DEEP LEARNING
part II: neural networks

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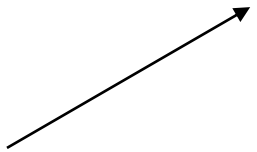
MS DATA SCIENCE 2020-2021

About tensors

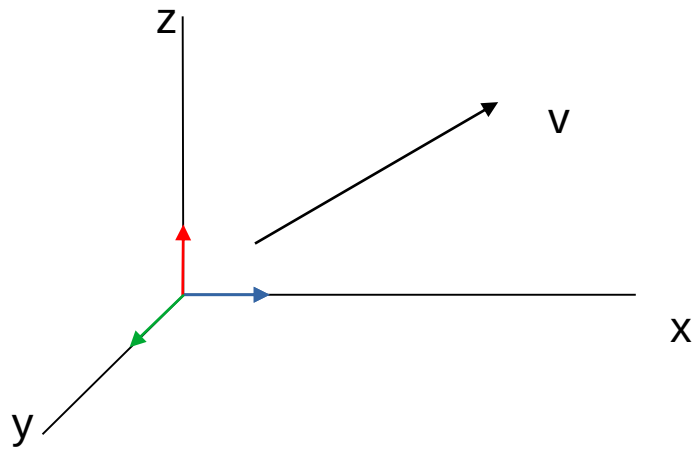
- Vector



  - Usually, an **arrow**
  - Something with a **magnitude** and a **direction**
  - Representing “stuff”
    - Velocity, Force, Area, ...

About tensors

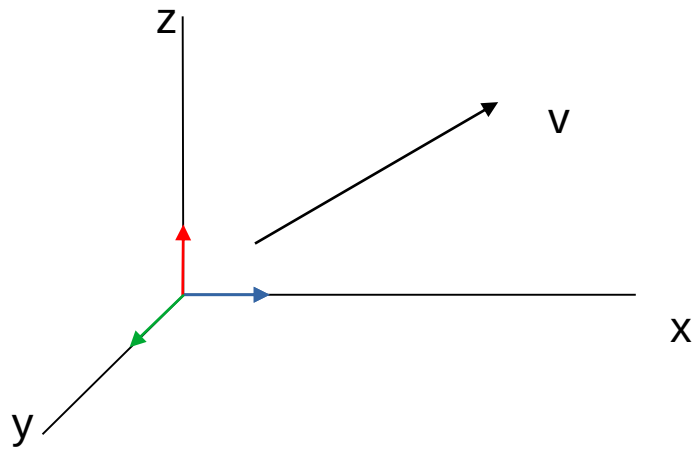
- Vector
- Unit-vector



  - i, j, k
  - length = 1
  - v = a*i + b*j + c*k

About tensors

- Vector
- Unit-vector
- Component



– v = (a, b, c)

$$\left|\begin{matrix} a \\ b \\ c \end{matrix}\right| \longleftarrow$$

This is a **rank-1 tensor**

tensors

- Generalization of vectors
- Rank is related to the number of “simultaneous” directions
- In a N-dimensional space:

0	scalar
1	vector
2	NxN matrix
>=3	tensor

tensors in pytorch

- np.ndarray
- on steroids
- GPUs love tensors
- can convert to/from numpy

about activation functions

- step
- sigmoid
- tanh
- ReLU
- → depends on the data!
- see notebook

about neural networks

- perceptron
- Feed-forward NN
- Multilayer perceptron
- CNN
- RNN
- …

why layers?

- Layer == collection of neurons
- Each layer has its purpose
- Learning is done with the layers

- **ALL NEURONS IN ALL LAYERS WORK IN THE EXACT SAME WAY**
  - **Calculate sum of weighted inputs + bias**
  - **Calculate the result of the activation function**

how many neurons?

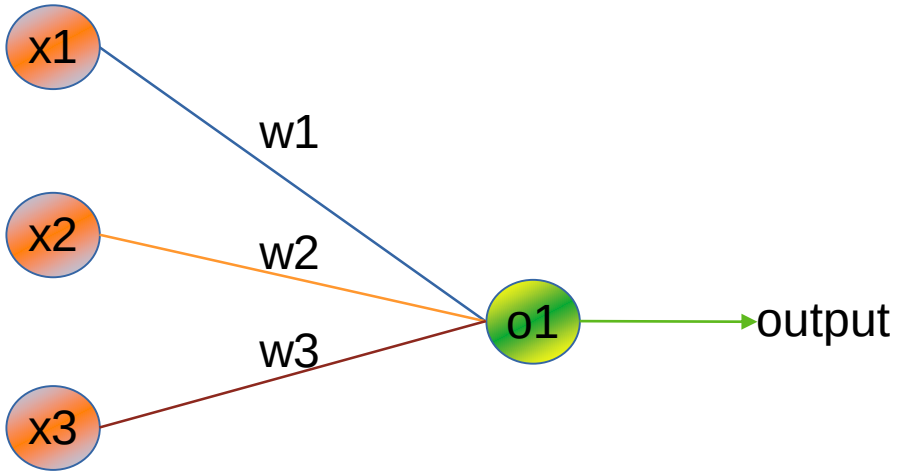
- Input layer
  - Number of features + 1 (for bias)
- Output layer
  - 1
  - 1
  - N
- Hidden layer
  - # samples / factor * (input + output)
  - Empirical
  - Factor in (1,10) to avoid overfitting

how many layers?

- Input layer
  - 1(of course)
- Output layer
  - 1 (of course)
- Hidden layer
  - 1 (universal approximation theorem)

- Not so deep…
  - 0 layer -> linearly separable functions
  - 1 layer -> any continuous function
  - 2 layers -> arbitrary decision boundaries
  - >2 layers -> complex representations, automatic feature engineering

perceptron

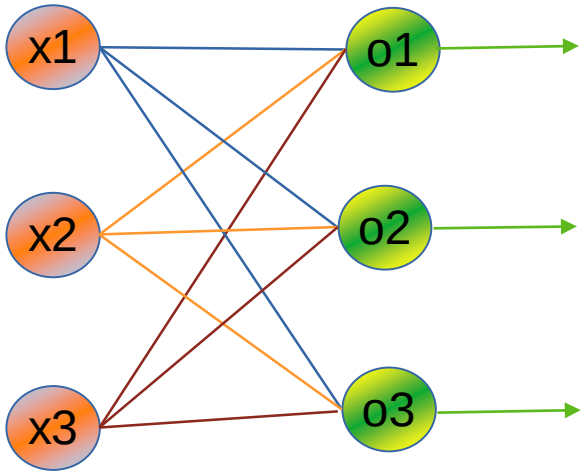


Perceptron
. binary classifier

+ can implement logic gates

- XOR does not work

Feed-Forward NN

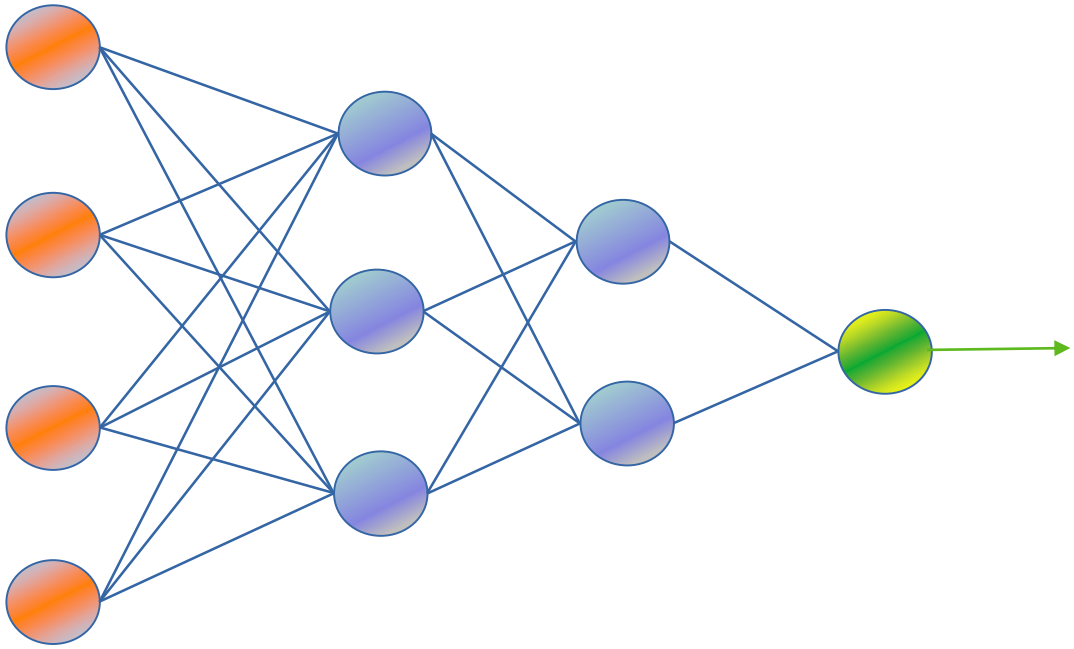


Basic Neural Network
. classification
. computer vision

+ w/wout hidden layers
+ no backpropagation
+ easy to design
+ highly responsive to noisy data
+ number of layers ~ complexity of func

- static weights
- no deep learning

Multi-layer perceptron

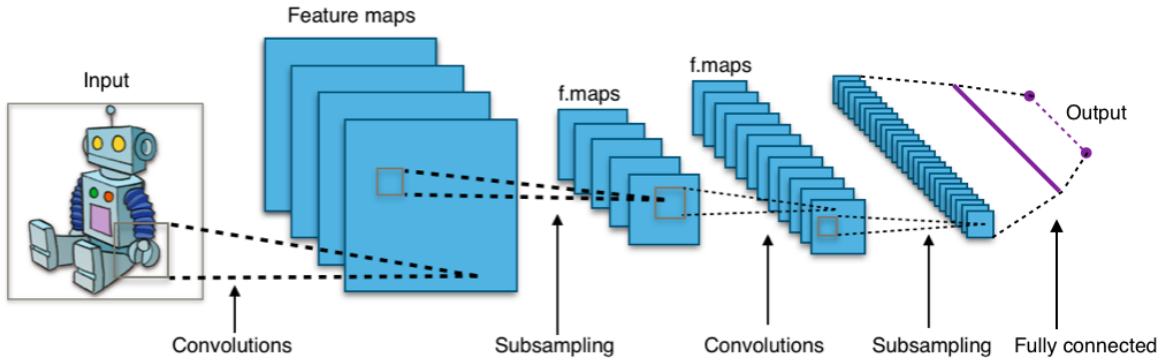


Standard Neural Network
. speech recognition
. complex classification

+ hidden layers
+ backpropagation
+ deep learning

- difficult to design
- dynamic weights

Convolutional NN



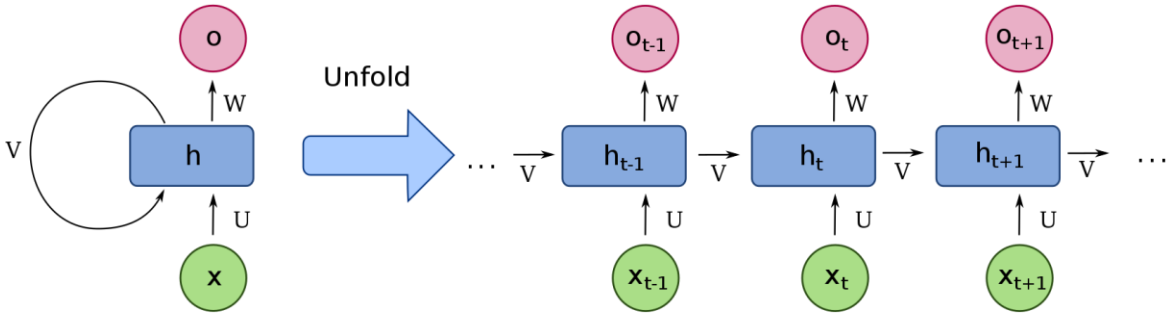
source: wikipedia

CNN

. image classification

+ 3D arrangements of neurons
+ learn image by part
+ FF-only if more convolutional layers
+ FF + BP if outputs to fully connected
+ fewer parameters than fully connected

Recurrent NN



source: wikipedia

RNN

. speech recognition
. text to speech
. sentiment analysis

\+ save the output of a layer
\+ model sequential data

\- gradient vanishing

about frameworks

- pytorch
  - Low level API
  - Fine tuning
  - Focus: Broader machine learning
- Tensorflow
  - Low/High level API
  - Focus: Machine learning
- Keras
  - High level API
  - Works on Tensorflow, Theano, etc..
  - Focus: Deep Neural Networks

- We’re gonna use pytorch (and a bit of Keras)

about frameworks

- pip install torch torchvision
- pip install –upgrade tensorflow
- pip install keras

- Use a virtual-environment if you do not want to mess up too badly. Your choice.
  - Python3-venv
  - Conda
  - …

- Or google colab (I’ll be using this one)