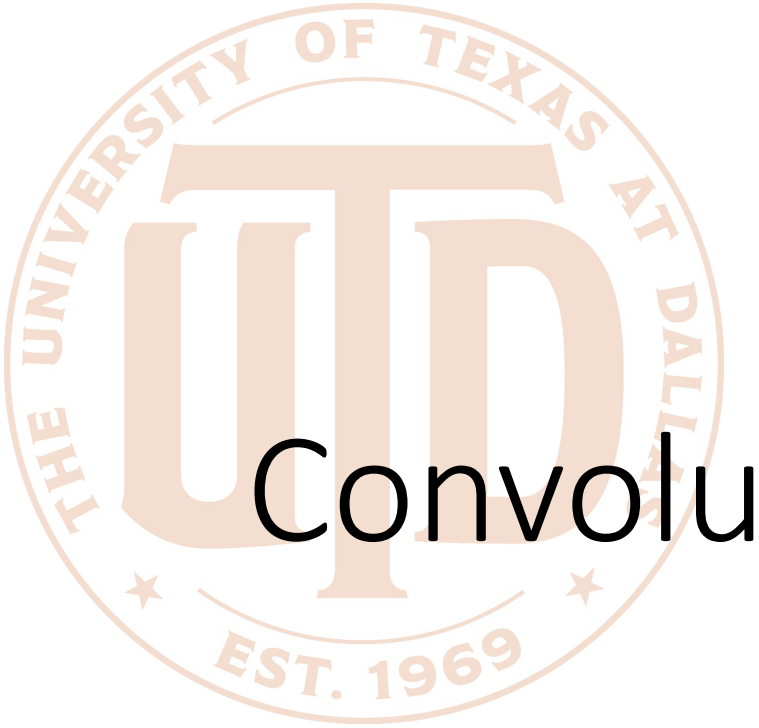


Convolutional Neural Networks I

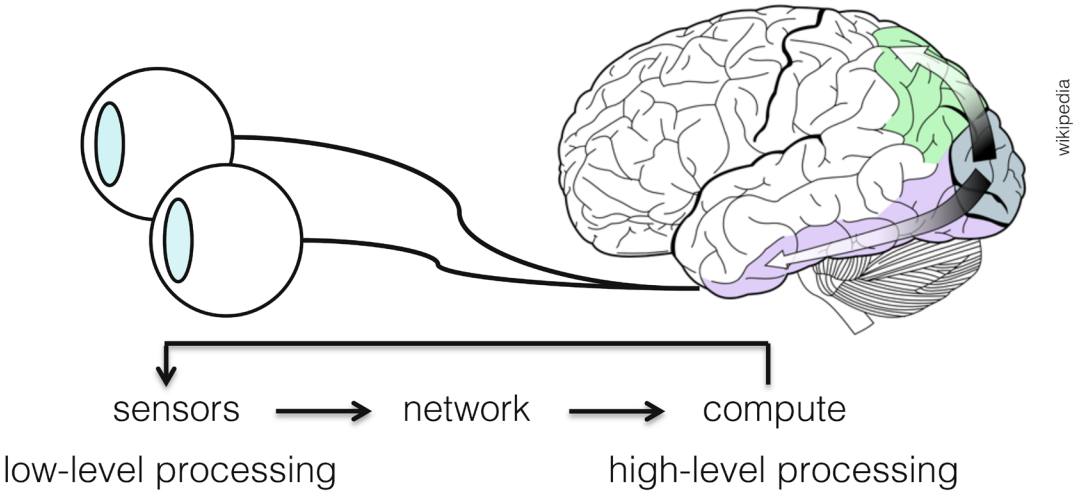
CS 4391 Introduction Computer Vision

Instructor Yu Xiang

The University of Texas at Dallas

Some slides of this lecture are courtesy Stanford CS231n

Visual Perception vs. Computational Perception



Image

Neural Network

High-level information

- Depth
- Motion
- Object classes
- Object poses
- Etc.

Mathematic Models

- Try to model the human brain with computational models, e.g., neural networks

x ⇨  ⇨ y

Image

$f(x)$

Object class

Mathematic Models

- What is the form of the function $f(x)$?
  - No idea!
  - Concatenate simple functions (neurons)

x

$$f(x)$$

$$y \in \{+1, -1\}$$

Dog

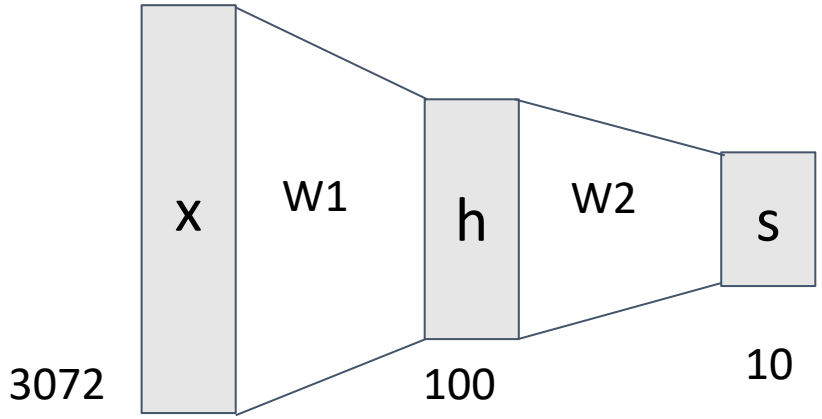
Neural Network: Concatenation of functions

Linear score function: $f = Wx$

2-layer Neural Network

$$f = f_2(f_1(x)) = W_2 \max(0, W_1 x)$$

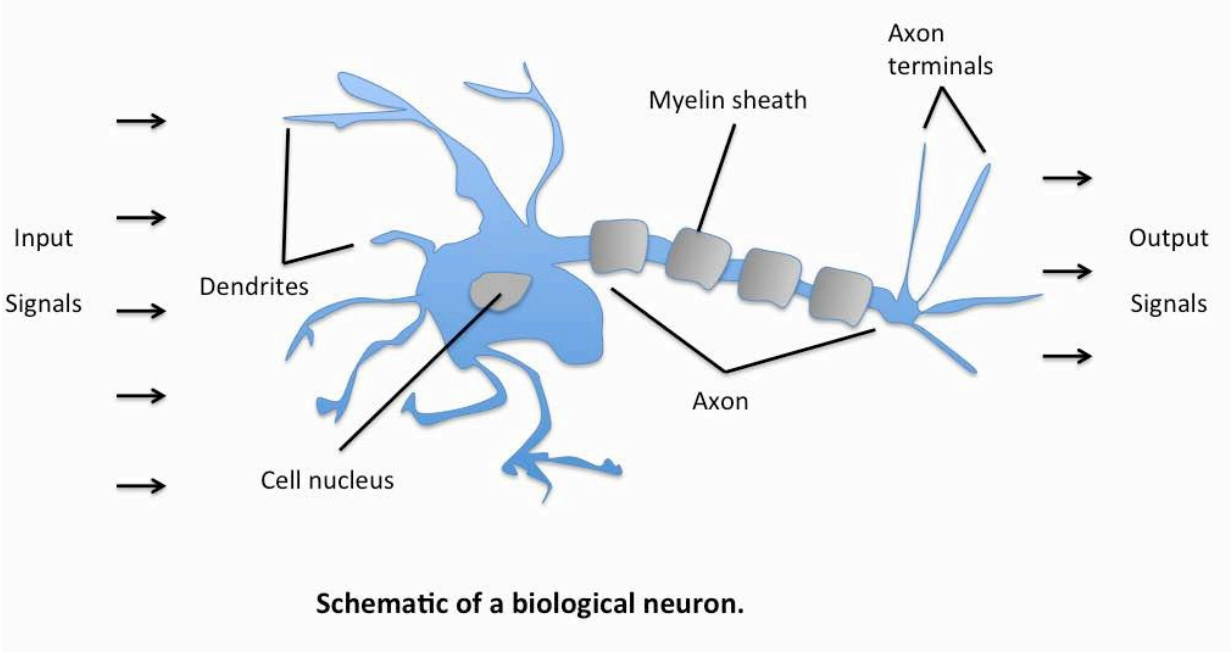
Non-linearity



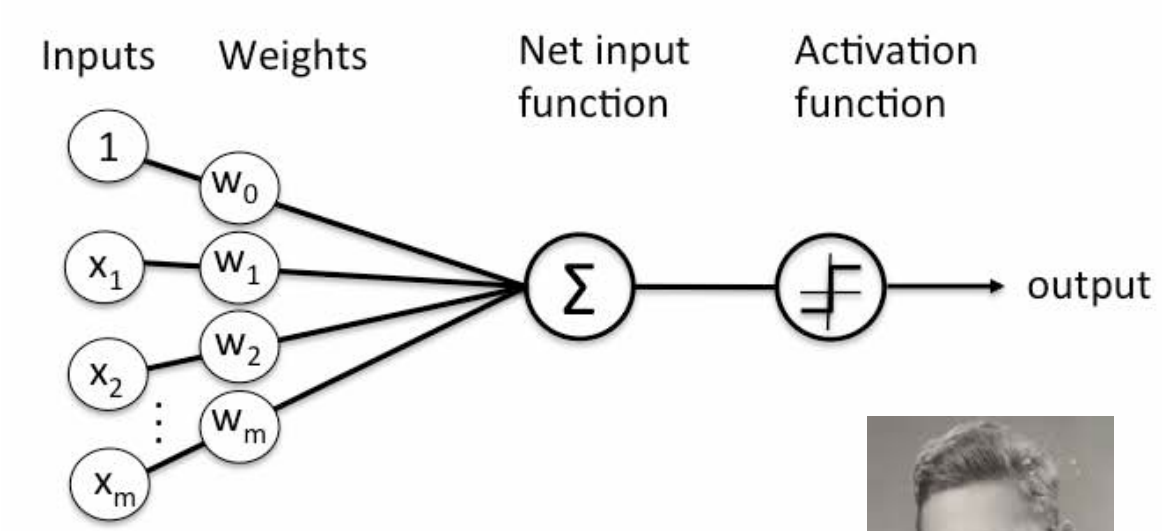
$$h = f_1(X)$$
$$s = f_2(h)$$

Need to learn the weights!

Frank Rosenblatt's Perceptron



Schematic of a biological neuron.



$$\sigma(\mathbf{w}^T\mathbf{x}+b) = \begin{cases} 1 \text{ if } \mathbf{w}^T\mathbf{x}+b \geq 0, \\ 0 \text{ otherwise.} \end{cases}$$

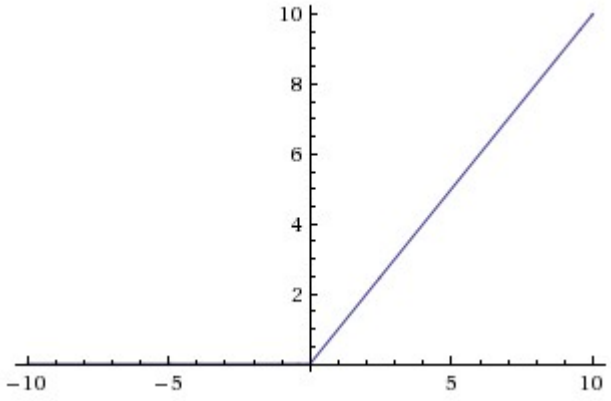
Frank Rosenblatt
(1928-1971)

Activation Functions

2-layer Neural Network

$$f = f_2(f_1(x)) = W_2 \max(0, W_1 x)$$

Rectified Linear Unit (**ReLU**)
max(0,x)

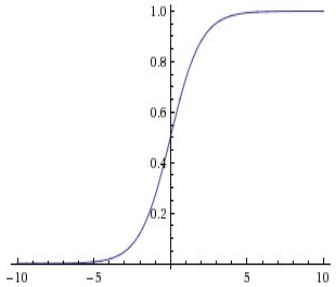


Introduce non-linearity to the network

Activation Functions

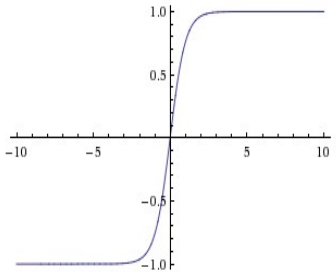
Sigmoid

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

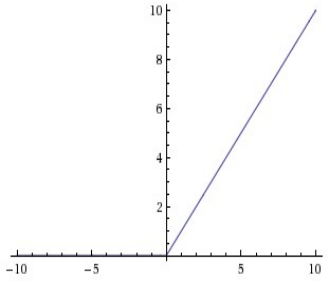


tanh tanh(x)

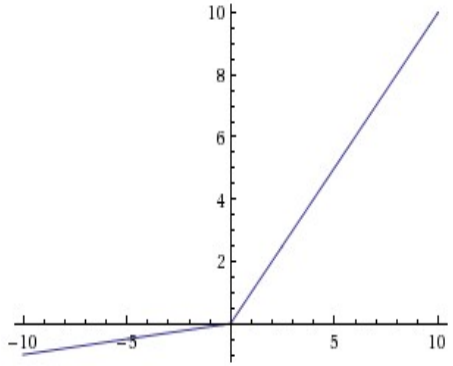
$$\frac{e^{2x}-1}{e^{2x}+1}$$



ReLU max(0,x)



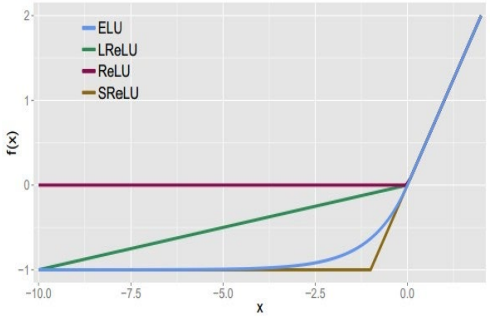
Leaky ReLU
max(0.1x, x)



Maxout $\max(w_1^T x + b_1, w_2^T x + b_2)$

ELU Exponential Linear Unit

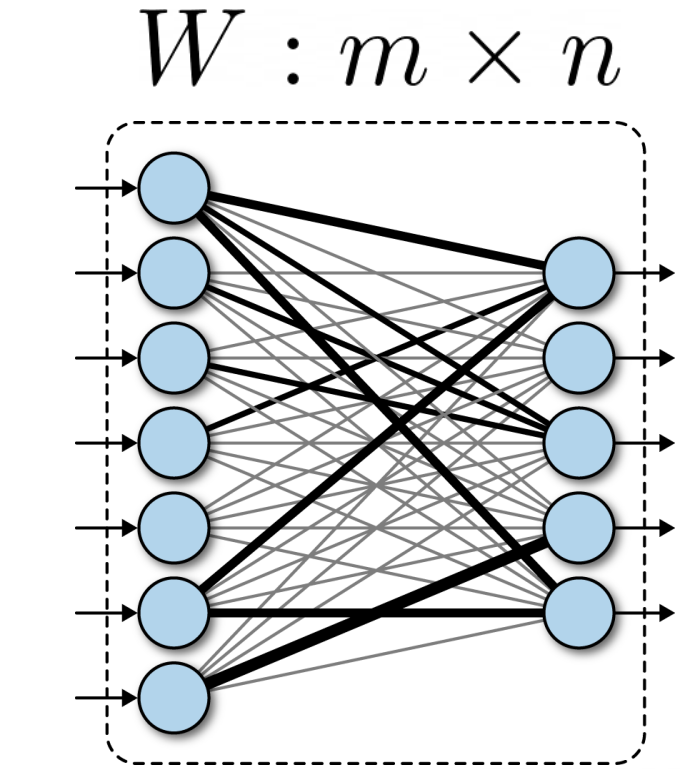
$$f(x) = \begin{cases} x & \text{if } x > 0 \\ \alpha\left(\exp(x) - 1\right) & \text{if } x \leq 0 \end{cases}$$



Fully Connected Layer

$$y = Wx$$

$x : n \times 1$ $W : m \times n$ $y : m \times 1$



Fully Connected Layer

- What is the drawback of only using fully connected layers?

$$y = Wx$$

- Consider an image with 640 x 480
  - x is with dimension 307,200
  - The weight matrix of the fully connect layer is too large

Further Reading

- Stanford CS231n, lecture 5, Convolutional Neural Networks http://cs231n.stanford.edu/schedule.html
- Deep learning with PyTorch https://pytorch.org/tutorials/beginner/deep_learning_60min_blitz.html
- AlexNet (2012): https://papers.nips.cc/paper/2012/hash/c399862d3b9d6b76c8436e924a68c45b-Abstract.html
- Vgg16 (2014): https://arxiv.org/abs/1409.1556
- GoogleNet (2014): https://arxiv.org/abs/1409.4842
- ResNet (2015): https://arxiv.org/abs/1512.03385