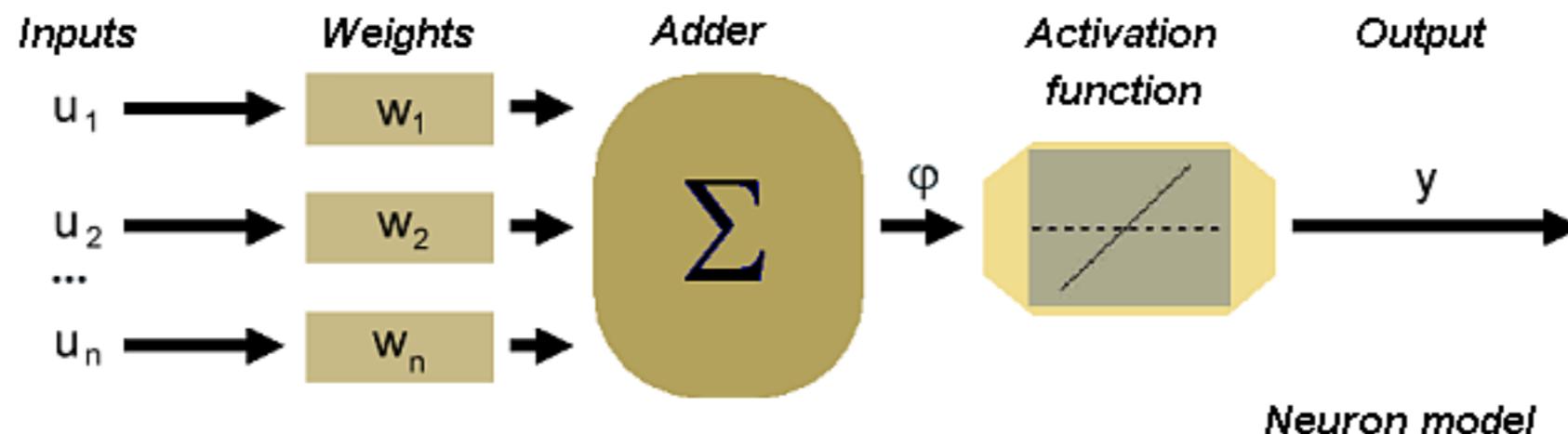
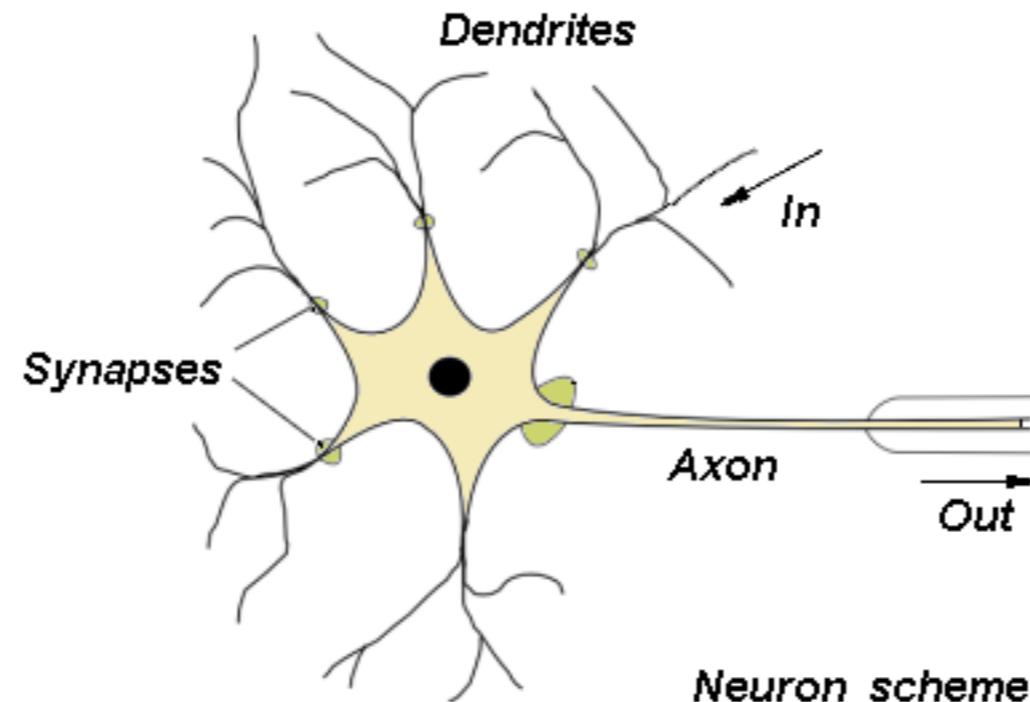


Machine Learning for Applications in Computer Vision

Neural Networks and
Deep Learning

Perceptron

- The human brain (10^{10} cells) is the archetype of neural networks



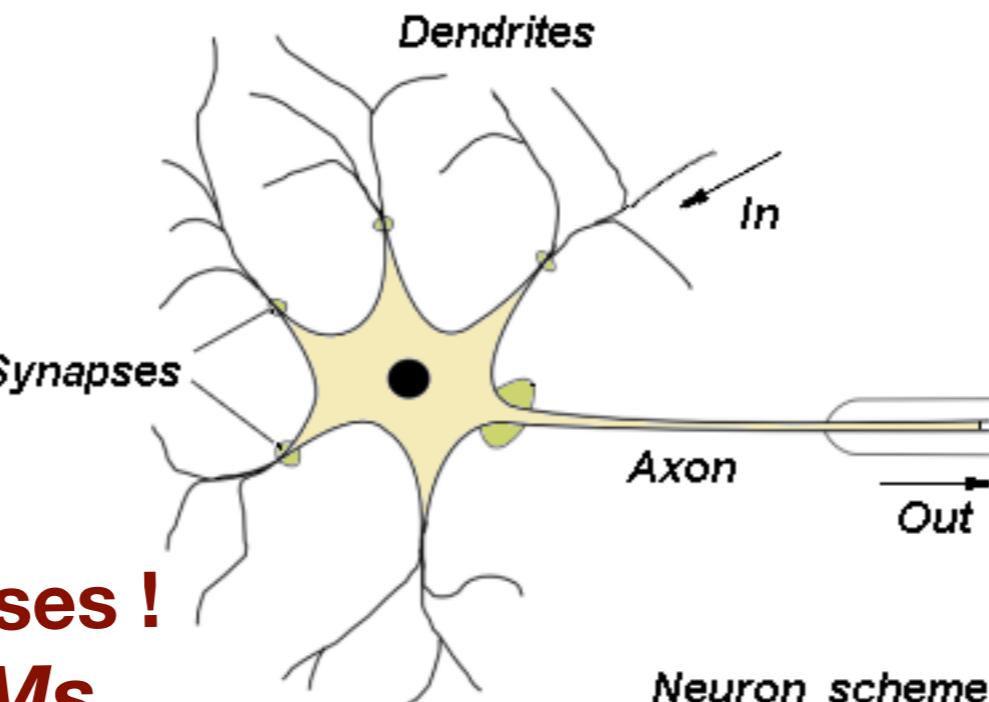
<http://home.agh.edu.pl/~vlsi/AI/intro/>



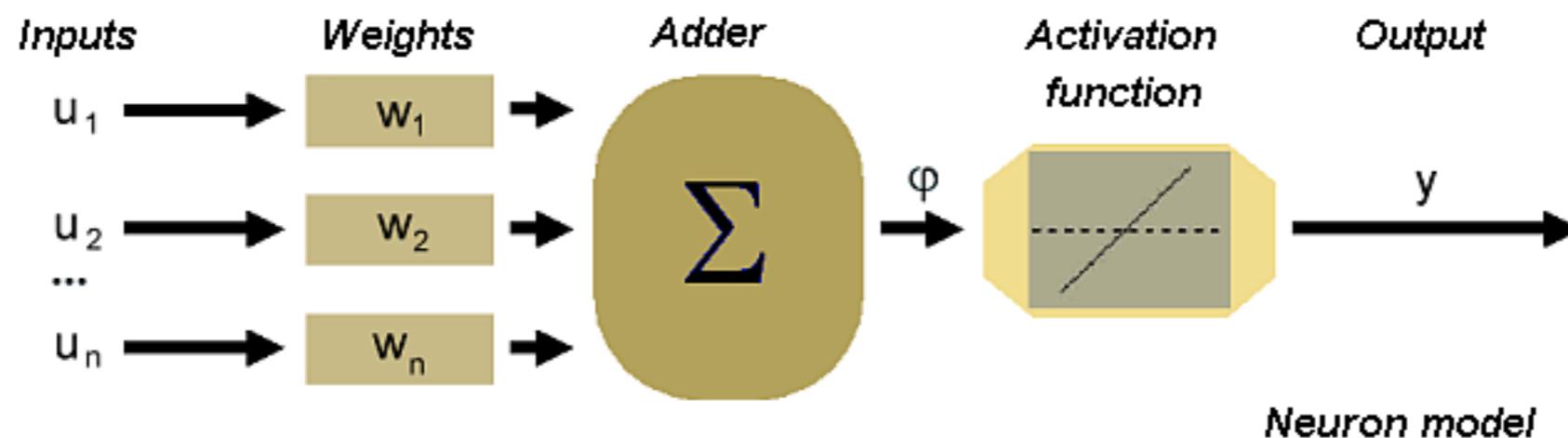
Perceptron

- The human brain (10^{10} cells) is the archetype of neural networks

**Finds a hyperplane
to separate the classes !
Very similar to SVMs**



Neuron scheme



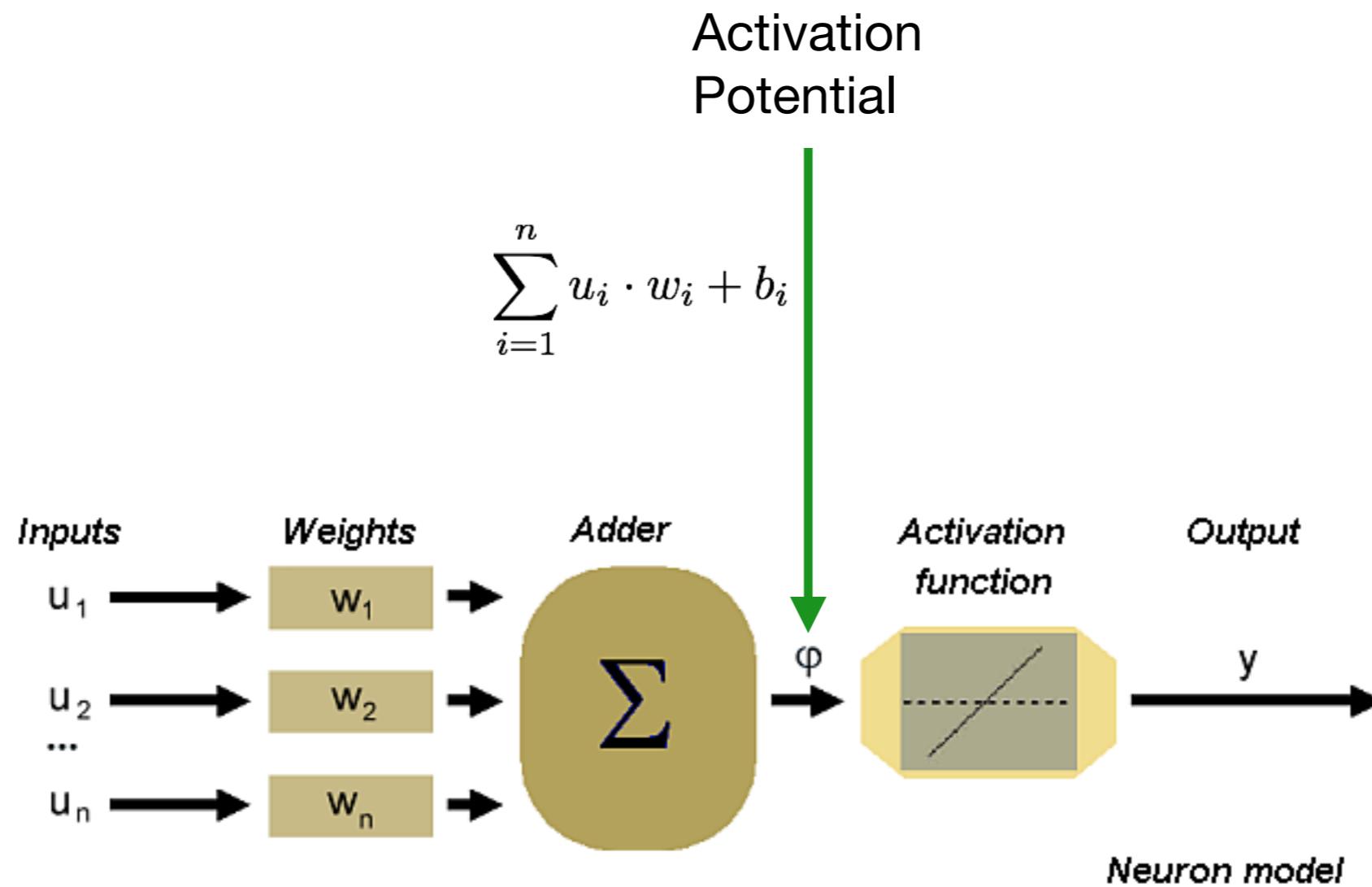
Neuron model

<http://home.agh.edu.pl/~vlsi/AI/intro/>



Perceptron

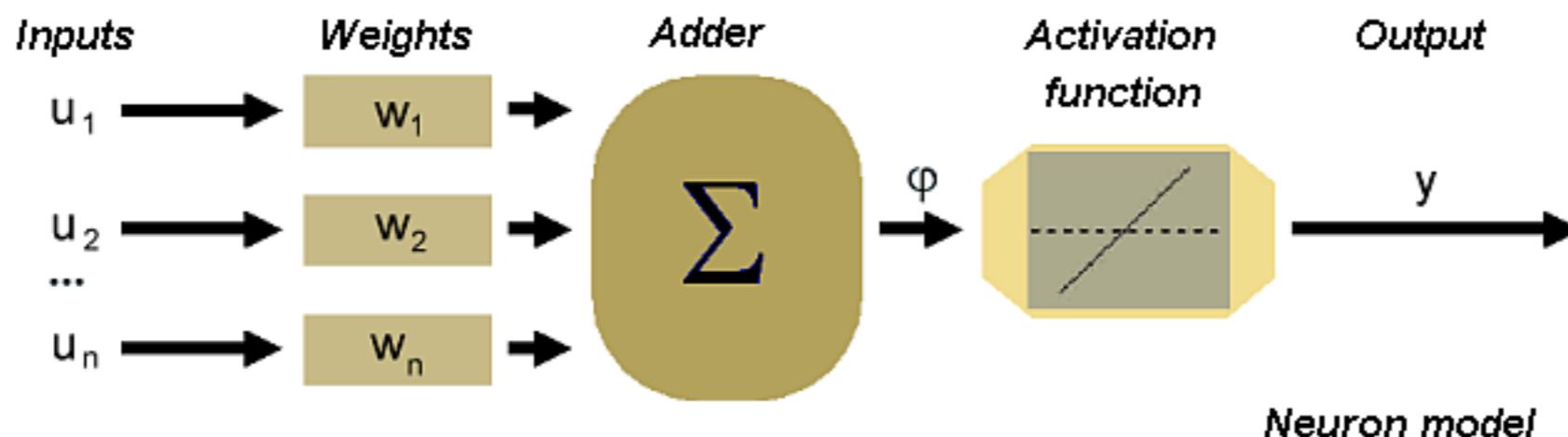
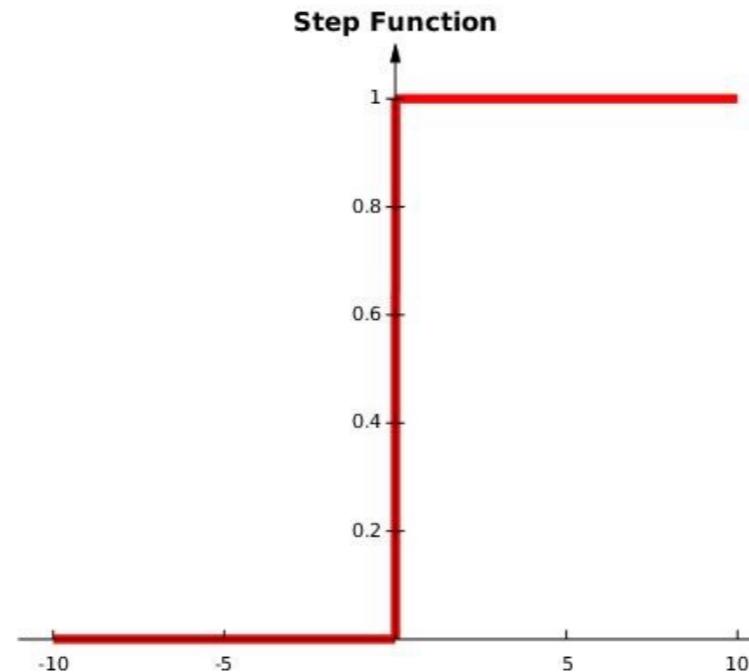
- The human brain (10^{10} cells) is the archetype of neural networks



Neuron Activations

- Different type of activation functions

Threshold activation (binary classifier)

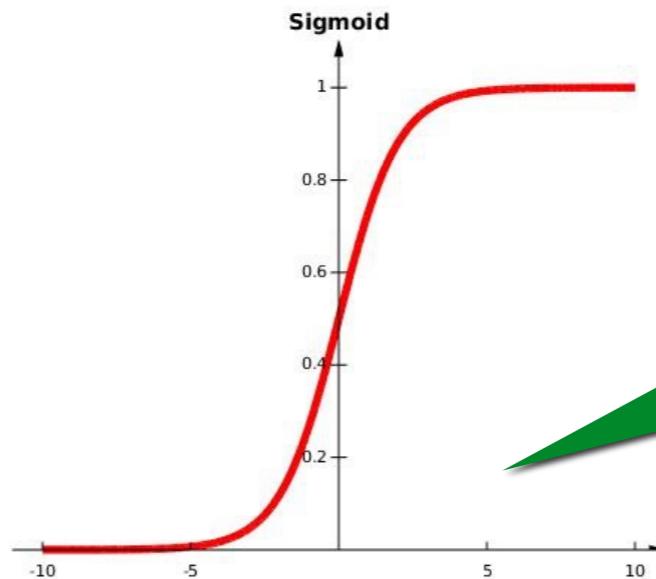


Neuron Activations

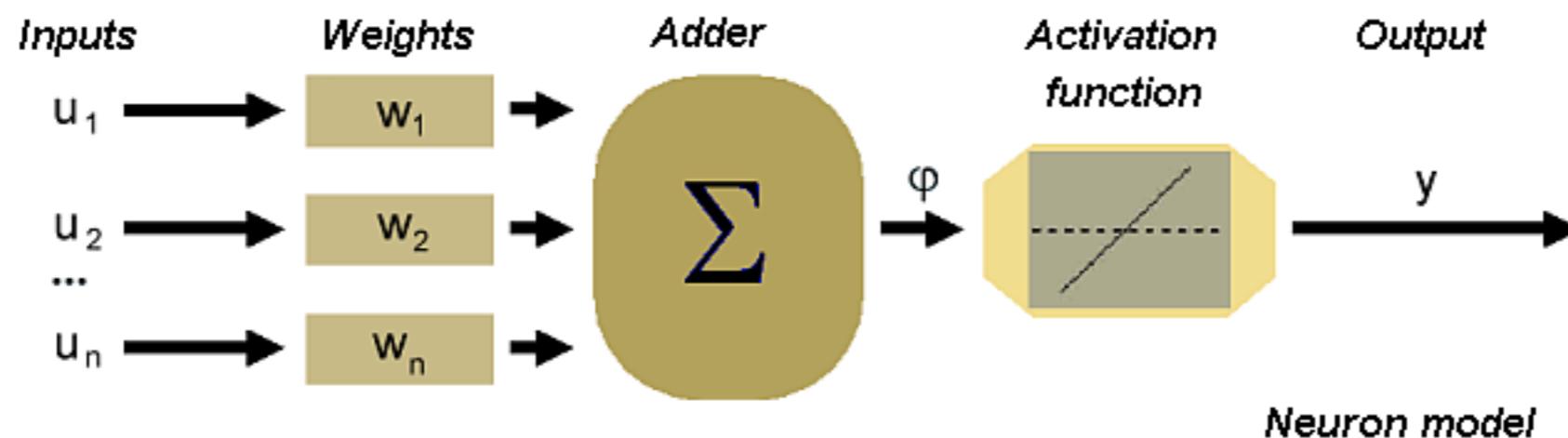
- Different type of activation functions

Sigmoid activation

$$y = \frac{1}{1 + \exp^{-\phi}}$$



More accurate !
Describe the non-linear
characteristics of biological
neurons

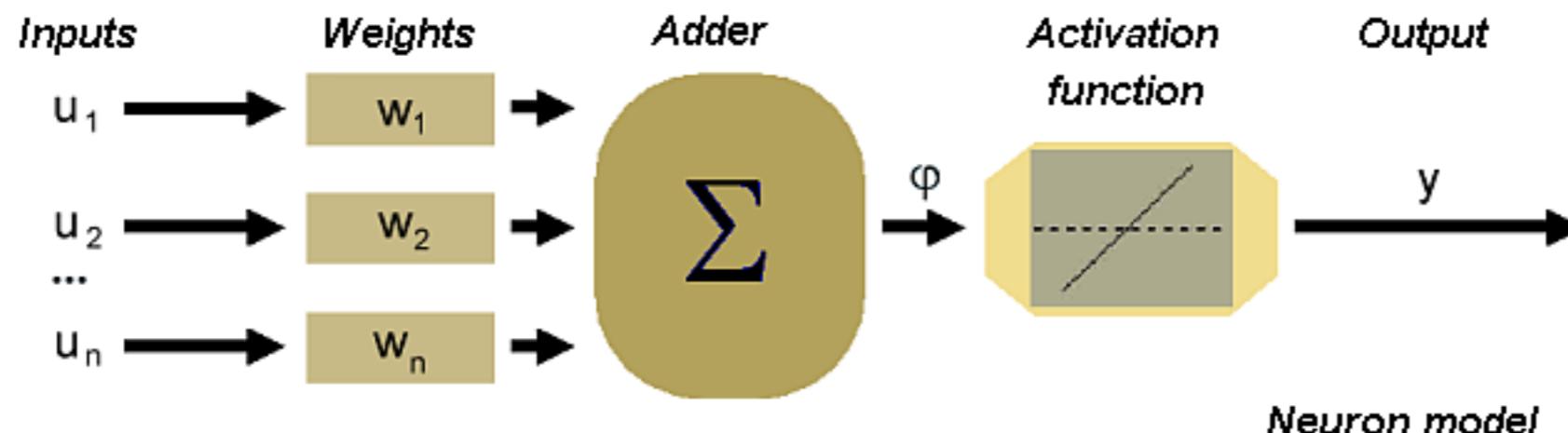
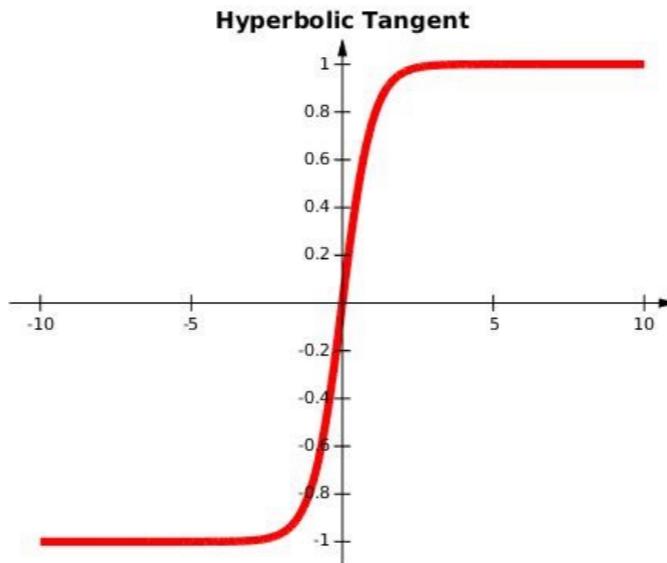


Neuron Activations

- Different type of activation functions

Tangent activation

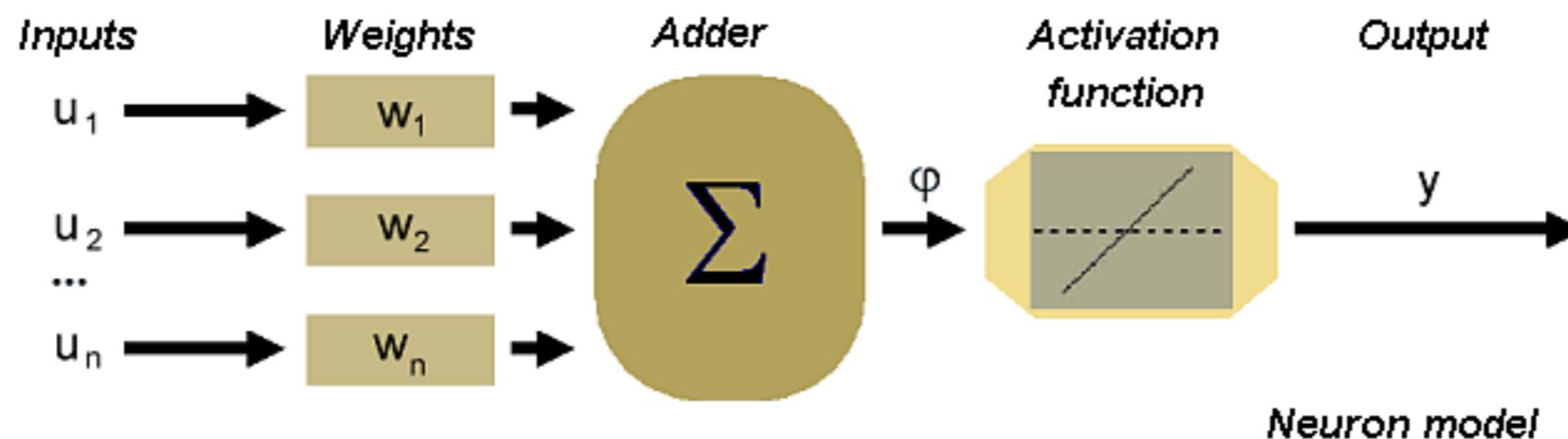
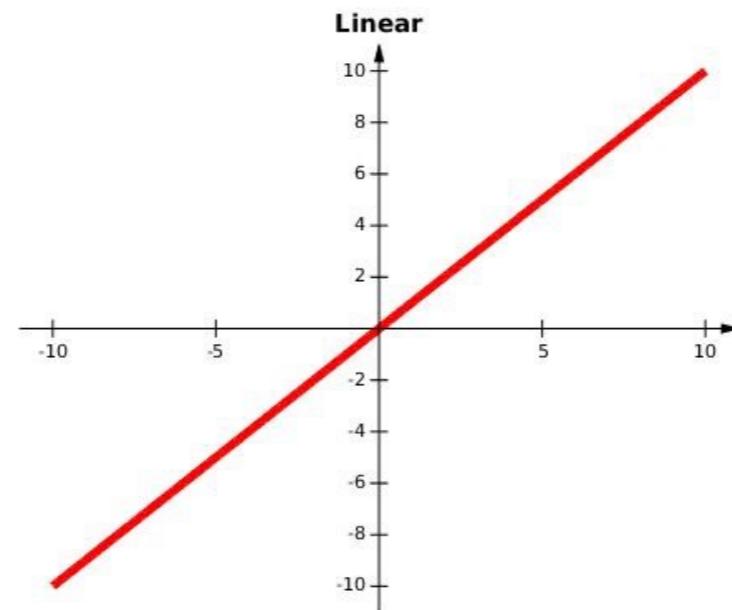
$$y = \frac{\exp^\phi - \exp^{-\phi}}{\exp^\phi + \exp^{-\phi}}$$



Neuron Activations

- Different type of activation functions

Linear activation

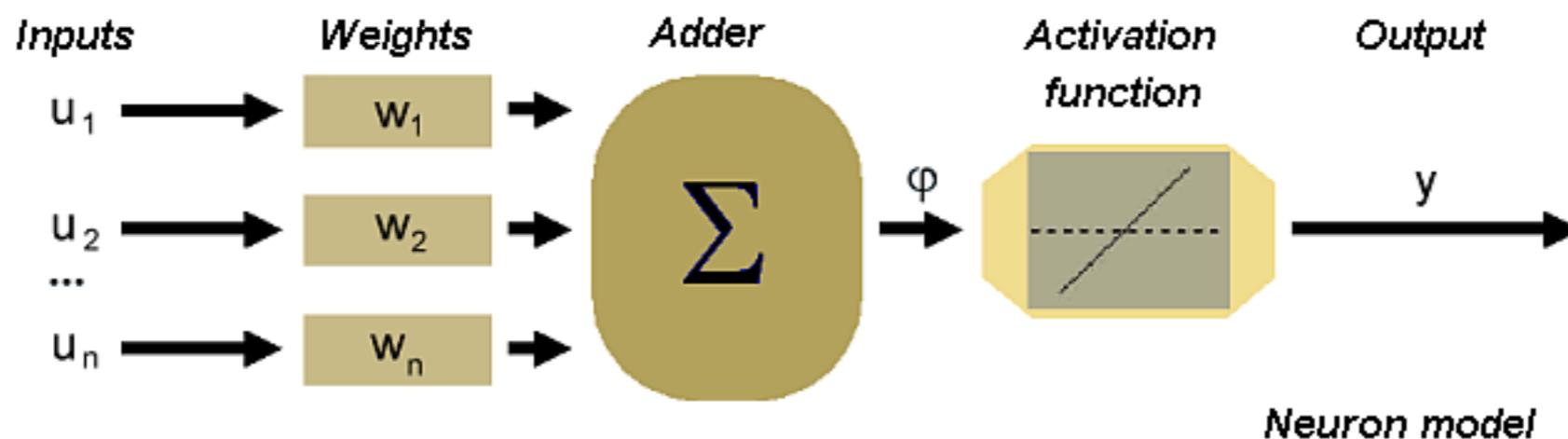
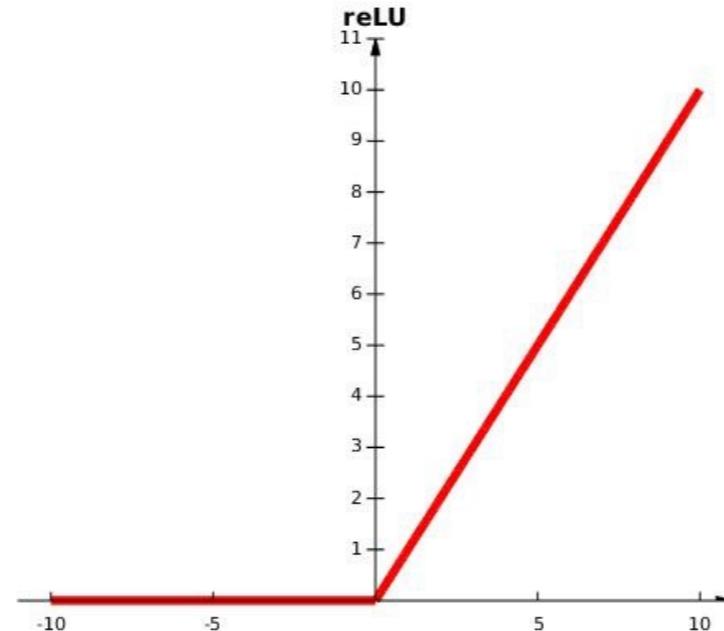


Neuron Activations

- Different type of activation functions

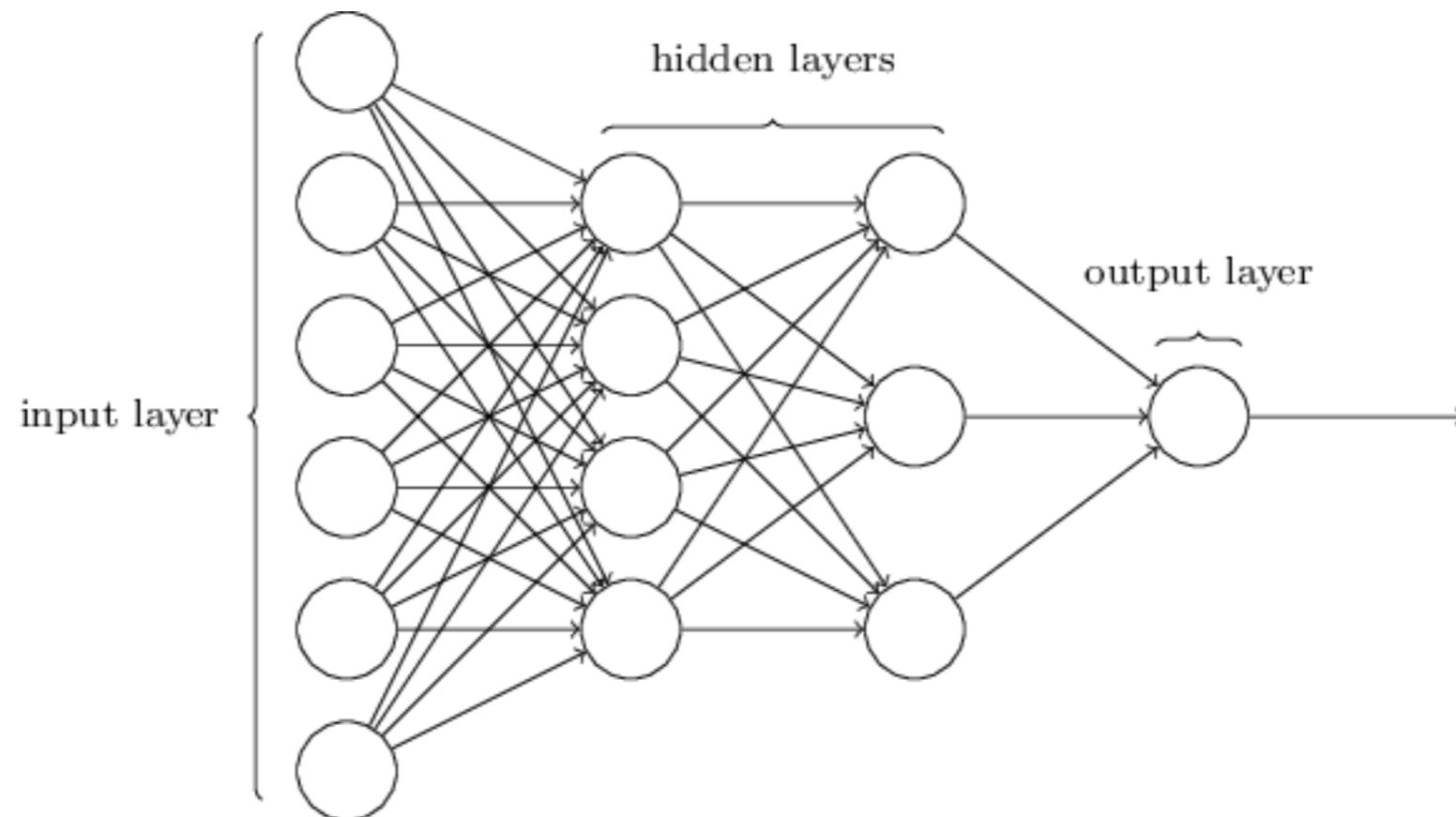
rectified Linear Unit activation

$$y = \max(0, \phi)$$



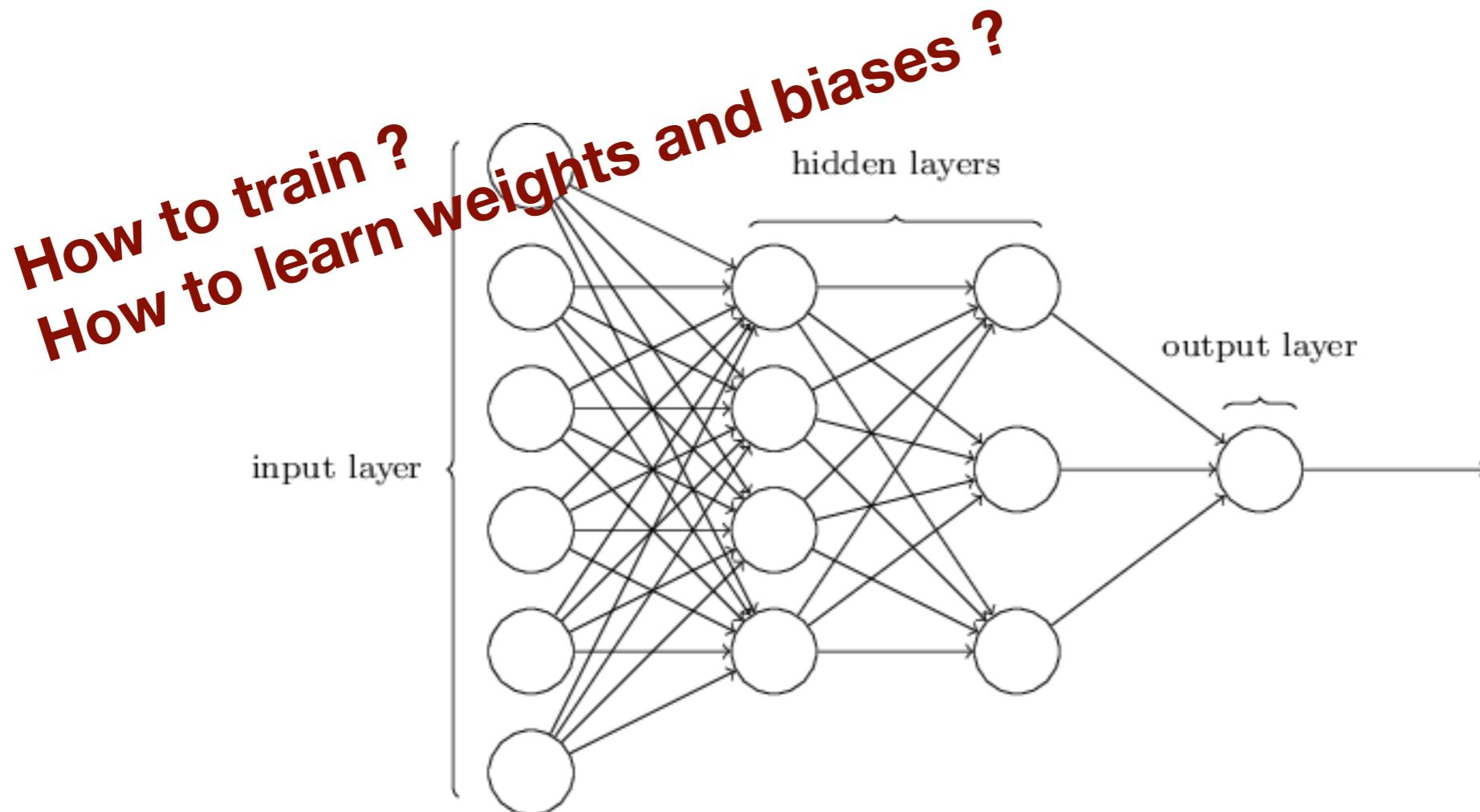
Simple Neural Network

- Best reference: neuralnetworksanddeeplearning.com



Simple Neural Network

- Best reference: neuralnetworksanddeeplearning.com

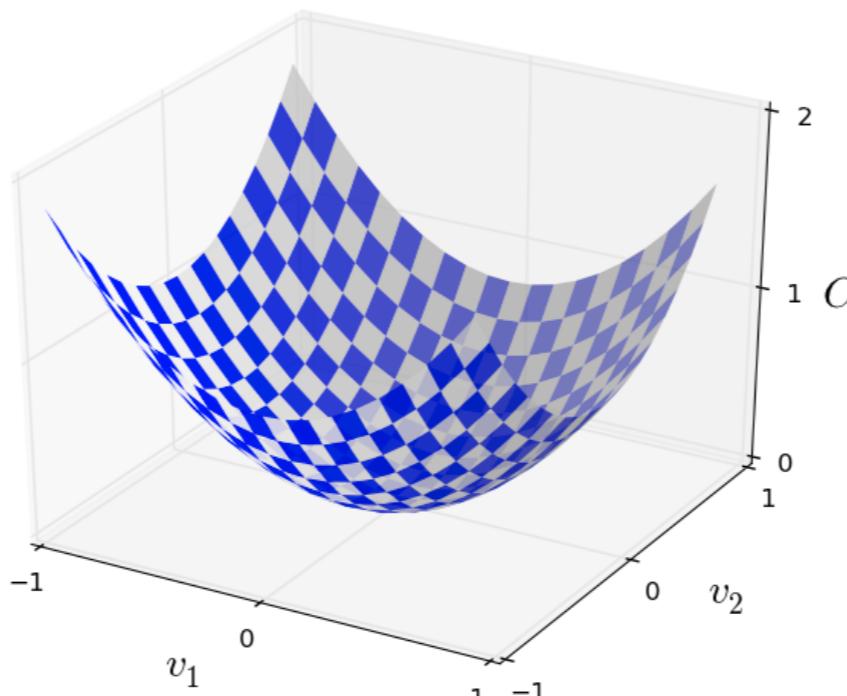


Back Propagation

- Define a cost function

$$C(w, b) \equiv \frac{1}{2n} \sum_x \|y(x) - a\|^2$$

prediction ground truth



- **Goal:** Find global minimum



Back Propagation

- Define a cost function

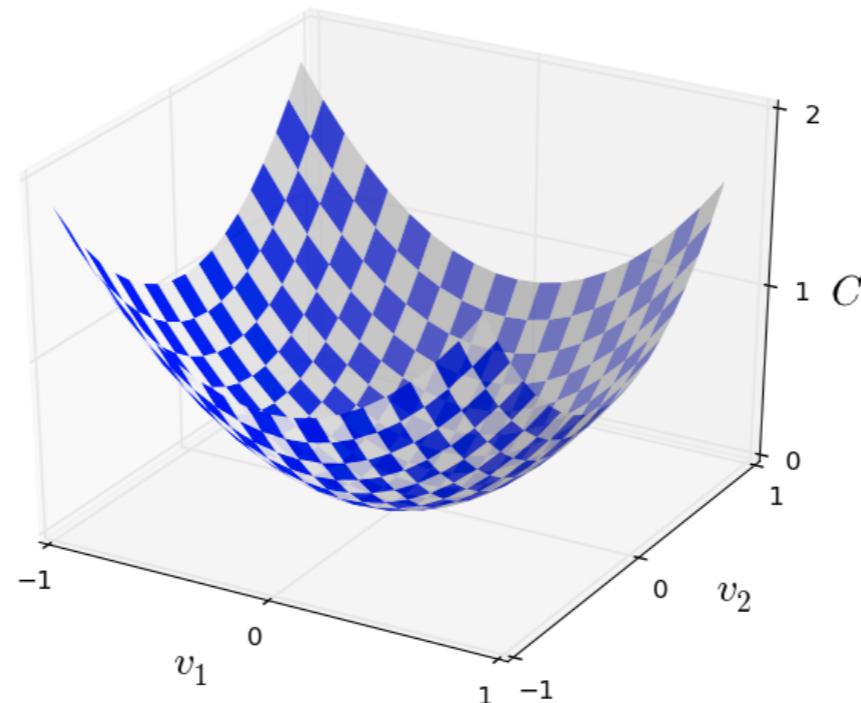
$$C(w, b) \equiv \frac{1}{2n} \sum_x \|y(x) - a\|^2$$

prediction ground truth



- **Goal:** Find global minimum

Gradient Descent



Back Propagation

- Define a cost function

$$C(w, b) \equiv \frac{1}{2n} \sum_x \|y(x) - a\|^2$$

ground truth
↓
prediction

- Minimize the error (derivative of the cost) with gradient descent

- Gradient descent update rule:

$$w_k \rightarrow w'_k = w_k - \eta \frac{\partial C}{\partial w_k}$$
$$b_l \rightarrow b'_l = b_l - \eta \frac{\partial C}{\partial b_l}$$

Learning rate



Back Propagation

- Define a cost function

$$C(w, b) \equiv \frac{1}{2n} \sum_x \|y(x) - a\|^2$$

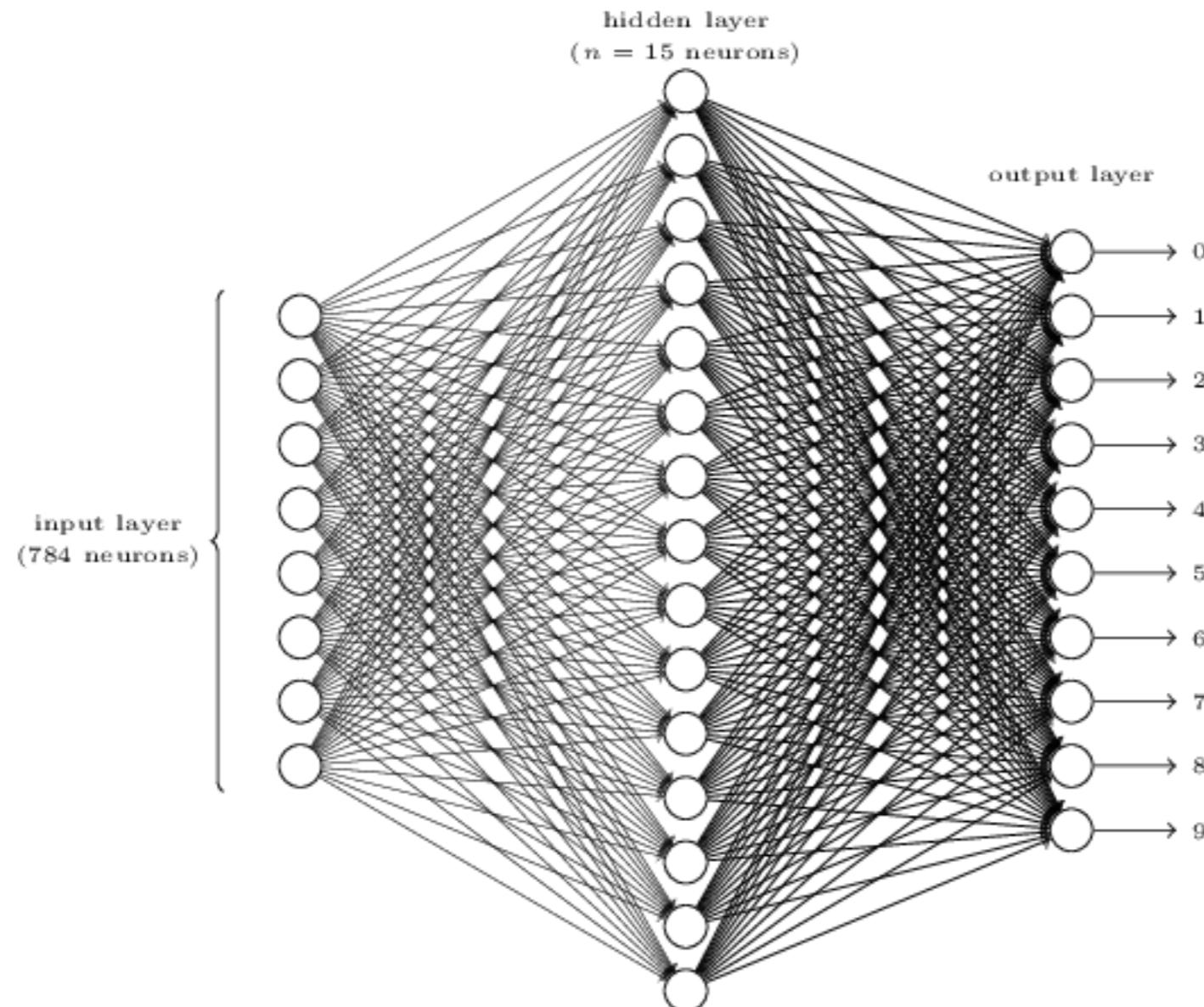
ground truth
↓
prediction

- Propagate the error through layers

- Take the derivate of the output of the layer w.r.t the input of the layer
- Apply update rule for the parameters



MNIST Digit Classification with NN



Deep Learning

- so far:
 - extract features (pixel intensities, edges, lines,...)
 - train a classifier to find the best hyperplane(s)



Deep Learning

- can we model high-level abstractions in data ?



Deep Learning

- can we model high-level abstractions in data ?
 - don't rely on hand-crafted features

Yes



Deep Learning

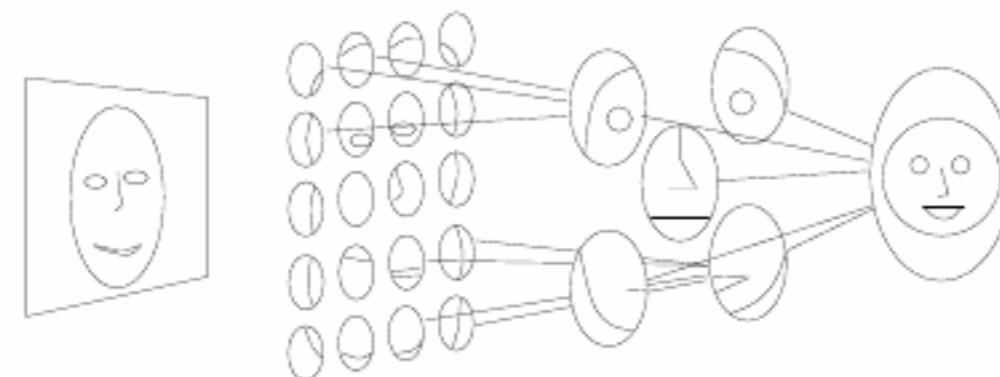
- can we model high-level abstractions in data ?
 - don't rely on hand-crafted features
 - consider the images as observations

Yes



Deep Learning

- can we model high-level abstractions in data ? *Yes*
- don't rely on hand-crafted features
- consider the images as observations
- construct hierarchies (hierarchical feature extraction) with a deep architecture composed of multiple **non-linear** transformations



http://www.kip.uni-heidelberg.de/cms/vision/projects/recent_projects/hardware_perceptron_systems/image_recognition_with_hardware_neural_networks/



Deep Learning

- **Unsupervised**

- Auto encoders
- Restricted Boltzman Machines
- Deep Belief Networks



Deep Learning

- **Supervised**

- Multilayer perceptron
- ***Deep Convolutional Neural Networks***

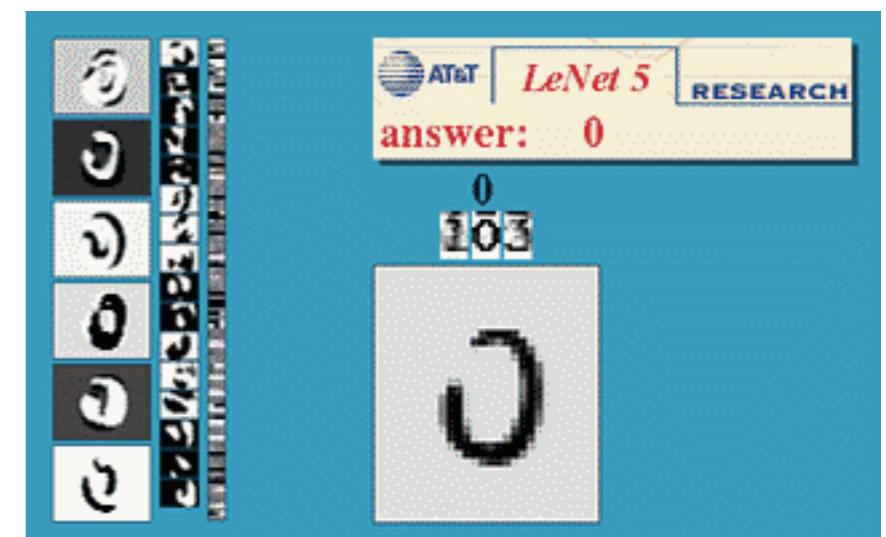
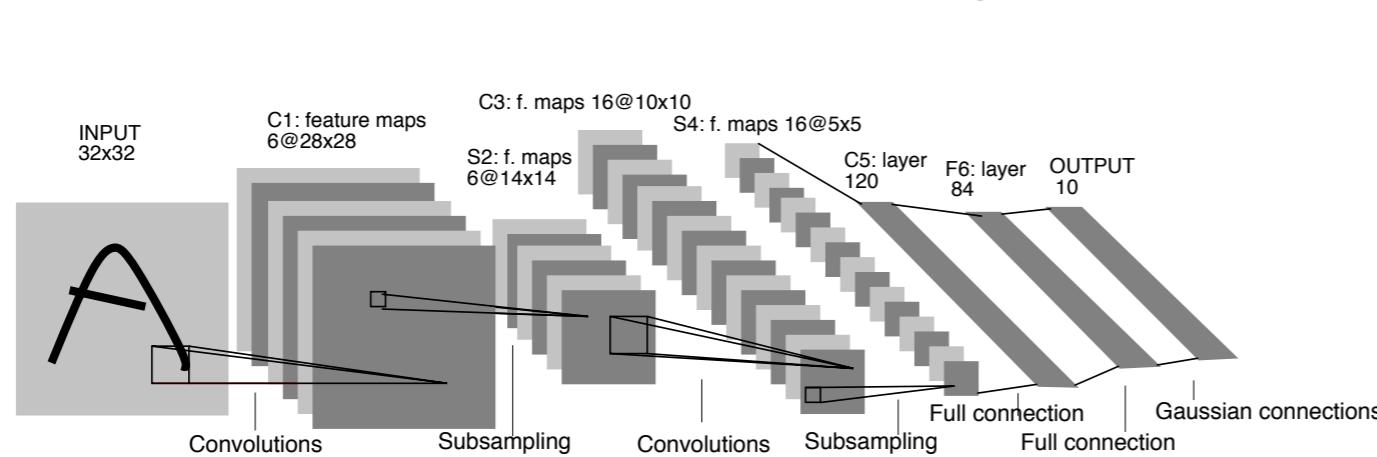


Deep Learning

- Supervised

- Multilayer perceptron
- **Deep Convolutional Neural Networks**

LeNet - First Deep Convolutional Neural Network
for hand written digit classification



https://www.youtube.com/watch?v=FwFduRA_L6Q

