1000*3=3 million!

ConVnet for Image Feature Extraction

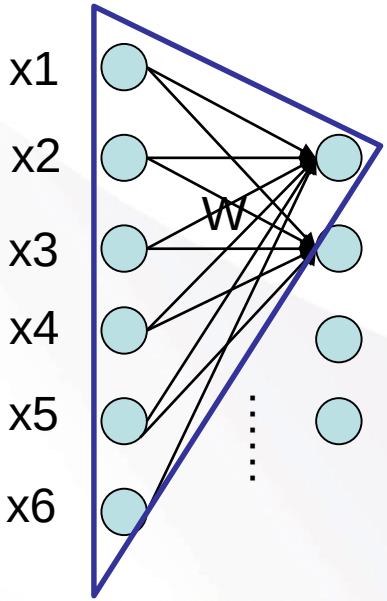
Full connected neural network



Just for the first layer:
3 million * #(first hidden layer nodes) parameters!!

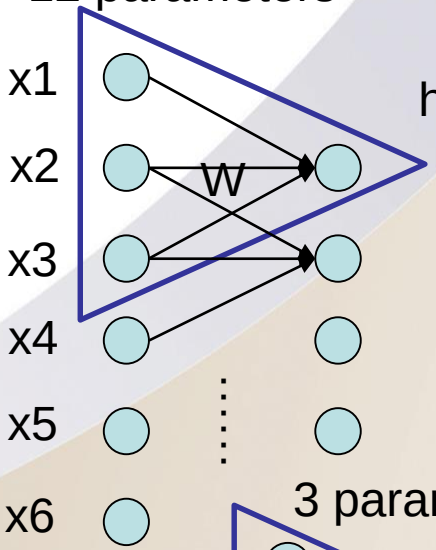
ConVnet for Image Feature Extraction

W:6*4=24 parameters



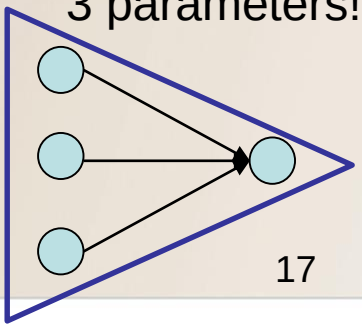
$h1=x1*w_{11} + x2*w_{12} + x3*w_{13} + x4*w_{14} + x5*w_{15} + x6* w_{16}$

3*4=12 parameters



$h1=x1*w_{11} + x2*w_{12} + x3*w_{13}$

3 parameters!



Local receptive field
Shared weights and biases

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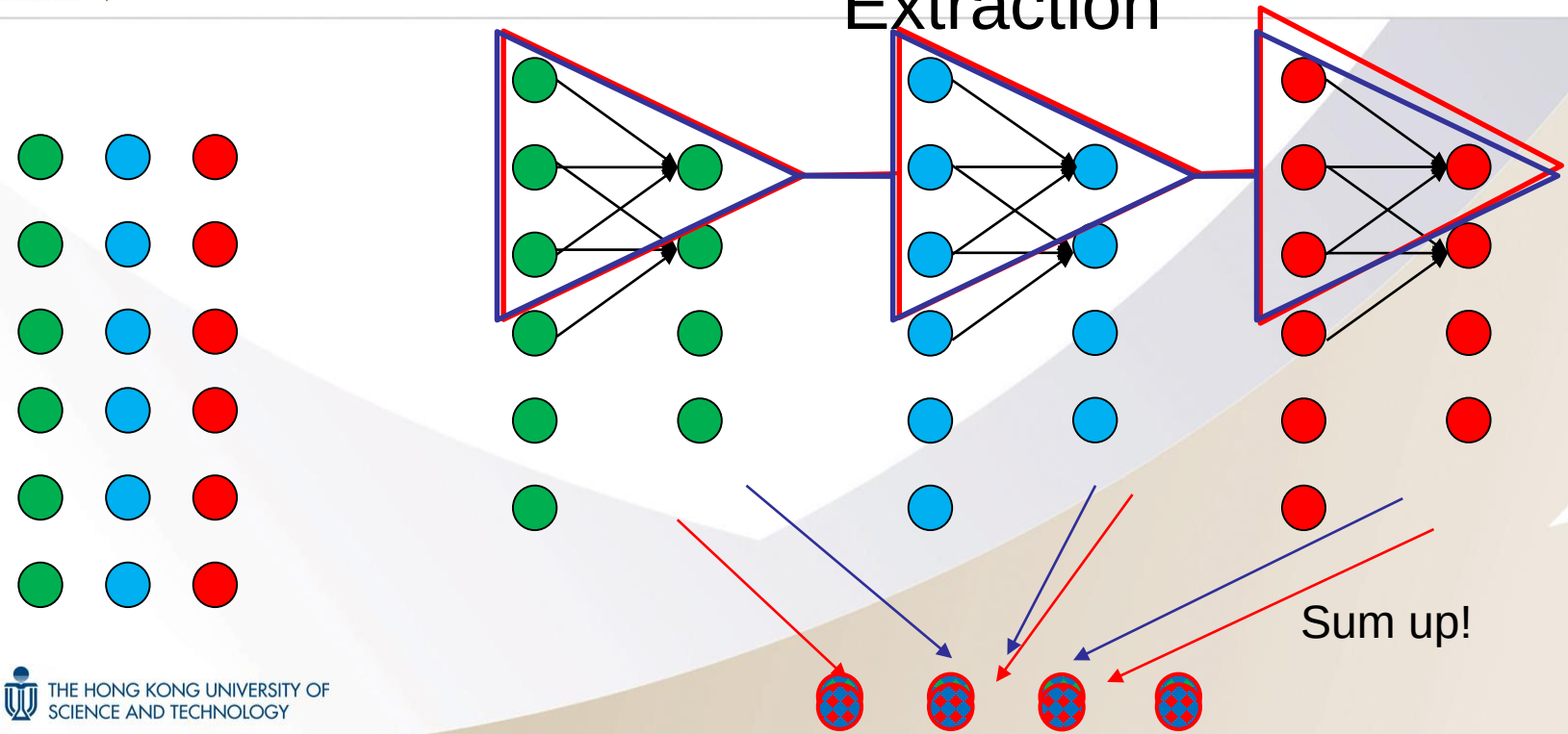
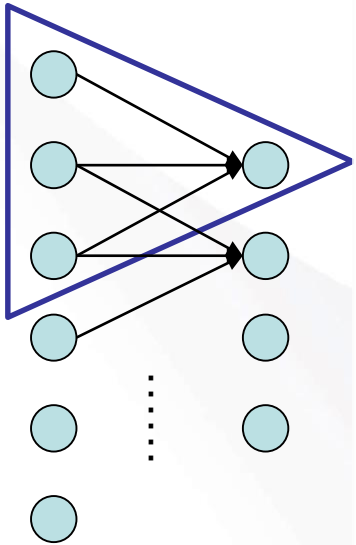
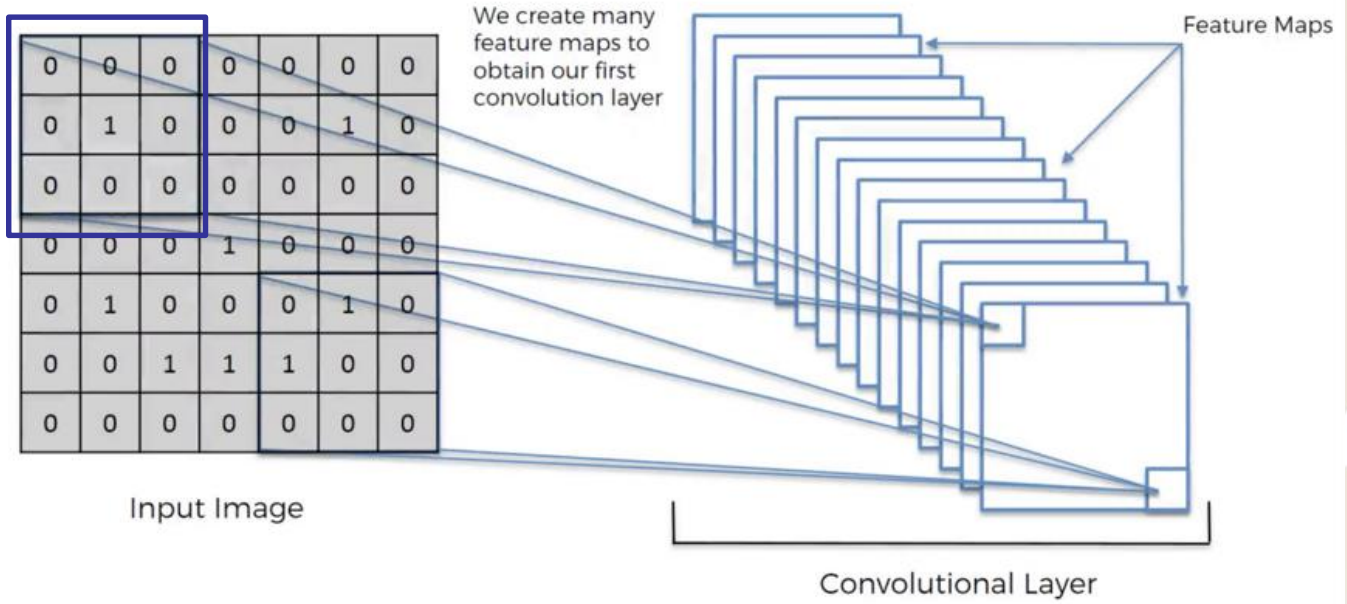
ConVnet for Image Feature Extraction

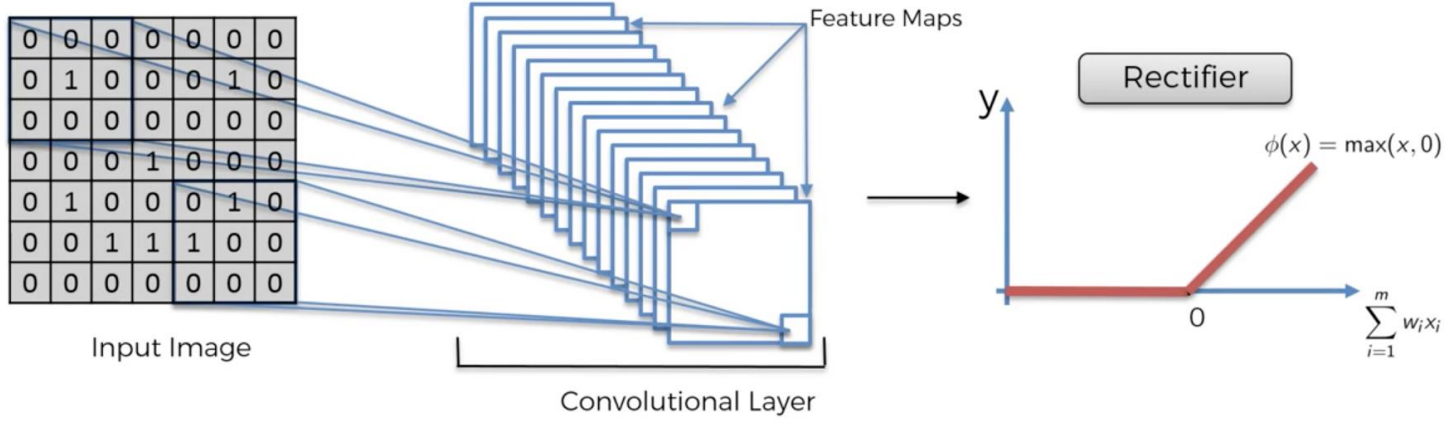


ConVnet for Image Feature Extraction



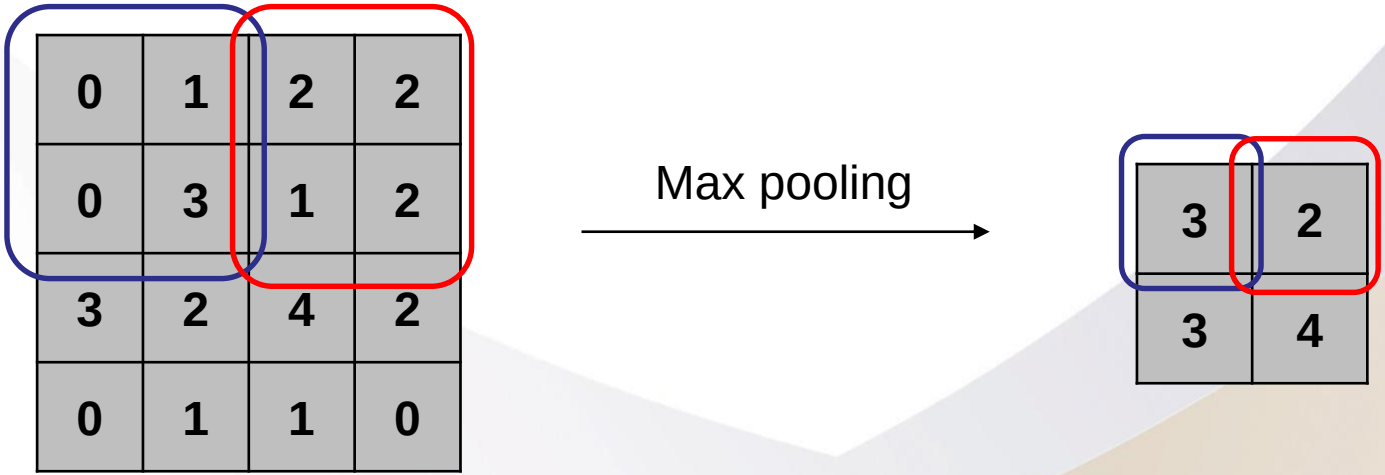


ConVnet for Image Feature Extraction



Activation: make the function non-linear

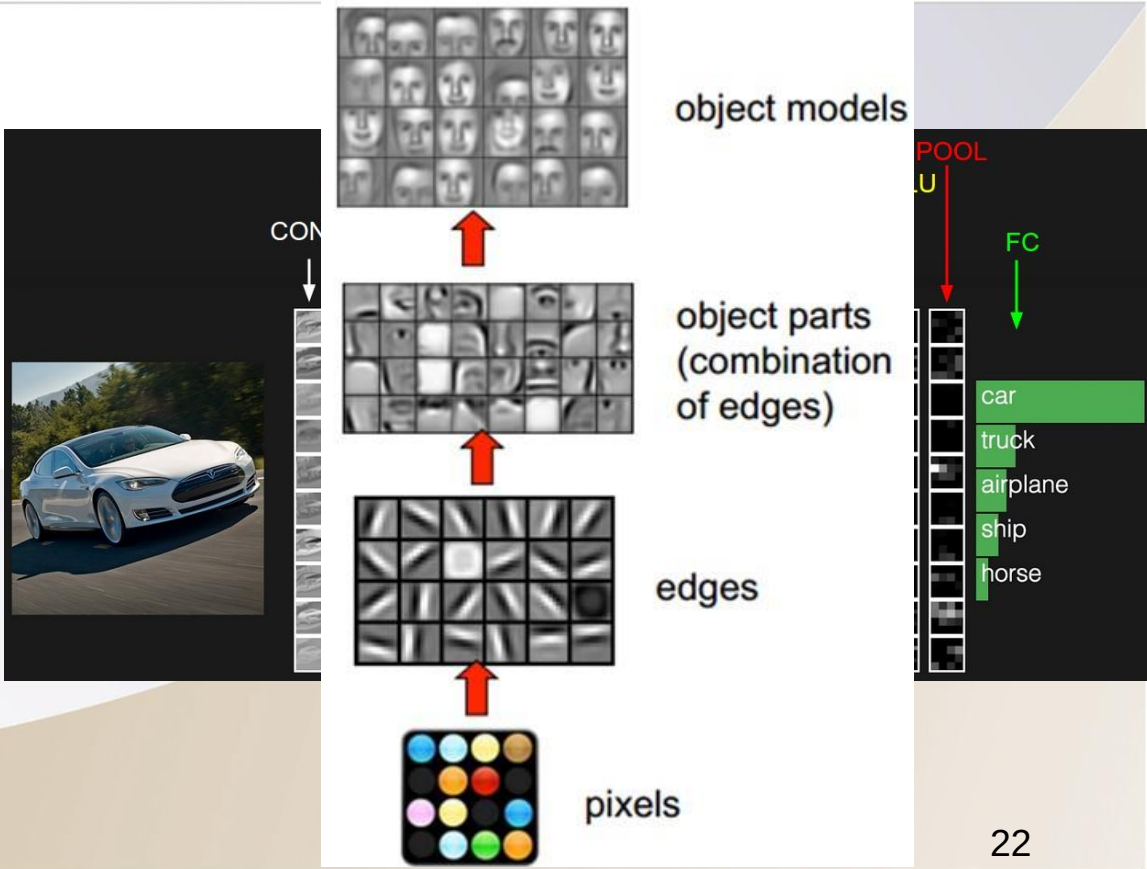
ConVnet for Image Feature Extraction



Pooling: reduce the dimension

CNN for Image Feature Extraction

- Local receptive field
- Shared weights and biases
- Activation
- Pooling



Tensorflow 2.0 features

Eager

Keras

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Machine Learning Components

Data

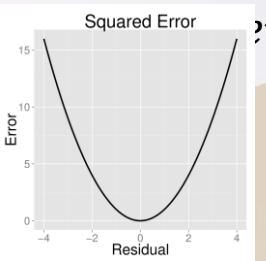
Model

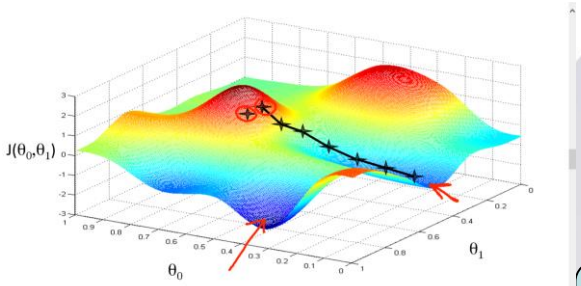
$parameters$

Loss

$$Loss = \sum_{i}^{n} (predicted - truth)^2$$

$$= \quad ers)$$





Optimizer

$$\frac{\partial\ loss}{\partial\ parameters}$$

Metric

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Source: https://hackernoon.com/gradient-descent-aynk-7cbe95a778da

Thanks

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