KAIST Summer Session 2018

Module 3. Deep Learning with PyTorch

Regression and Neural Network

KAIST College of Business

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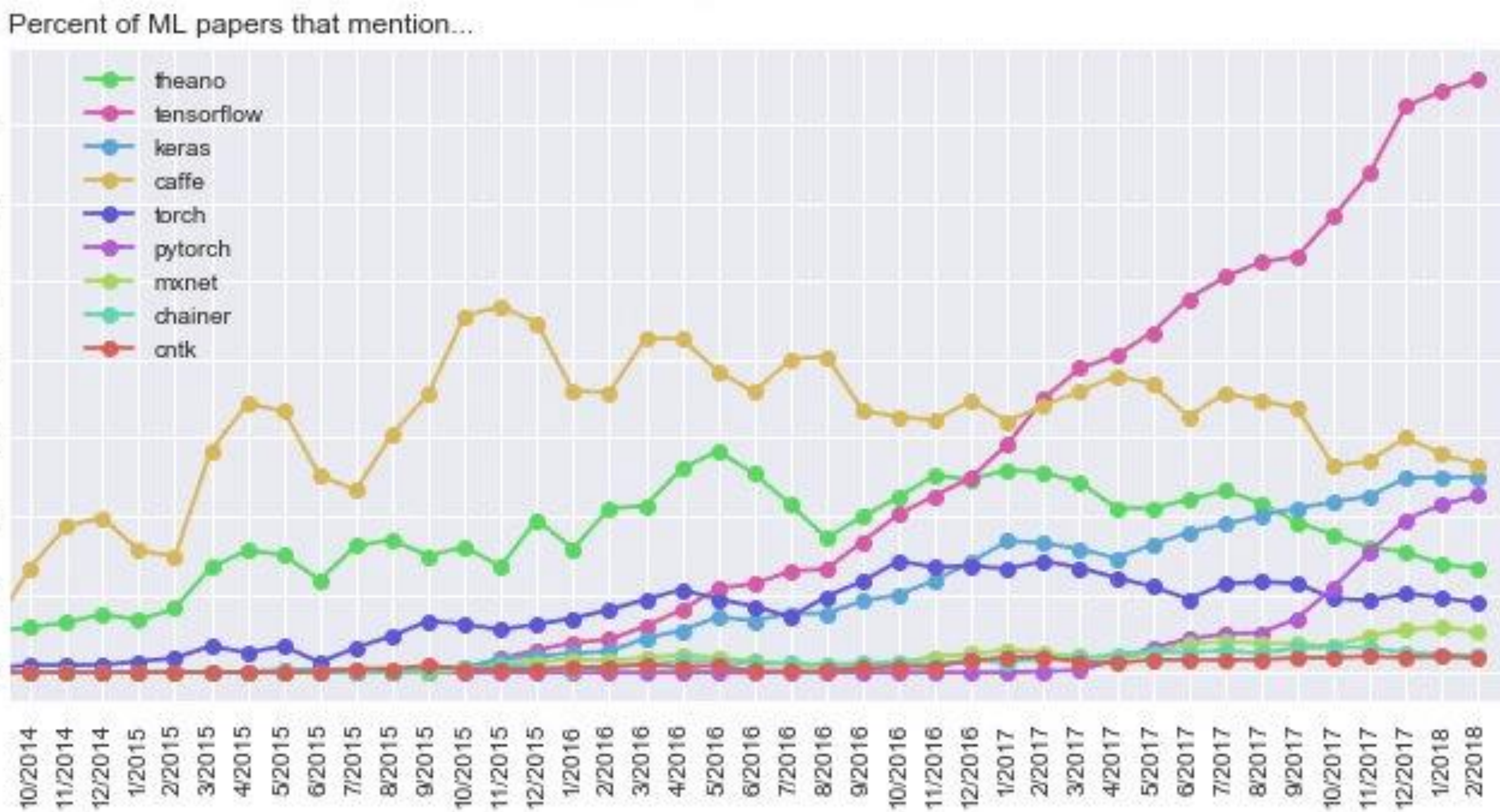
16 August, 2018


Percent of ML papers that mention...
theano
tensorflow
keras
caffe
torch
pytorch
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Let's Get Started

Please ensure that you are on the latest pip and numpy packages.
Anaconda is our recommended package manager

OS	Linux	MacOS	**Windows**	
Package Manager	**conda**	pip	Source	
Python	2.7	3.5	**3.6**	3.7
CUDA	8	9.0	9.2	**None**

Run this command:

```
conda install pytorch-cpu -c pytorch
pip3 install torchvision
```

https://pytorch.org/

(Optional) if any problems,
Try to run the anaconda prompt as administrator
In addition, type these first:

```
python –m pip install –upgrade pip
pip install –upgrade setuptools
pip install torchvision
```

Linear Regression

Statistical Style versus Machine Learning Style

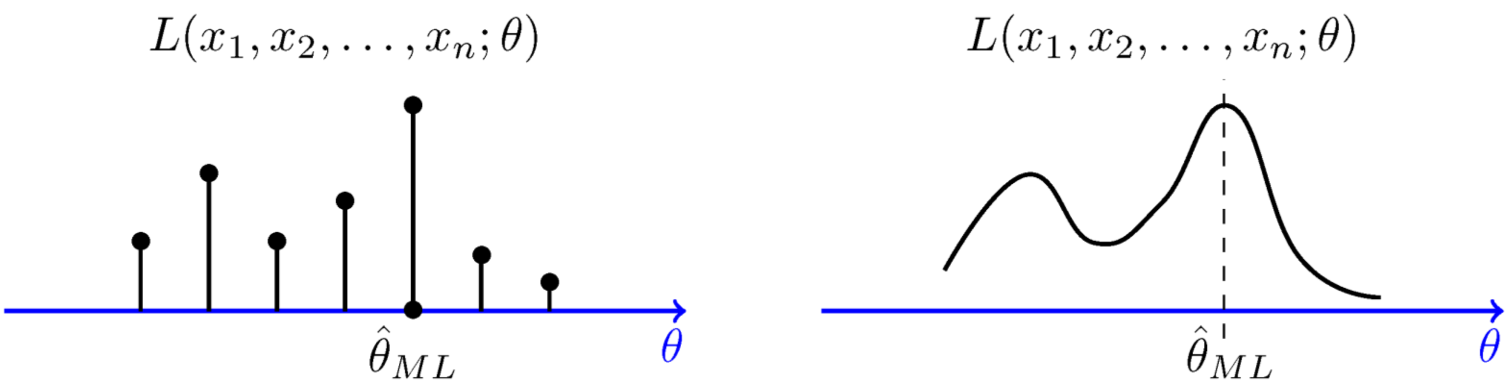
- (Statistical style) Maximum likelihood estimation (MLE)
  - MLE is same as Ordinary Least Square (OLS) under the GM assumptions

- Linear regression in a machine learning style

- Linear regression in the PyTorch way

Statistical Style versus Machine Learning Style

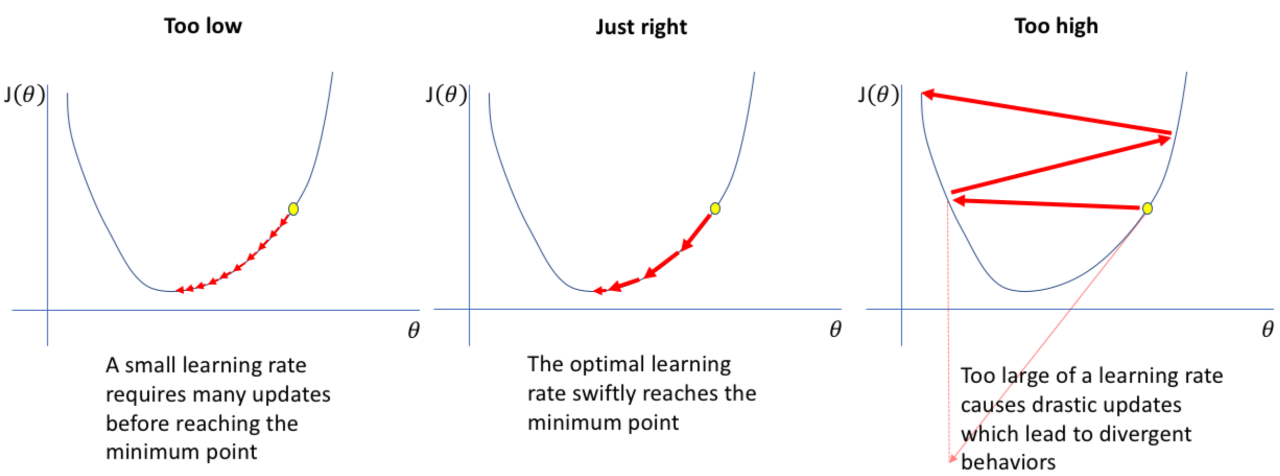
- (Statistical style) Maximum likelihood estimation (MLE)
  - Suppose that we have observed $X_1 = x_1, X_2 = x_2, X_3 = x_3, \ldots, X_n = x_n$. The maximum likelihood estimate of θ is the value that maximizes the likelihood function, $L(x_1, x_2, \ldots, x_n\ ;\ \theta)$



  - We need to the likelihood function. What if there are many variables and it has a complex functional form?

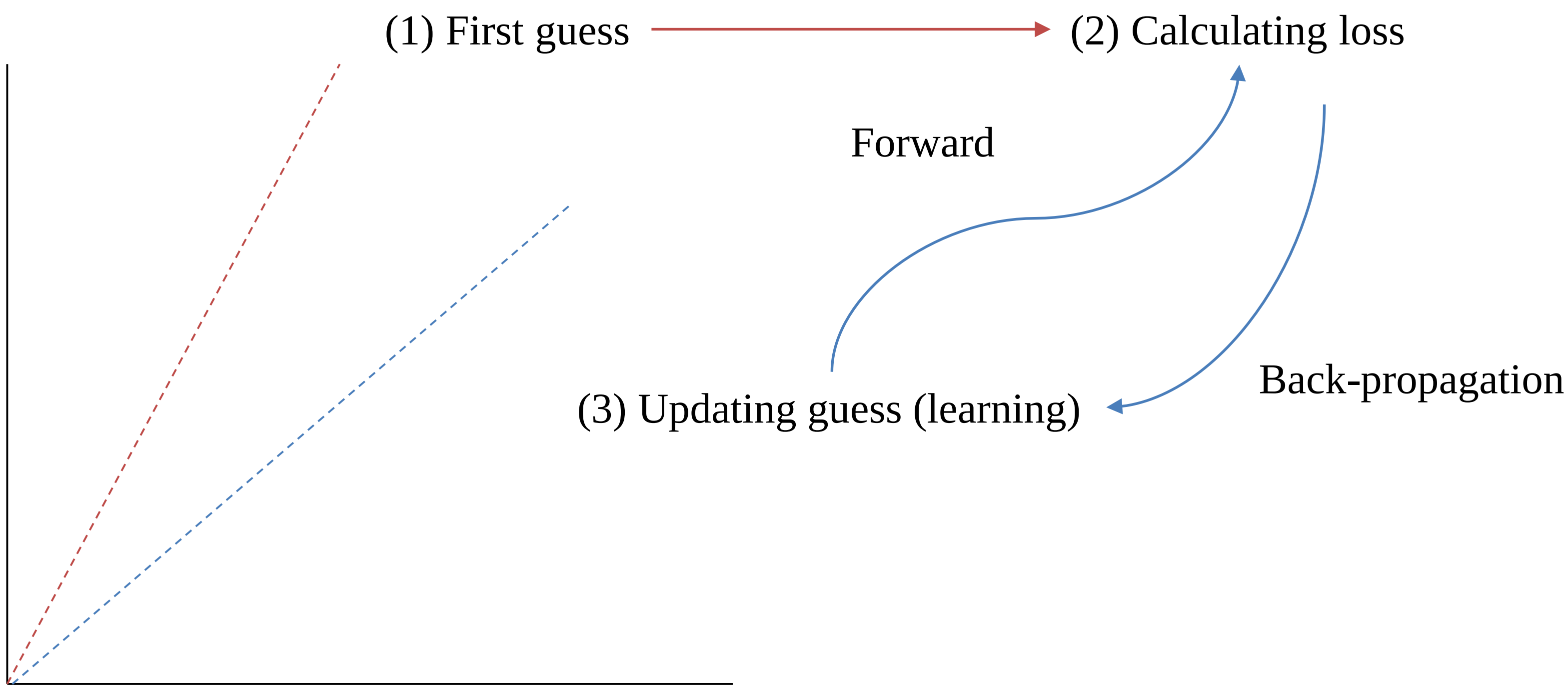
Statistical Style versus Machine Learning Style

- Machine learning is to gradually train the model to minimize a loss function
  - (1) Loss function → Mean squared error (MSE) for linear regression
  - (2) Optimization → Gradient descent for back-propagation
  - (3) Learning rate



Statistical Style versus Machine Learning Style

- Forward and back-propagation

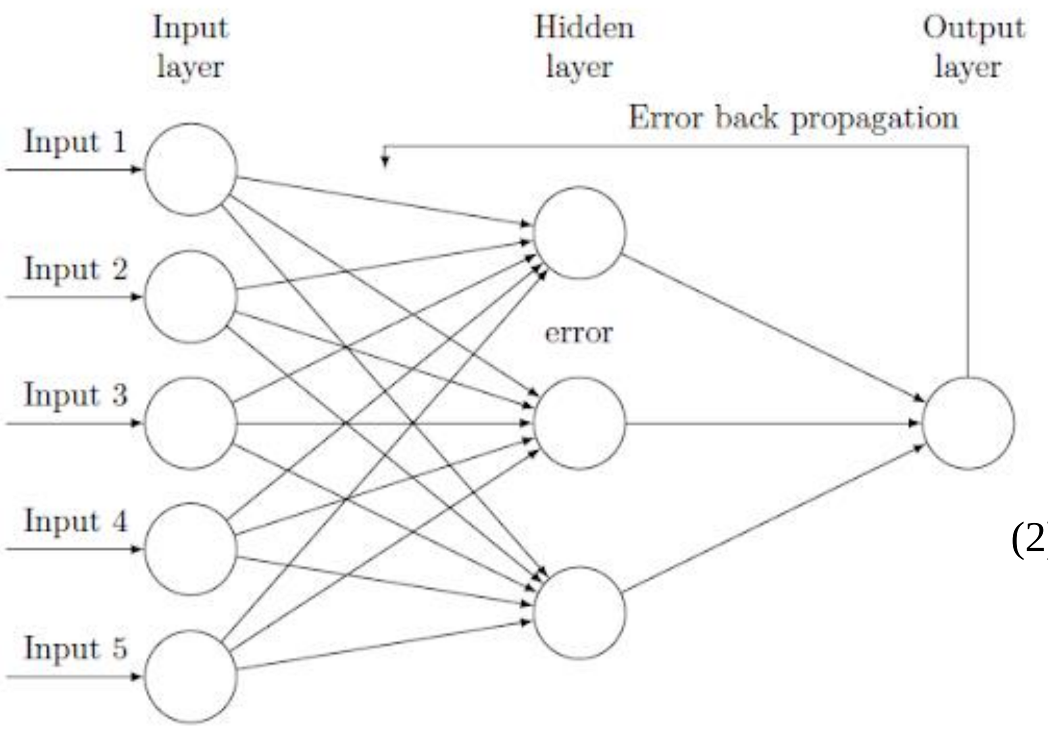


Statistical Style versus Machine Learning Style

- Forward and back-propagation in neural networks

Forward

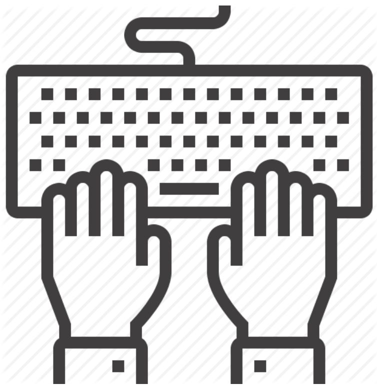
(1) First guess



(2) Calculating loss

Back-propagation

(3) Updating guess (learning)



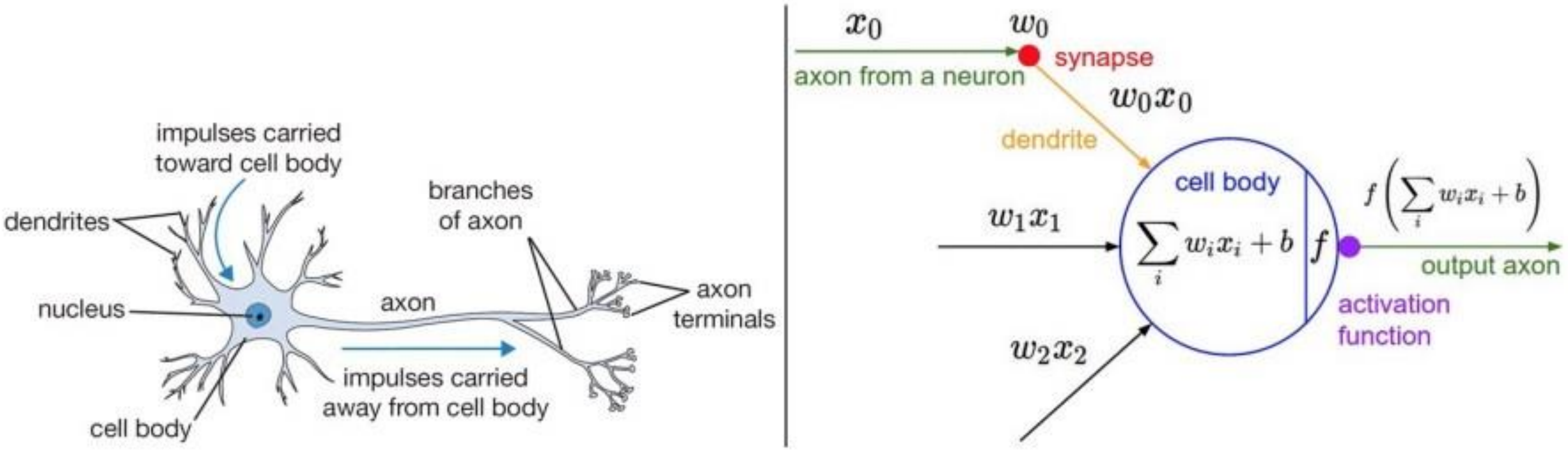
Linear Regression

M3.4 Linear Regression.ipynb

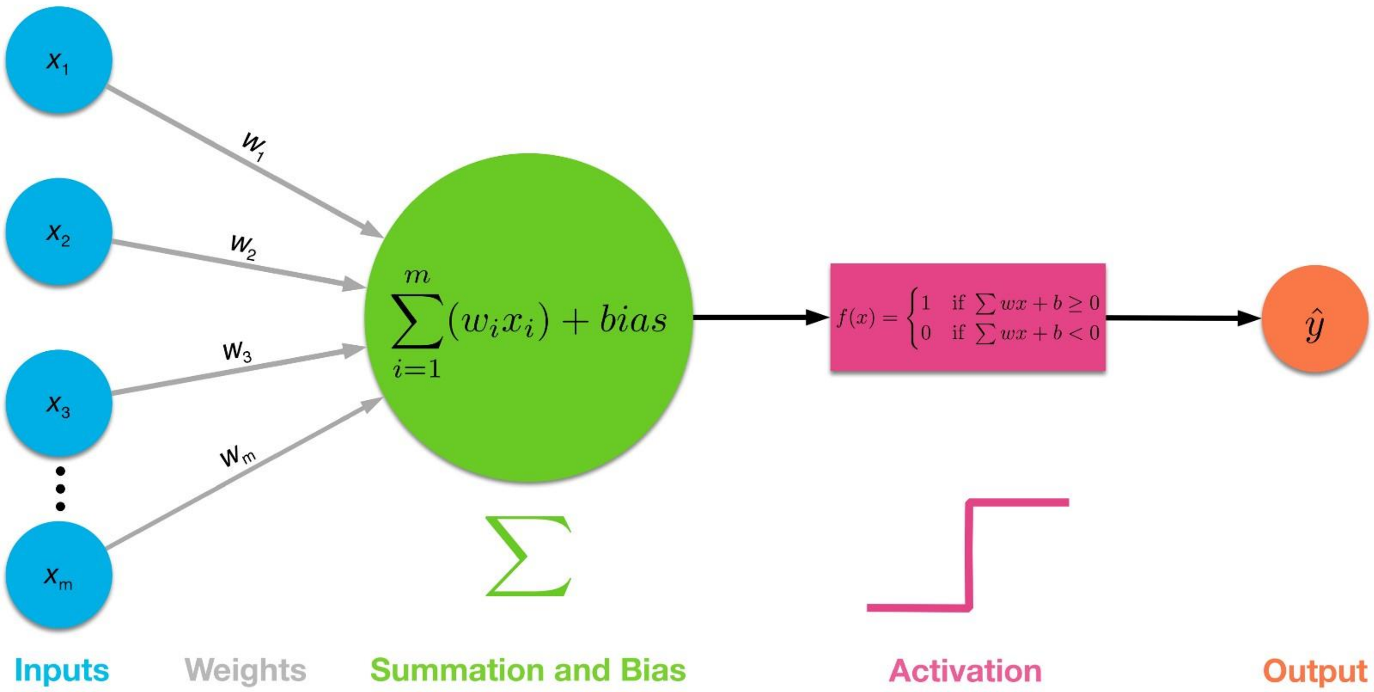
Neural Network

Neural Networks

- Artificial neural network mimics the human brain
  - ➢ Single neuron is activated (=1) or not (=0).



Linear Model + Activation = Neuron

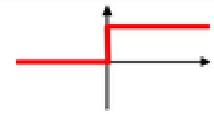
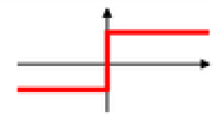
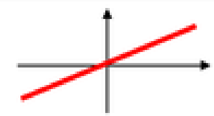
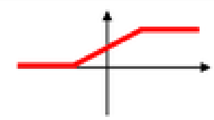
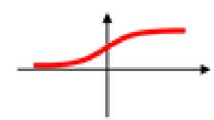
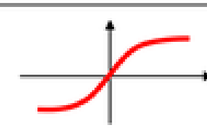


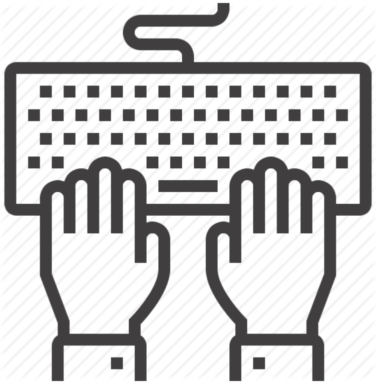
Linear Model

Activation Function

Linear Model + Activation = Neuron

- Activation function

Activation function	Equation	Example	1D Graph
Unit step (Heaviside)	$\phi(z) = \begin{cases} 0, & z < 0, \\ 0.5, & z = 0, \\ 1, & z > 0, \end{cases}$	Perceptron variant	
Sign (Signum)	$\phi(z) = \begin{cases} -1, & z < 0, \\ 0, & z = 0, \\ 1, & z > 0, \end{cases}$	Perceptron variant	
Linear	$\phi(z) = z$	Adaline, linear regression	
Piece-wise linear	$\phi(z) = \begin{cases} 1, & z \geq \frac{1}{2}, \\ z + \frac{1}{2}, & -\frac{1}{2} < z < \frac{1}{2}, \\ 0, & z \leq -\frac{1}{2}, \end{cases}$	Support vector machine	
Logistic (sigmoid)	$\phi(z) = \frac{1}{1 + e^{-z}}$	Logistic regression, Multi-layer NN	
Hyperbolic tangent	$\phi(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$	Multi-layer NN	

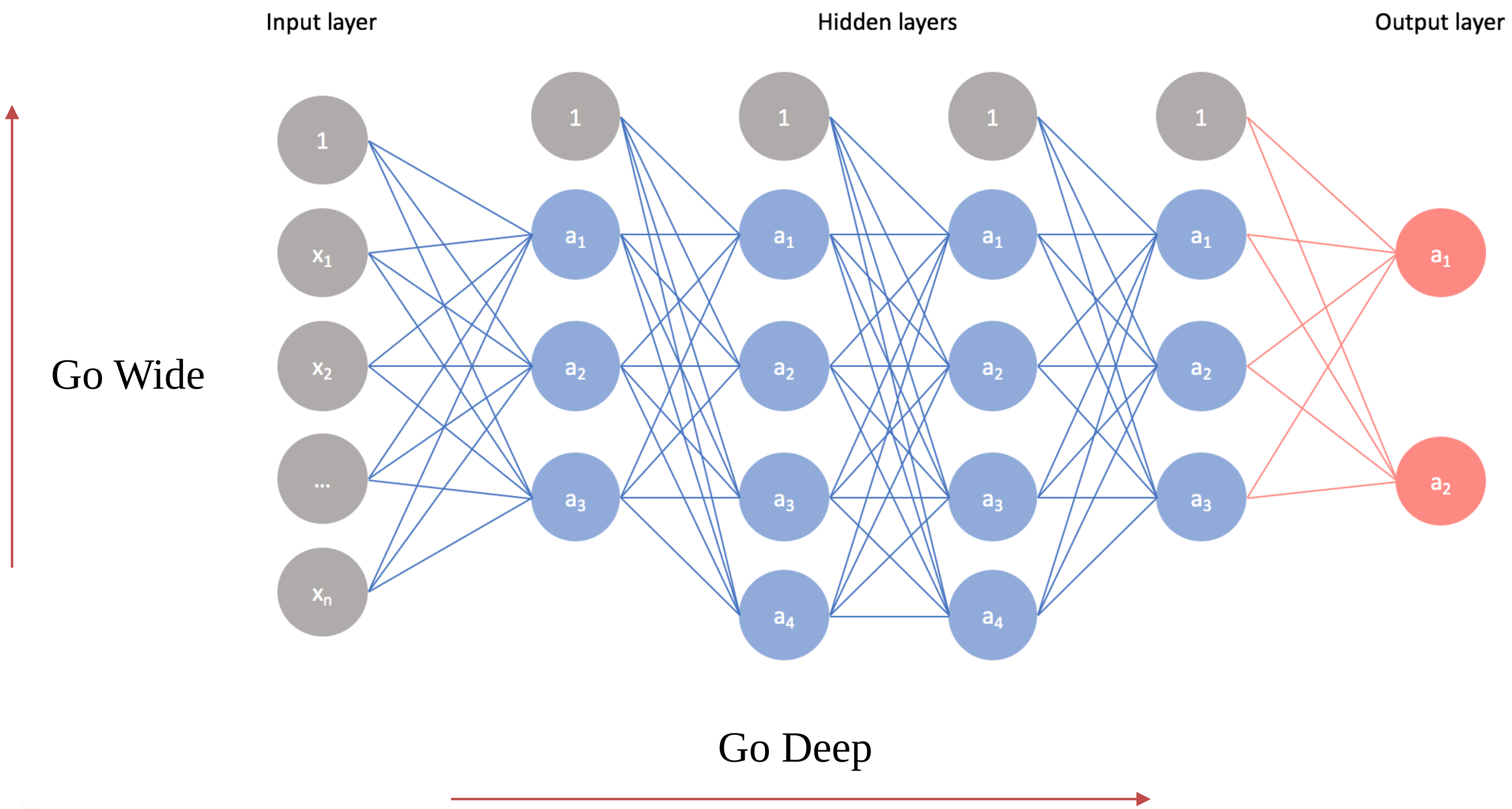


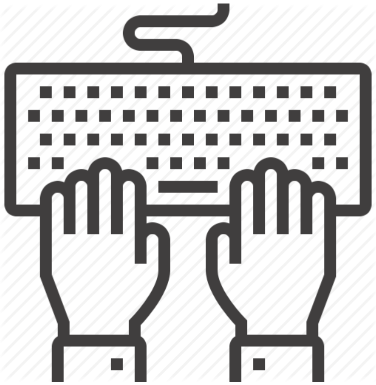
Neural Network

M3.4 Neural Network.ipynb

Go Wide & Go Deep

- Neural networks consist of multiple neurons at multiple layers



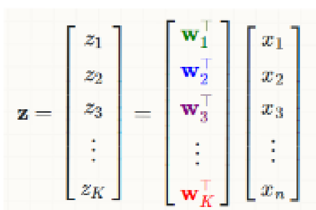


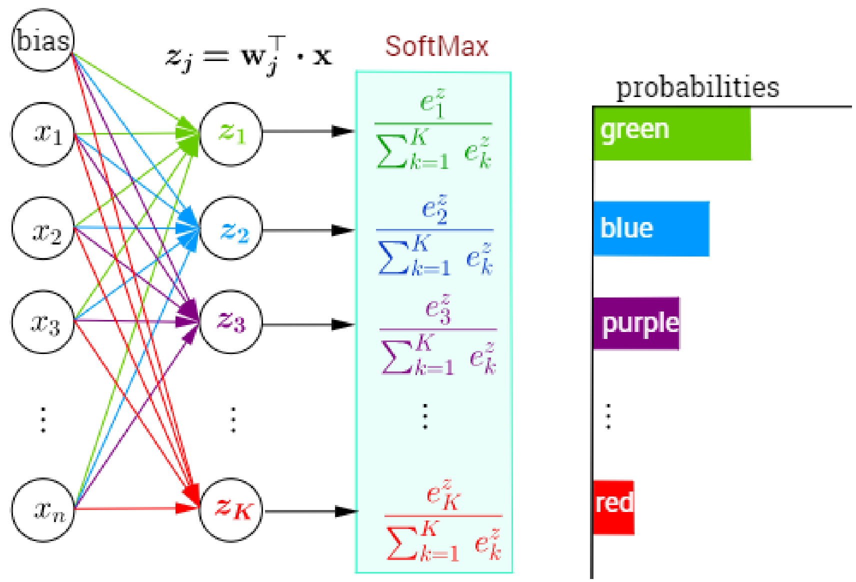
Neural Network

M3.4 Neural Network.ipynb

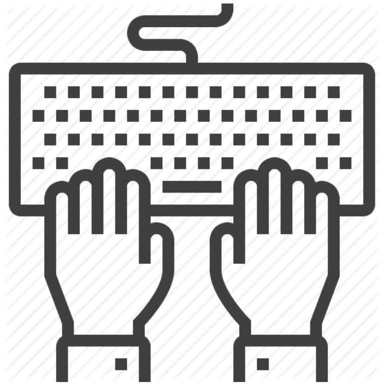
Multi-class Output

- Softmax function
  - ➢ $softmax\ (neuron\ j) = \frac{e^{z_j}}{\sum_K e^{z_k}}$





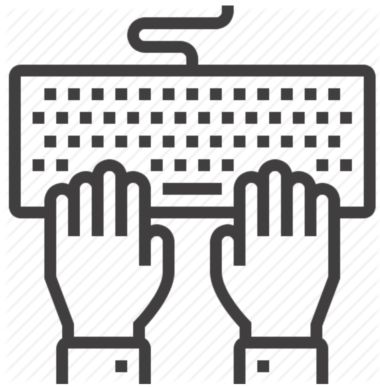
- Cross-entropy loss function for multi-class classification
  - ➢ Cross-entropy loss function = $-\sum_K \log\{softmax\ (neuron\ j)\}$



Neural Network

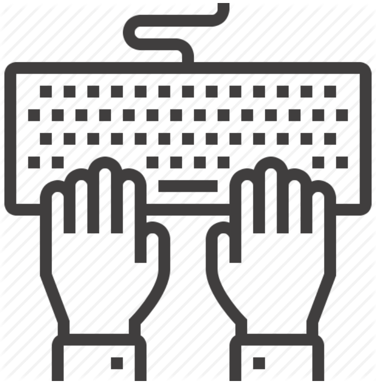
M3.4 Neural Network.ipynb

Projects for Neural Networks



MNIST Classifier using Neural Network

M3.4 Neural Network_MNIST.ipynb



CIFAR10 Classifier using Neural Network

M3.4 Neural Network_CIFAR10.ipynb

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