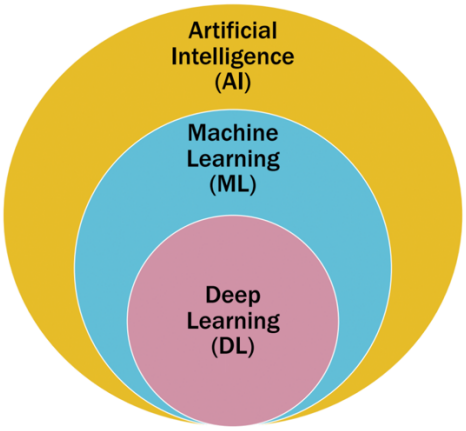
BMEG3105: Data Analytics for Personalized Genomics and Precision Medicine Fall 2023
Lecture 20 - Deep learning (Protein-RNA)
November 10 (week 10)
Lecturer: Professor Yu Li

Outline of lecture 20:

- Artificial intelligence VS Machine Learning VS Deep Learning
- Deep learning and biomedical imaging
    - Convolutional layer
- More discussion of convolutional layer

Artificial intelligence VS Machine Learning VS Deep Learning



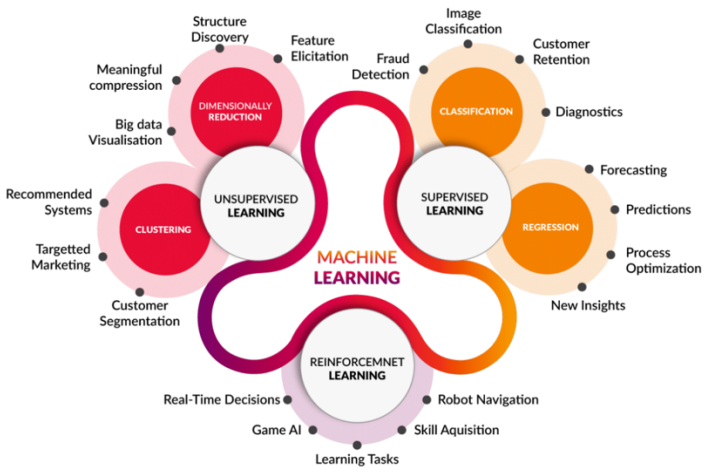
- Artificial Intelligence:
  Any technique can mimic human behavior.
- Machine Learning:
  A subset of AI, the model is trained and based on past data. Then the model can extract the pattern and make predictions from the data.
- Deep Learning:

  Constructed with Neural Network.

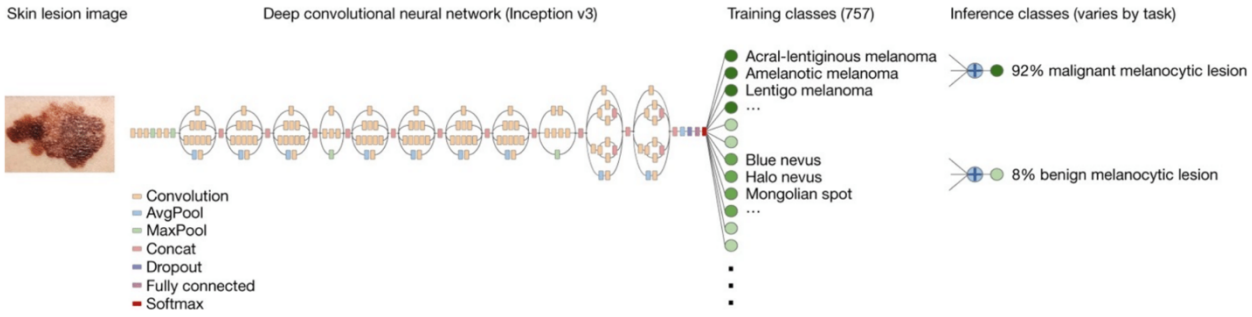
Types of Machine Learning

- Supervised Learning
  The model is trained by labelled dataset so the prediction of model will be 'supervised'. Accuracy of the model can be measured by comparing labelled input and output.
- Unsupervised learning
  Model is trained by unlabeled dataset and the model aims to cluster and extract patterns from the dataset.

- Reinforcement learning
  Model is based on rewarding desired behaviors and/or punishing undesired prediction.



Build models of real-life healthcare problems



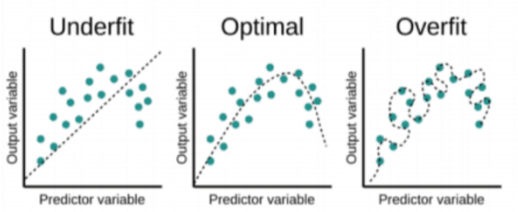
Example of calculation of parameters in binary classification

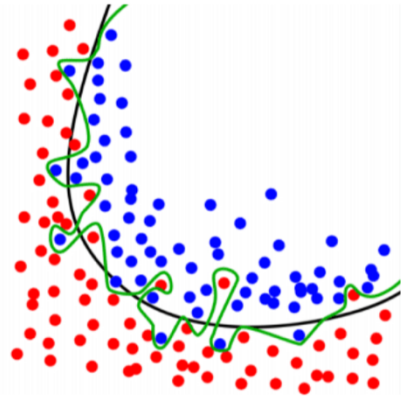
- Image (256*256*3), 3 layers for binary classification, internal layer has 1000 nodes

  Parameter: (256*256*3+1)*1000+(1000+1)*1= 196,610,001→We can have a super complex model.

Potential Issue for complicated models

- Overfitting: fit the noise of the training data
- Optimal
- Underfit: have a simple function and cannot fit the complex training data





The problem of fully-connected networks

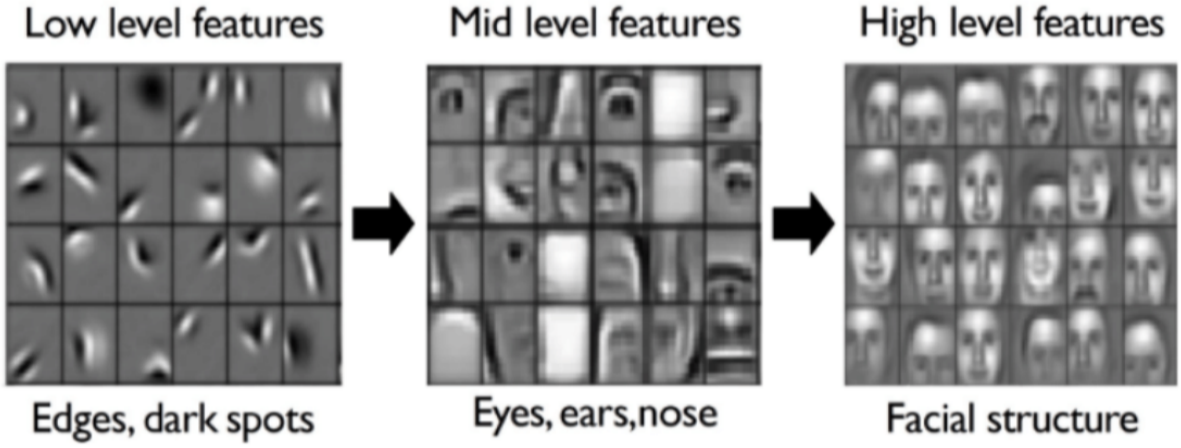
- How to determine the number of nodes and layers? (As many as possible)
- Storage
- Running time (Embedded systems)
- Hard to train
- Prior knowledge is ignored
- Overfitting

Properties of object in the image

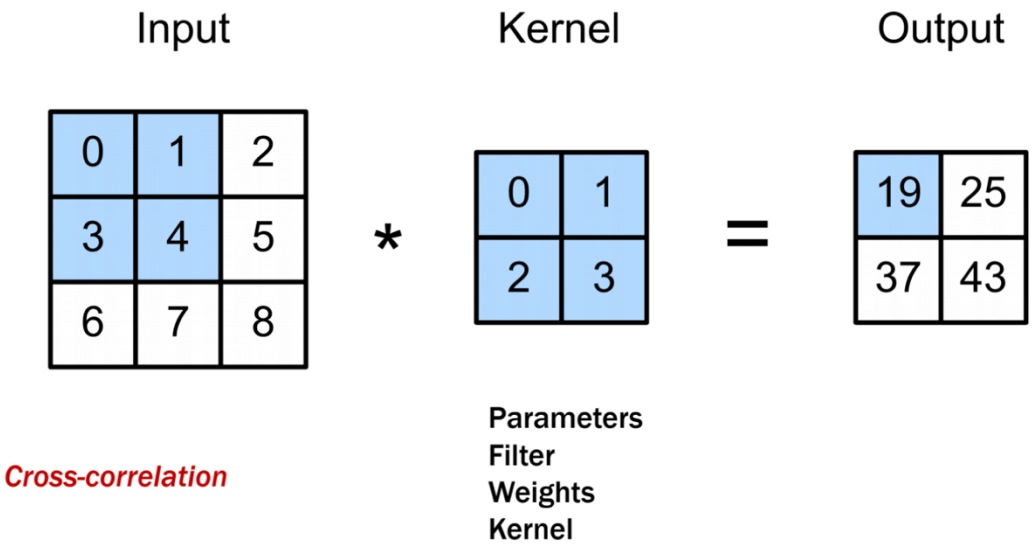
- Translation invariance (Capture the patch information)
- Locality (Focus on the local regions, should be aggregated later on)

Structure of CNN

- Conv layer 1: Low-level features → (Extract edges, dark spots)
- Conv layer 2: Mid-Level features → (More detailed, show the eyes, ears, nose)
- Conv layer 3: High-level features → (Facial structure)



Mechanism and Calculation of CNN



Steps:

1. Input the image data
2. Apply the n x n filter to extract the feature from the image
3. Sum up the product and export the output to another layer

Advantage of CNN

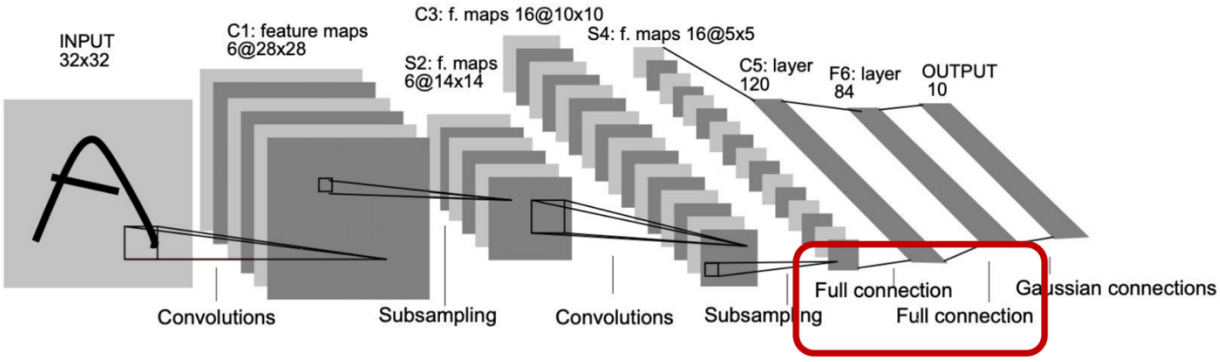
Share parameters:

1. Alleviate the overfitting issue
2. Detect spatial features
3. Locality

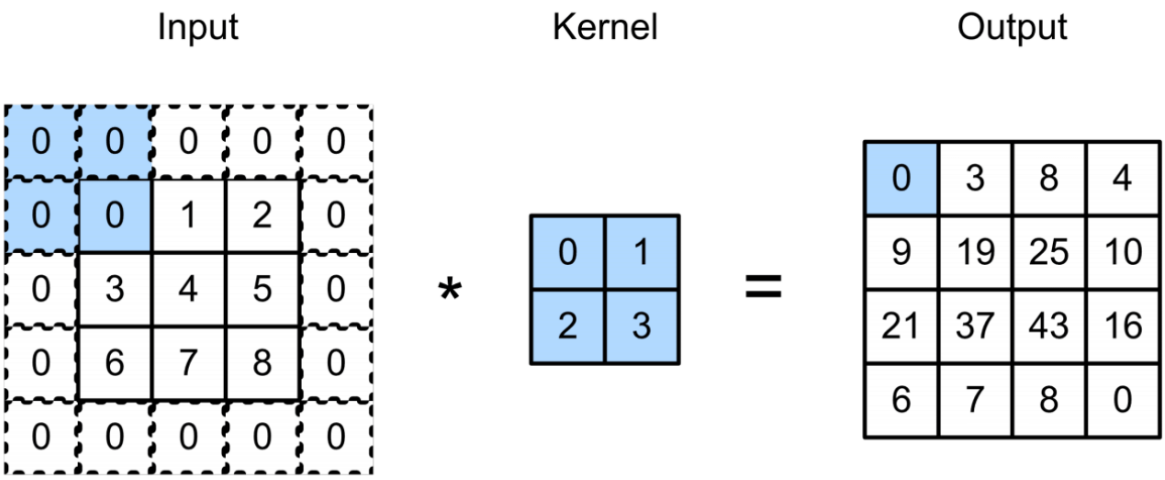
Number of parameters (depend on the properties of the images)

- 2D (grey in color) or 3D (RGB)
- If the size of the filter is 3x3, and the output is 6 feature maps. [2D]
  There are (3 x 3 + 1) x 6 = 60 parameters.
- If the size of the filter is 3x3, and the output is 6 feature maps. [3D]
  There are (3 x 3 x 3 + 1) x 6 = 168 parameters.

Flatten layer

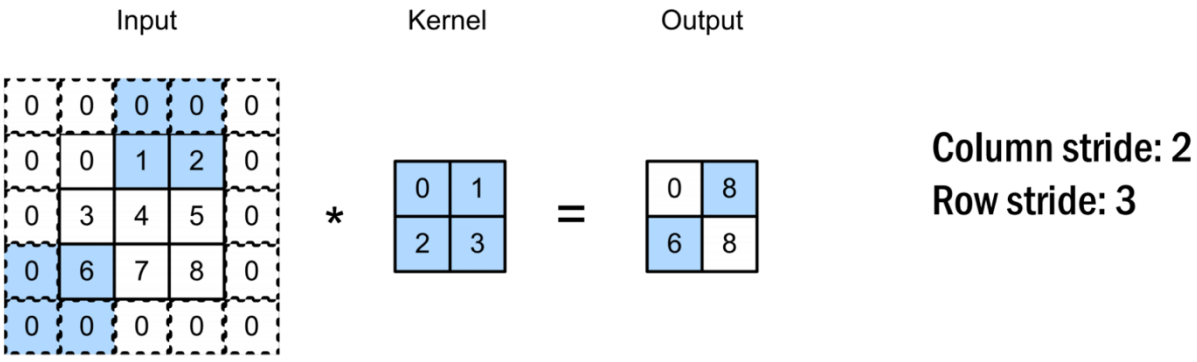


Padding



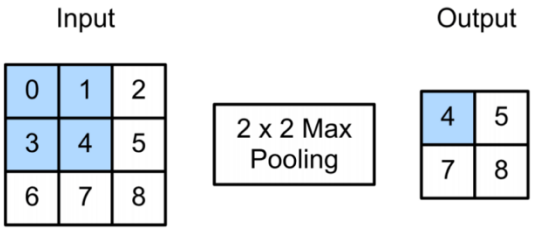
If the kernal size is 3 by 3, the output dimension is the same as the input

Stride



Column stride: 2
Row stride: 3

Pooling



Max pooling
Average pooling

Also combined with padding and stride

Conclusion (Summary)

1. Difference between AI, Machine Learning and Deep Learning
2. Function, mechanism and structure of Convolution Neural Network (CNN)
3. Discussion of convolutional layer (Flatten layer, Padding, Stride, Pooling)