# TUTORIAL 2

CSCI3230 (2019-2020 First Term)

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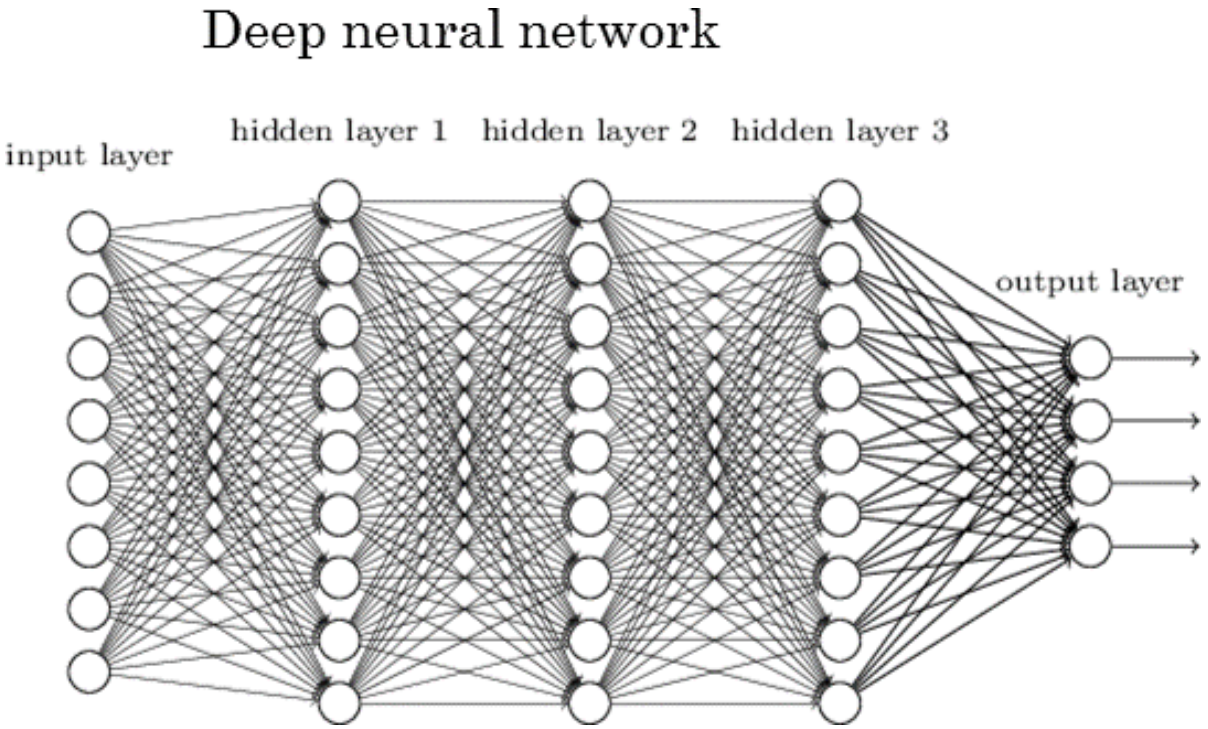
# Outline

- Deep Neural Network
  - Introduction
  - How DNN resolves Vanishing Gradient
  - Convolutional Neural Network

# Deep Neural Network

- No formal definition
- Some people call neural networks with more than one hidden layers “deep”



# Branches of DNN

- For each node or layer of the DNN, it can have many different structures:
  1. Convolutional Neural Network
  2. Recurrent Neural Network
  3. Restricted Boltzmann Machine
  4. Deep Belief Neural network
  5. Autoencoder
  6. ……

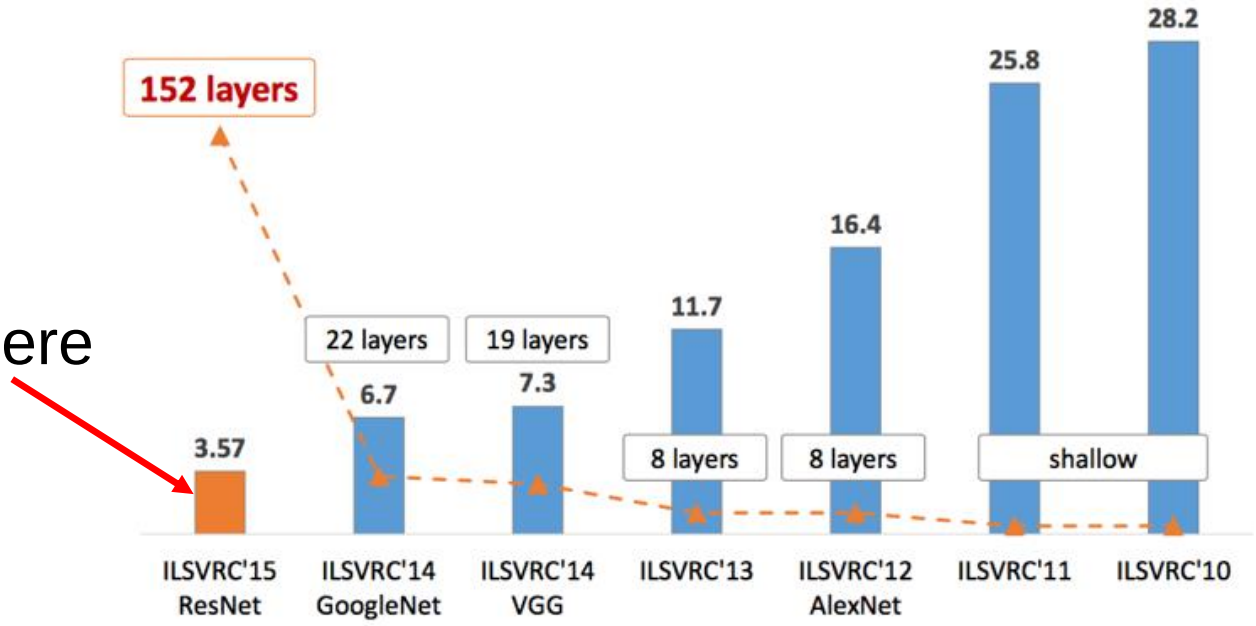
- The list is still increasing since DNN is a hot research topic in recent years

# Burst of DNN

IMAGENET Large Scale Visual Recognition Challenge (ILSVRC)

- The biggest computer vision challenge till 2017
- Millions of images to classify

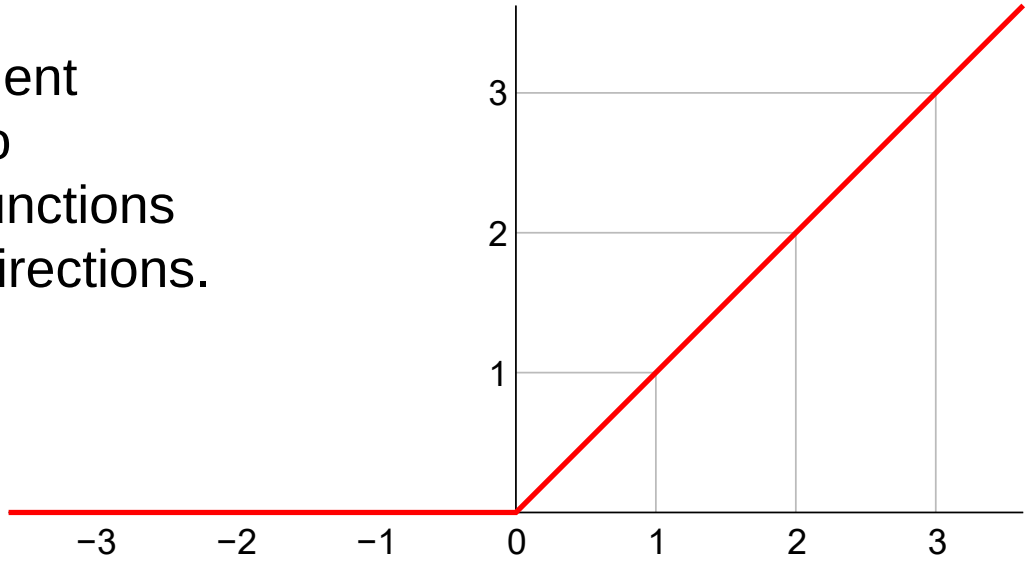
The machine beats human here



# How DNN resolves Vanishing Gradient

- **Rectified Linear Unit (ReLU)**
- $ReLU(x) = \max(0, x)$
- Also known as ramp function

Fewer vanishing gradient problems compared to sigmoidal activation functions that saturate in both directions.



# Convolutional Neural Network

- The most popular DNN in computer vision, and directly related to the coming course project.

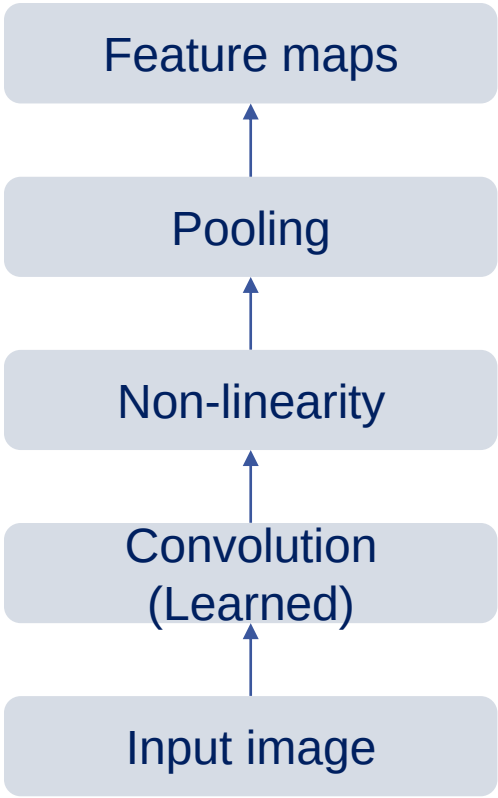
- **Convolution**
- A mathematical operation on two functions (f and g) to produce a third function

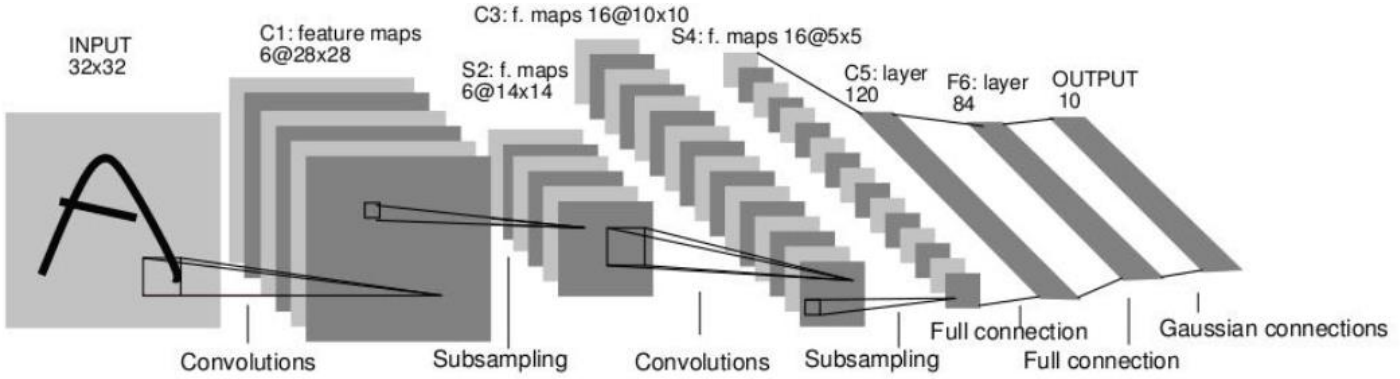
$$f[x] * g[x] = \sum_{k=-\infty}^{\infty} f[k] \cdot g[x-k]$$

$$(f * g)(t) = \int f(\tau)\, g(t-\tau)\, d\tau$$

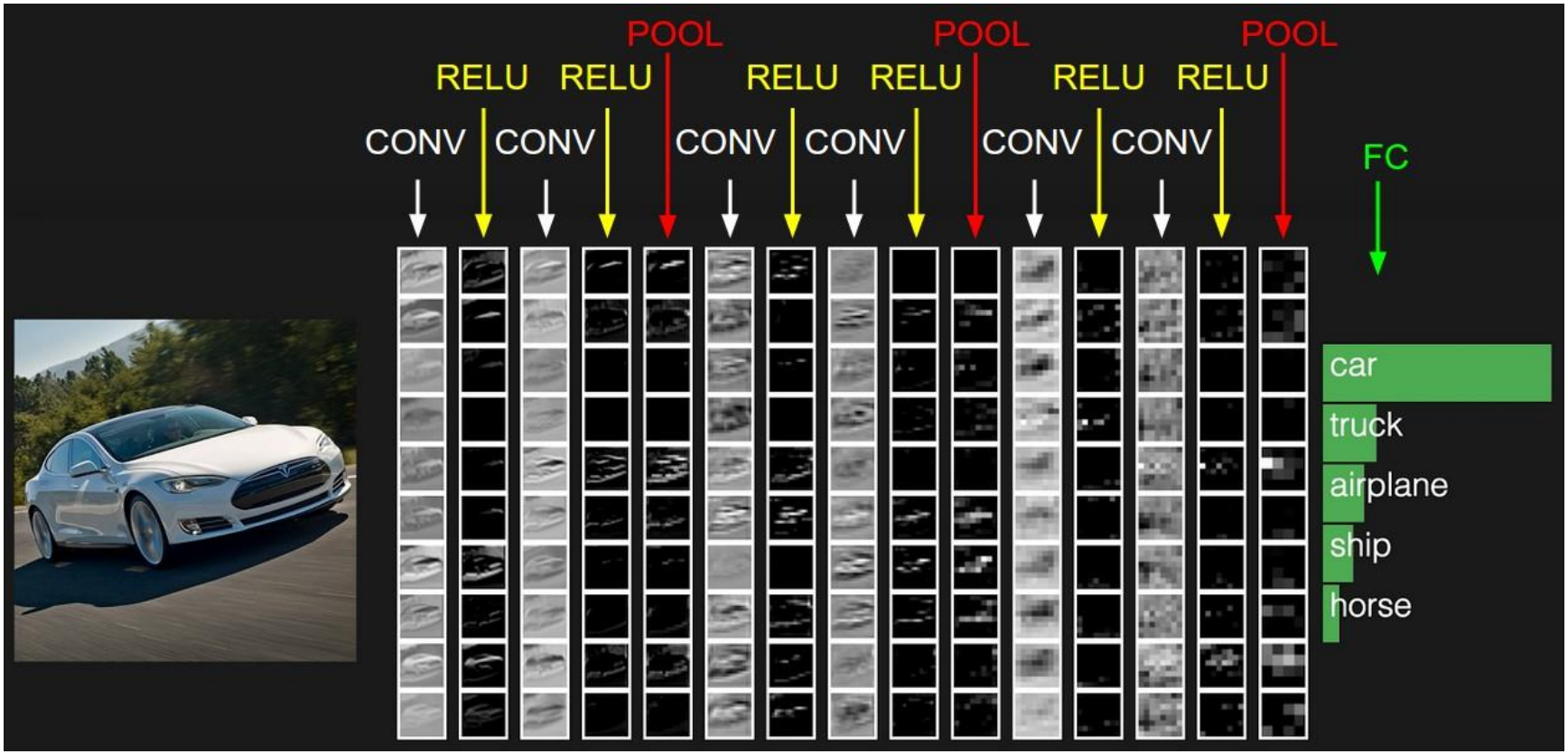
# Architecture

- Neural network with specialized connectivity structure
- Feed-forward:
  - Convolve input
  - Non-linearity (e.g. ReLU)
  - Pooling (local max or average)
- Train convolutional filters (kernels) via backpropagation



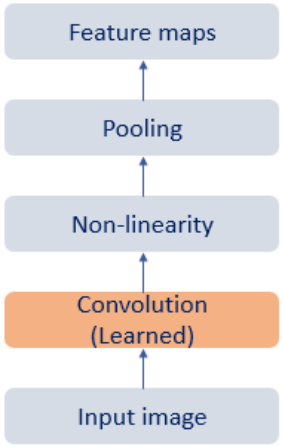



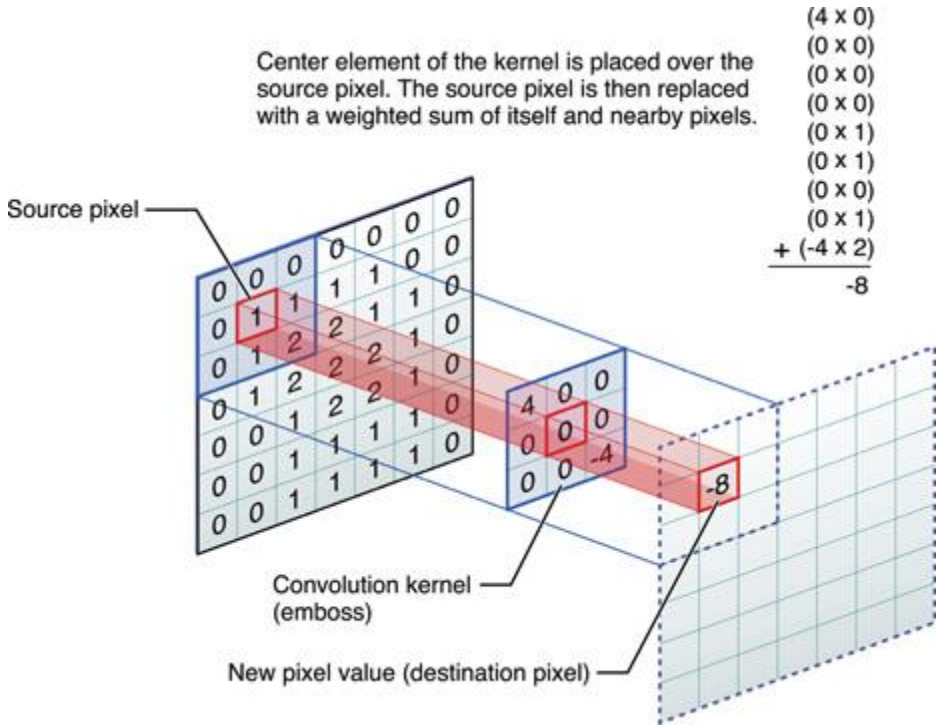
# Example


POOL
POOL
POOL
RELU
RELU
RELU
RELU
RELU
RELU
CONV
CONV
CONV
CONV
CONV
CONV
FC
car
truck
airplane
ship
horse

# Convolutional layer

1. Intuition
2. Local connectivity
3. Stride
4. Zero-padding
5. Parameter sharing



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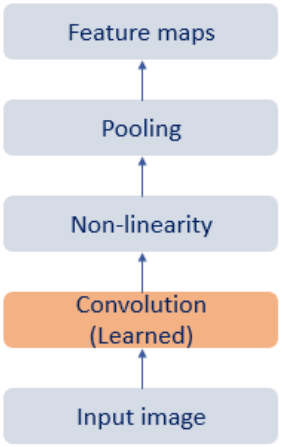
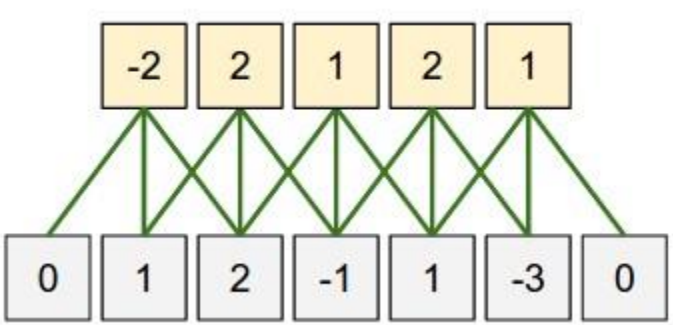
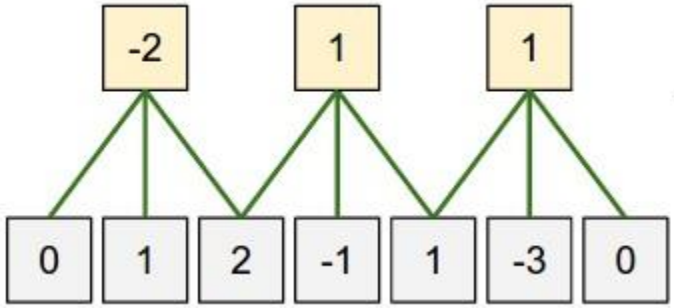
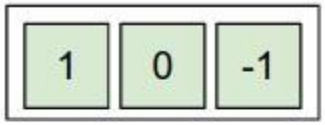
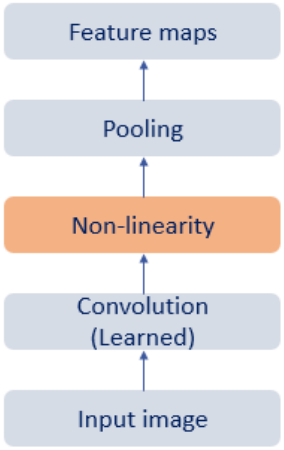


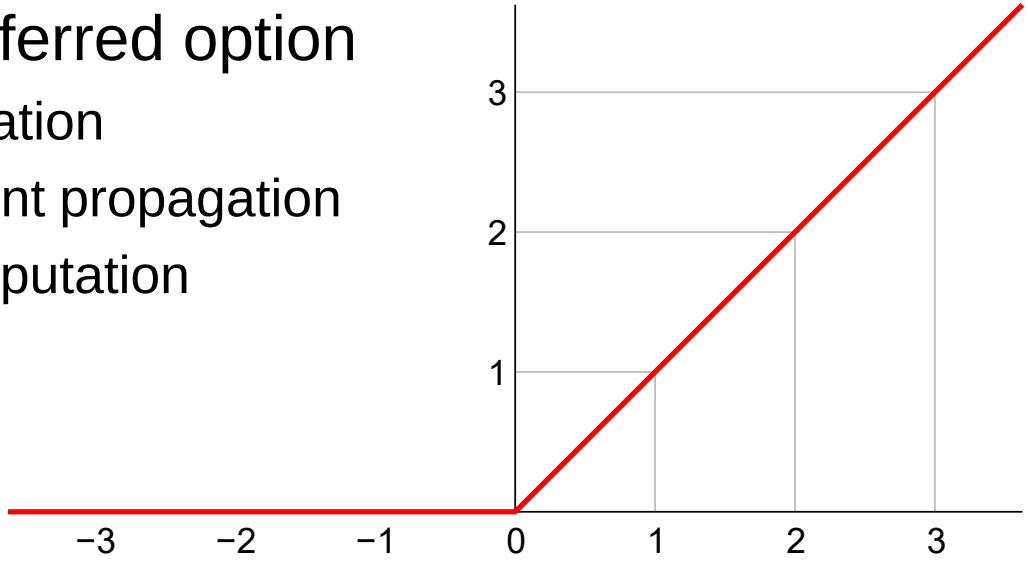



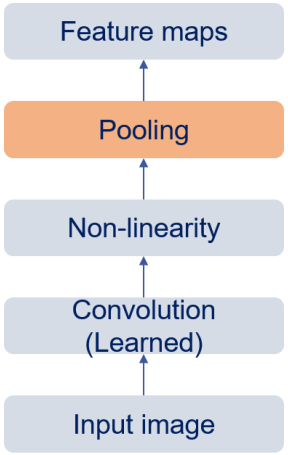
# Non-linearity Layer



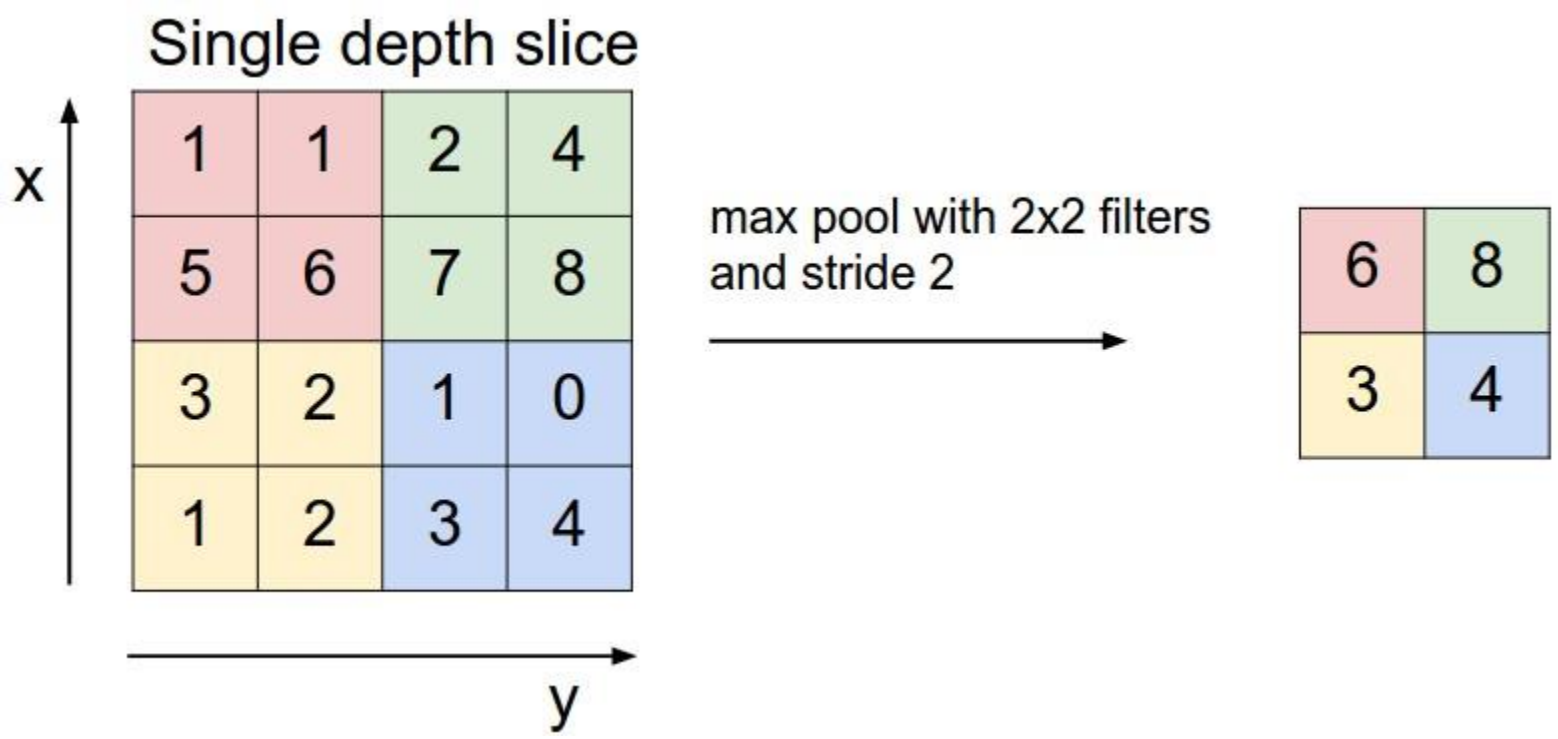

- Actually it's the activation function introduced before
- Tanh
- Sigmoid
- ReLU ➔ preferred option
  - Sparse activation
  - Better gradient propagation
  - Efficient computation
  - …



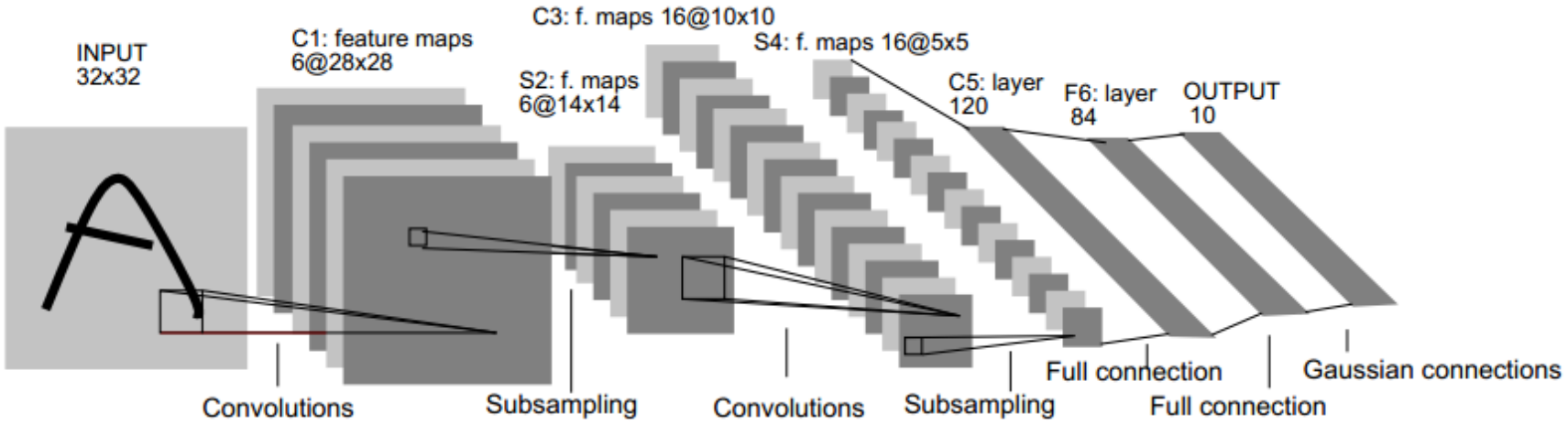
# Pooling layer




- A form of down-sampling
- Average pooling
- Max pooling (the most common one)



# CNN Example


INPUT
32x32
C1: feature maps
6@28x28
S2: f. maps
6@14x14
C3: f. maps 16@10x10
S4: f. maps 16@5x5
C5: layer
120
F6: layer
84
OUTPUT
10
Convolutions
Subsampling
Convolutions
Subsampling
Full connection
Full connection
Gaussian connections

# Summary

- Artificial Neural Network
  - Gradient Descent
  - Vanishing Gradient Problem
- Deep Neural Network
  - Introduction
  - How DNN resolves Vanishing Gradient
  - Convolutional Neural Network

# Reference

- CS231n Convolutional Neural Networks for Visual Recognition
  - https://cs231n.github.io/convolutional-networks/

# Next Week

- Introduction to TensorFlow
- Introduction to the Course Project