BMEG 3105: Data Analytics for Personalized Genomics and Precision Medicine

Lecture 21 – Deep learning & Biomedical imaging

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Contents

1. Review last lecture

-Challenges in single-cell data analytics
    Noise
    Doublet
    Dropout
    Batch effect
-Visualize gene expression data in 2D
    High dimension to 2D
-The process of t-SNE
-Protein binding preference

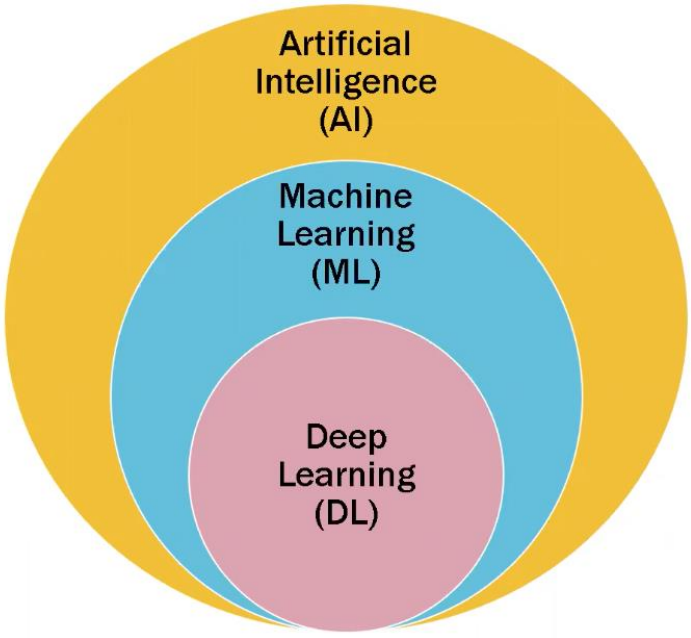
2. Artificial intelligence VS Machine learning VS Deep learning

-Health data

Diagnosing based on the symptom and lab tests
Curing the disease based on the diagnosing results and the patient's situation
Without the data, doctors cannot diagnose precisely
AI + Health data: AI-assisted disease diagnosing and curing

-AI vs ML vs DL

Artificial Intelligence (AI):
    Any techniques which enable computers to mimic human behavior
Machine Learning (ML):
    A subset of AI, which effectively perform a specific task without using explicit instructions, relying on patterns and inference from the data
Deep Learning (DL):
    A subset algorithm of ML, which takes advantage of multi-layer neural networks



-Machine learning tasks

-Unsupervised learning:

-Dimensionally reduction;

-Clustering.

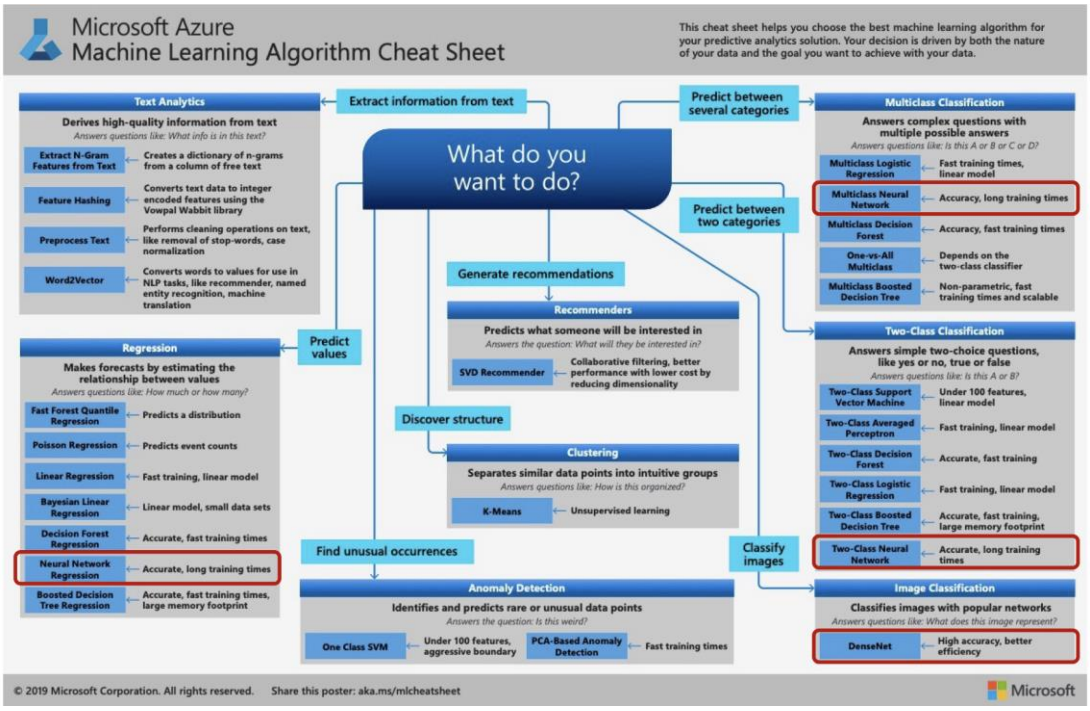
-Supervised learning:

-Classification;

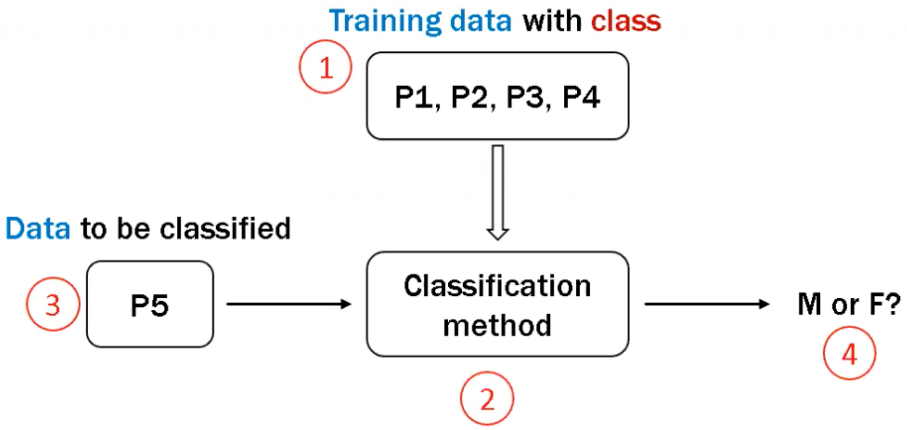
-Regression.

-Reinforcement learning.

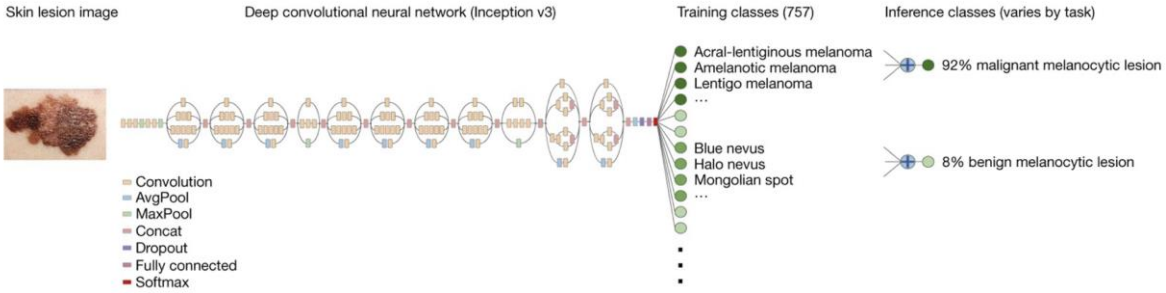
-Machine learning algorithms



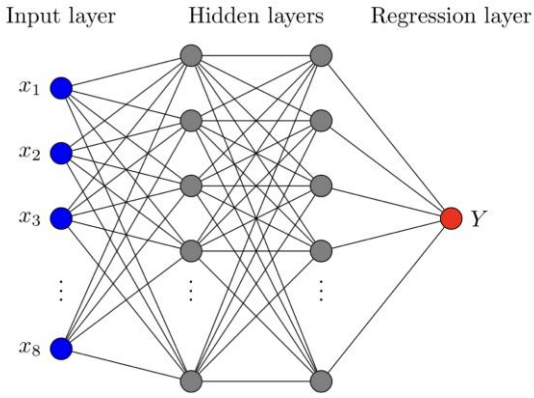
3. Deep learning and biomedical imaging



-Build models for real-life healthcare problems



-Fully-connected networks



❖ **To resolve complicated problems**
- ➢ Increase the number of nodes
- ➢ Increase the number of layers
- ➢ Add non-linear function

❖ **Fully-connected layers**
- ➢ A general function approximator
- ➢ We can approximate any function (relation) if we have enough nodes and layers
- ➢ Universal approximation theorem

-The problem of fully-connected networks:
- -How to determine the number of nodes and layers
- -Storage
- -Running time
- -Hard to train
- -Prior knowledge is ignored
- -Overfitting

-Image

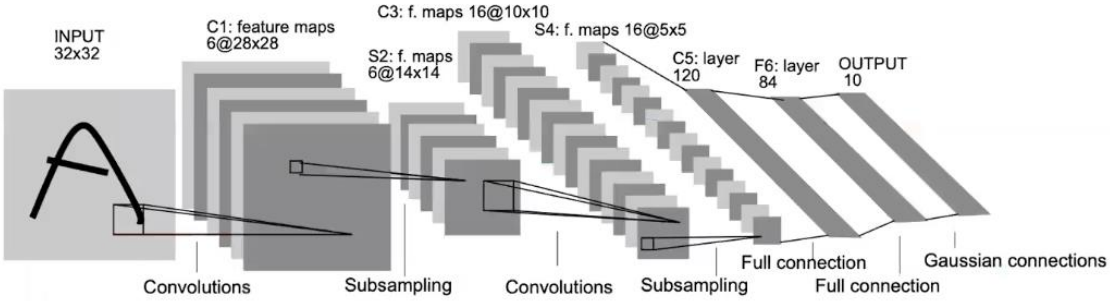
Images are different from data matrix----there is spatial information in the image----we should design models based on that.

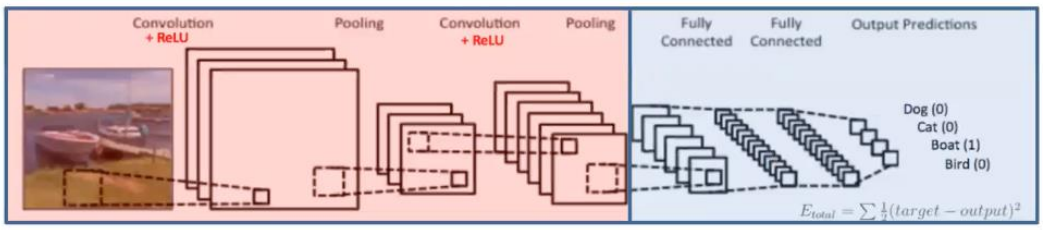
-Properties of objects in the images

-Translation invariance: Capture the patch information, no matter where it is.

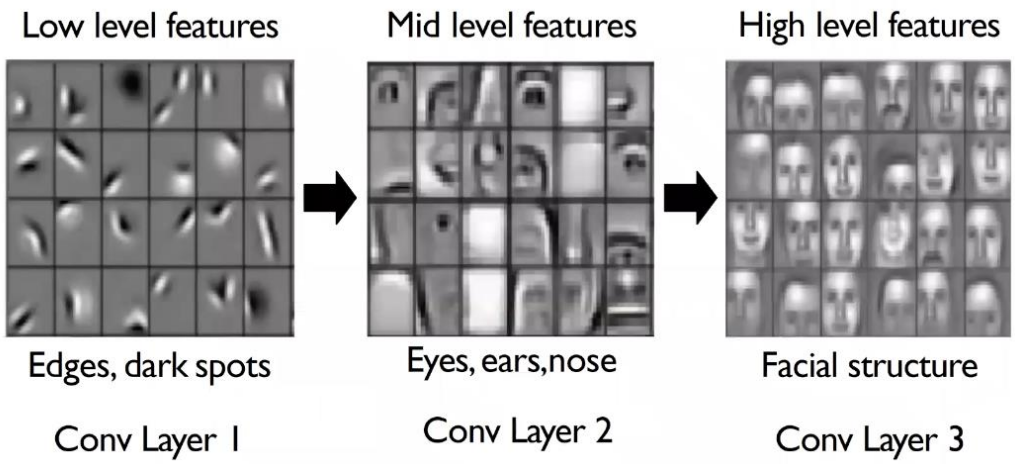
-Locality: Focus on the local regions first; should be aggregated later on.

-Convolutional layers



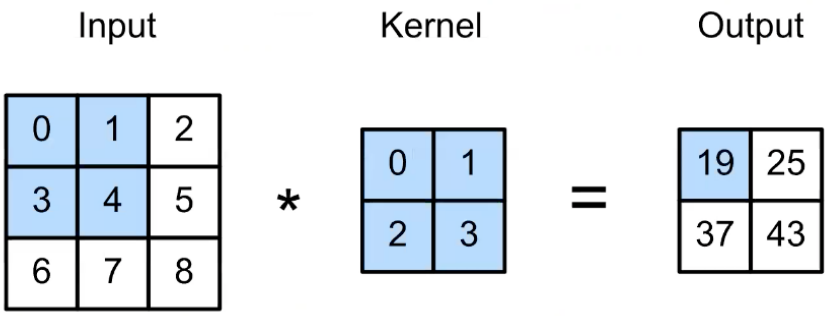


Hierarchical representation learning feature extraction---->
Fully-connected neural networks classification



Things we can get from CNN: spatial pattern

-Convolution operation

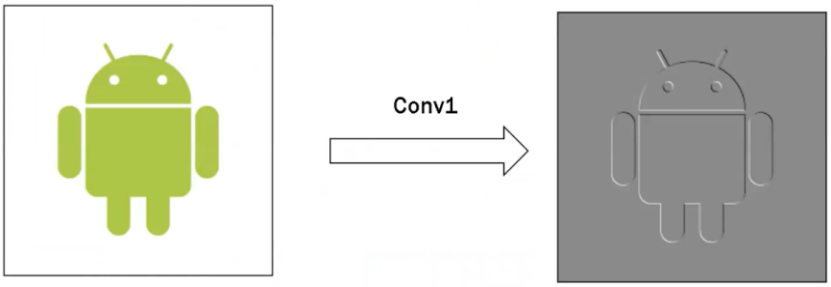


19 = 0*0 + 1*1 + 2*3 + 3*4
25 = 0*1 + 1*2 + 2*4 + 3*5
37 = 0*3 + 1*4 + 2*6 + 3*7
43 = 0*4 + 1*5 + 2*7 + 3*8

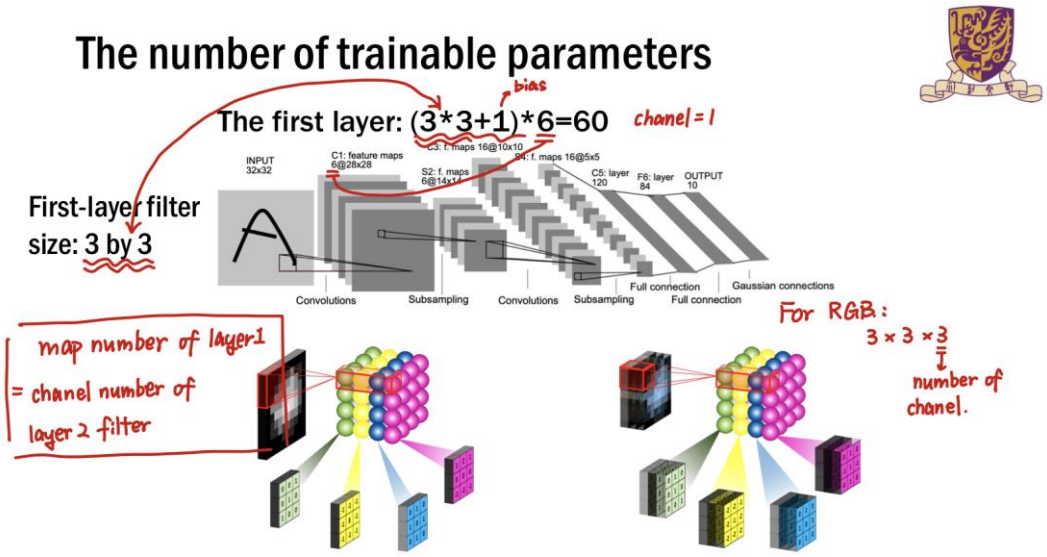
How to do convolution:

Share parameters—Alleviate the overfitting issue; detect translation invariant features; locality.

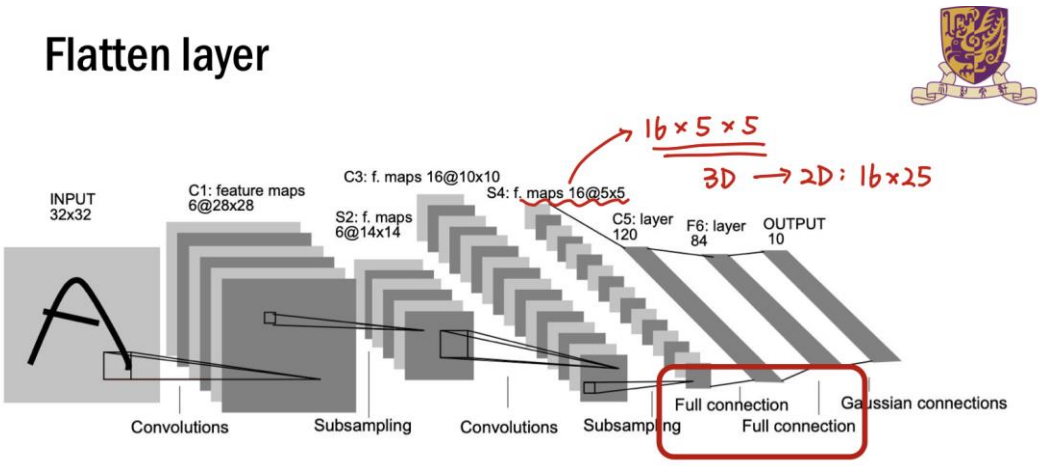
Output:



-The number of trainable parameters



-Flatten layer



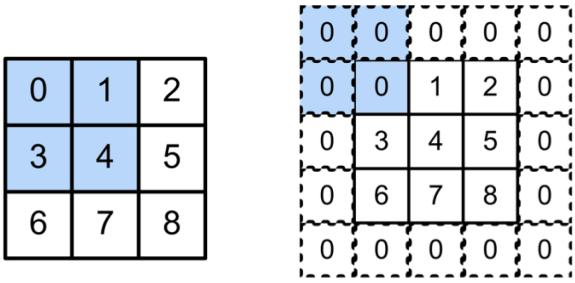
4. More discussion of convolutional layer

-Filter size

Usually 3 by 3 or 5 by 5

-How to deal with boundary

Padding: add zeros

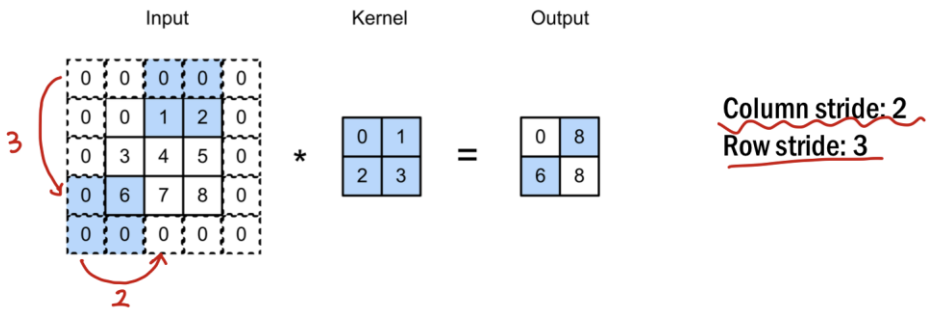


The output dimension is the same as the input if:

-Kernel: 3 by 3, padding: 1 for each edge

-Kernel: 5 by 5, padding: 2 for each edge

-Stride



-Pooling

Max pooling; average pooling.

(Also combined with padding and stride)