DASIL Python Workshop # 4

October 13th 2022

Introduction to Machine Learning Part #3

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Intro to Machine Learning Part #3

AGENDA

Other Types of Neural Networks

Model Evaluation

Unsupervised Learning Basics

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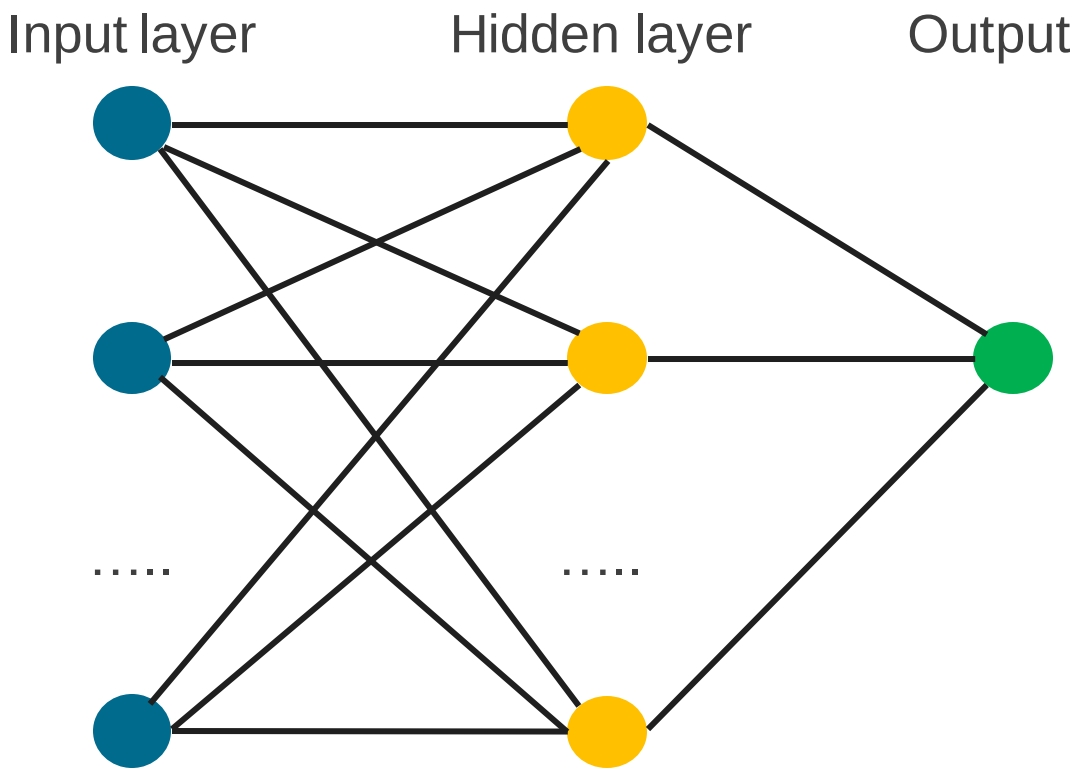
Other Neural Networks

- Recall: Artificial Neural Network



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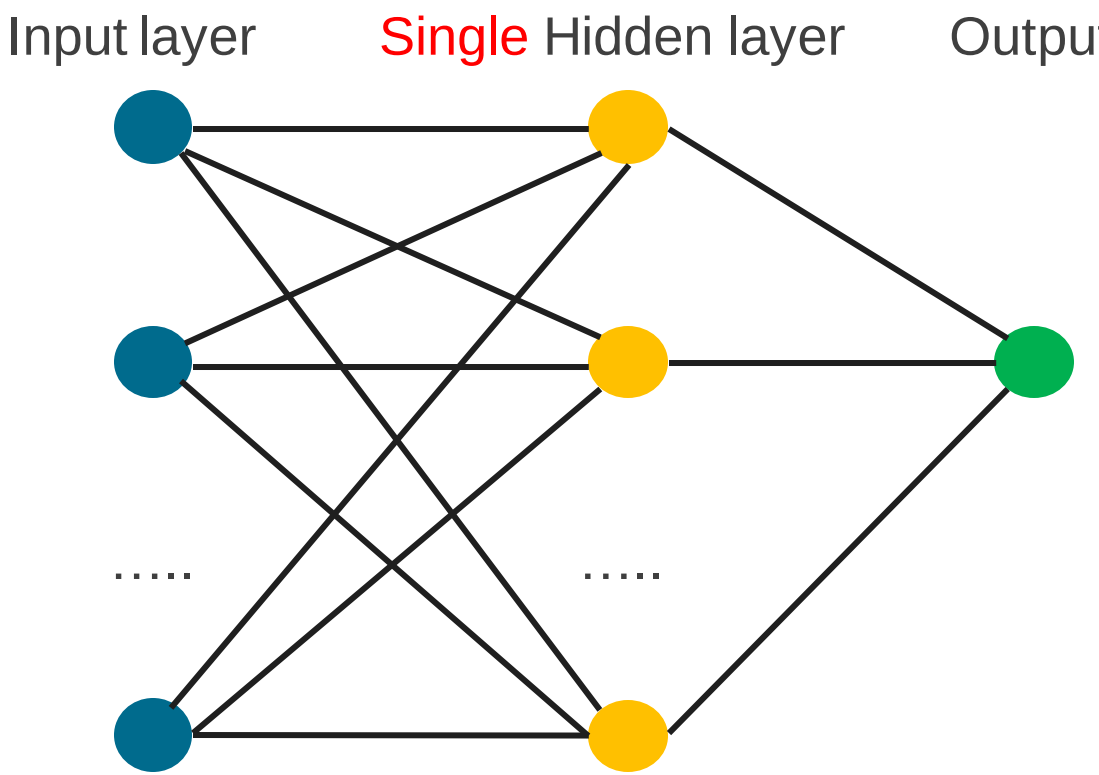
Other Neural Networks

- Shallow Neural Network



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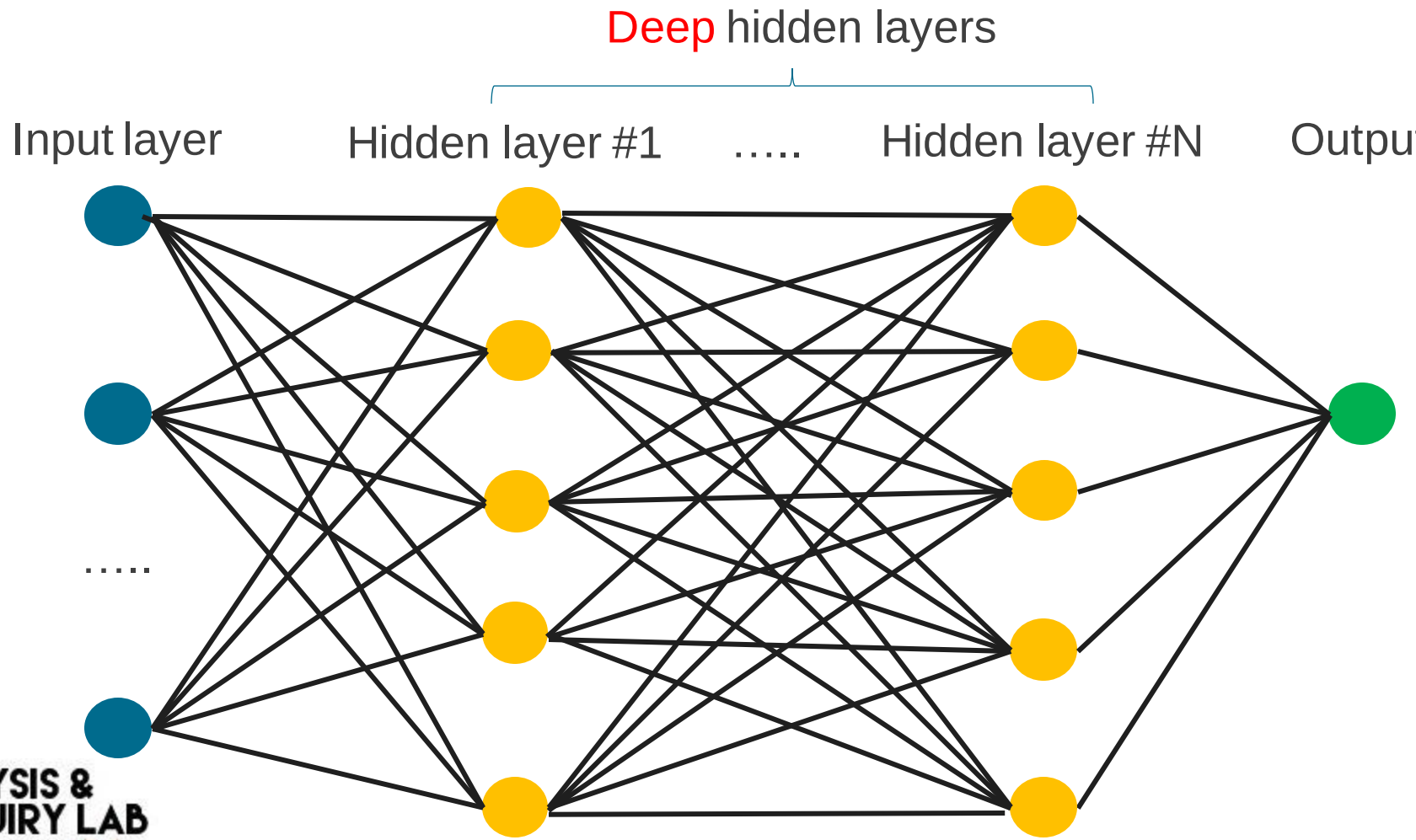
Other Neural Networks

- Deep Neural Network



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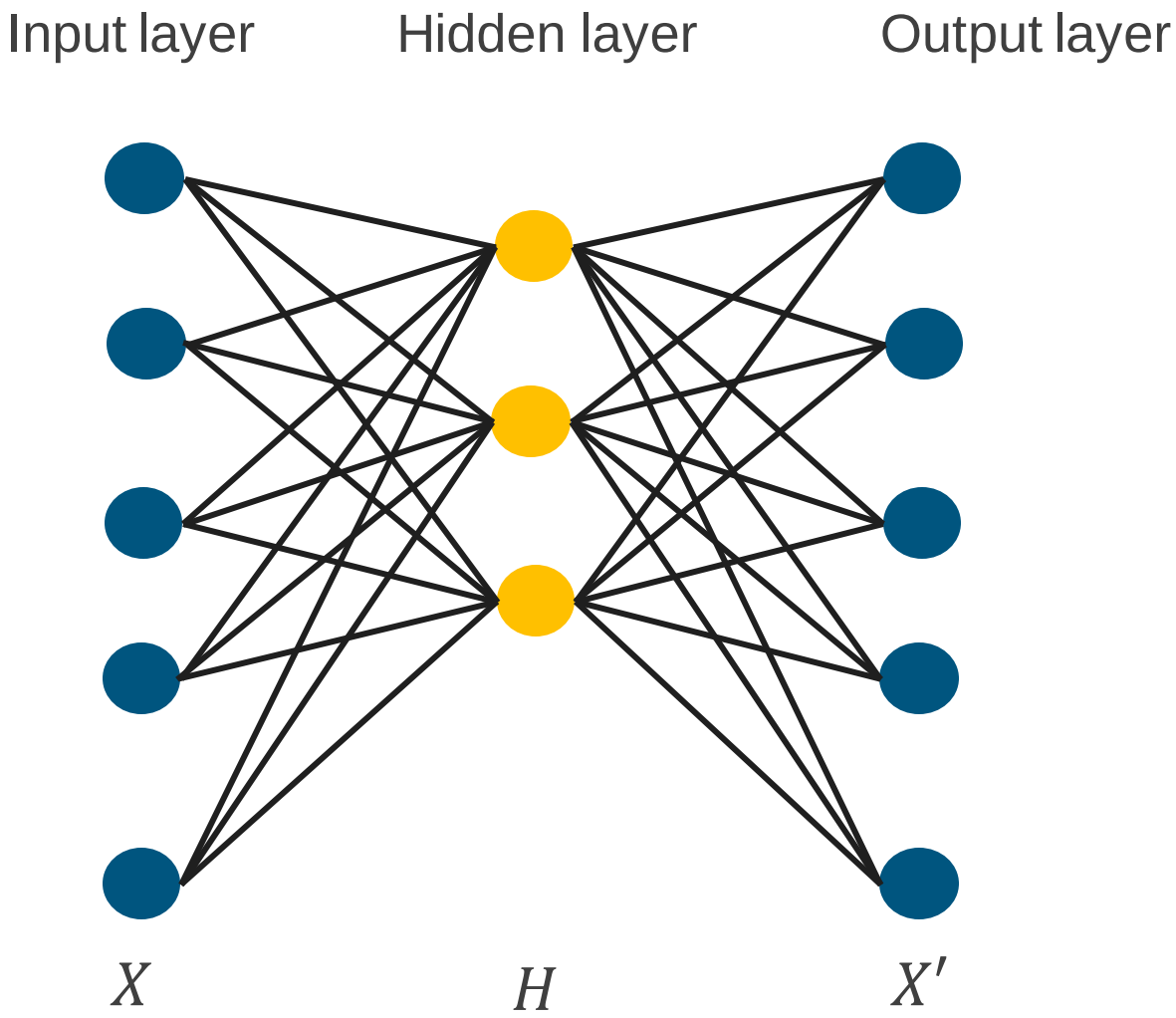
Other Neural Networks

- Auto-Encoder



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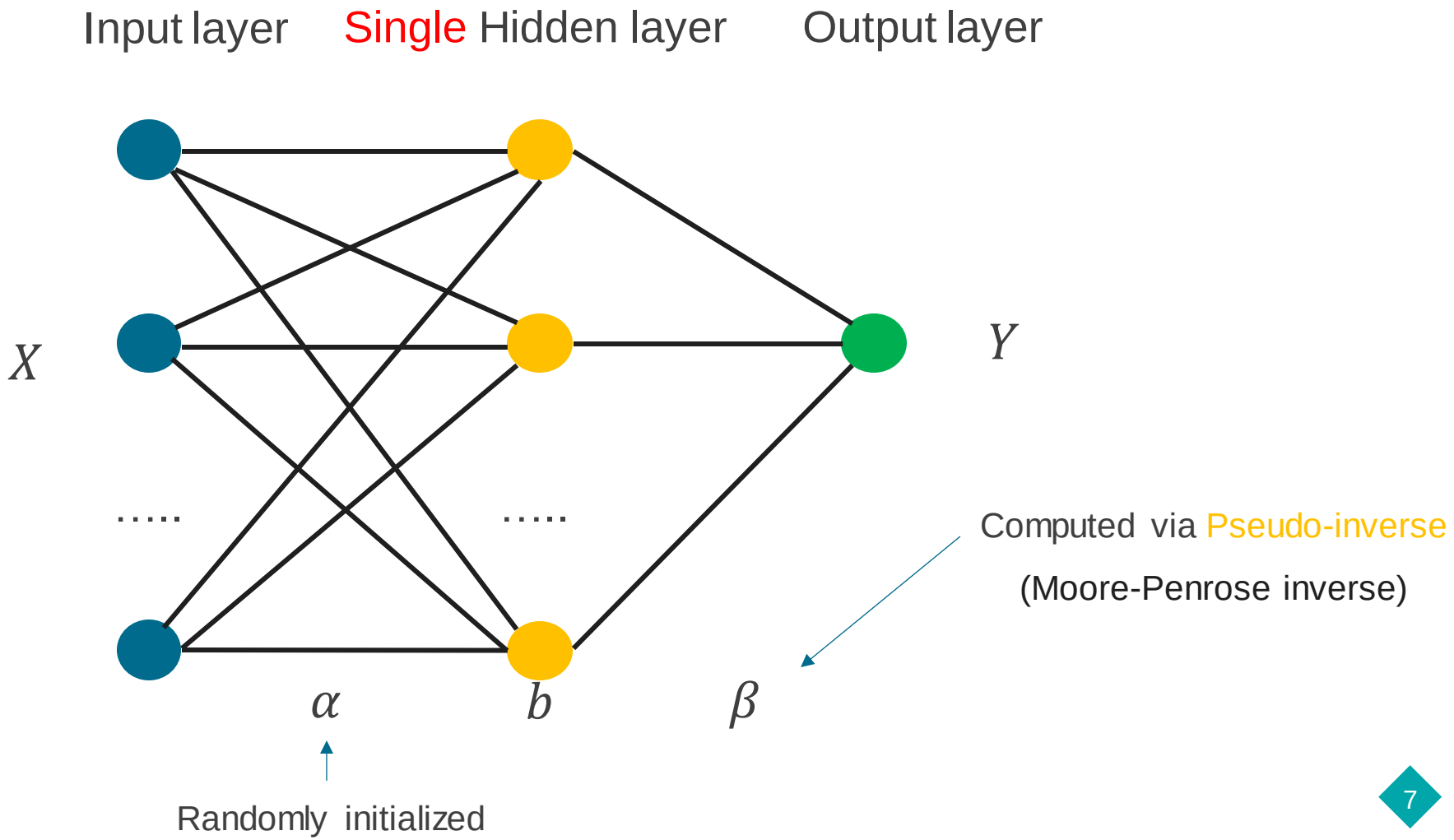
Other Neural Networks

- Extreme Learning Machine (ELM) (Huang et al. 2006)



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Other Neural Networks

- Convolutional Neural Networks

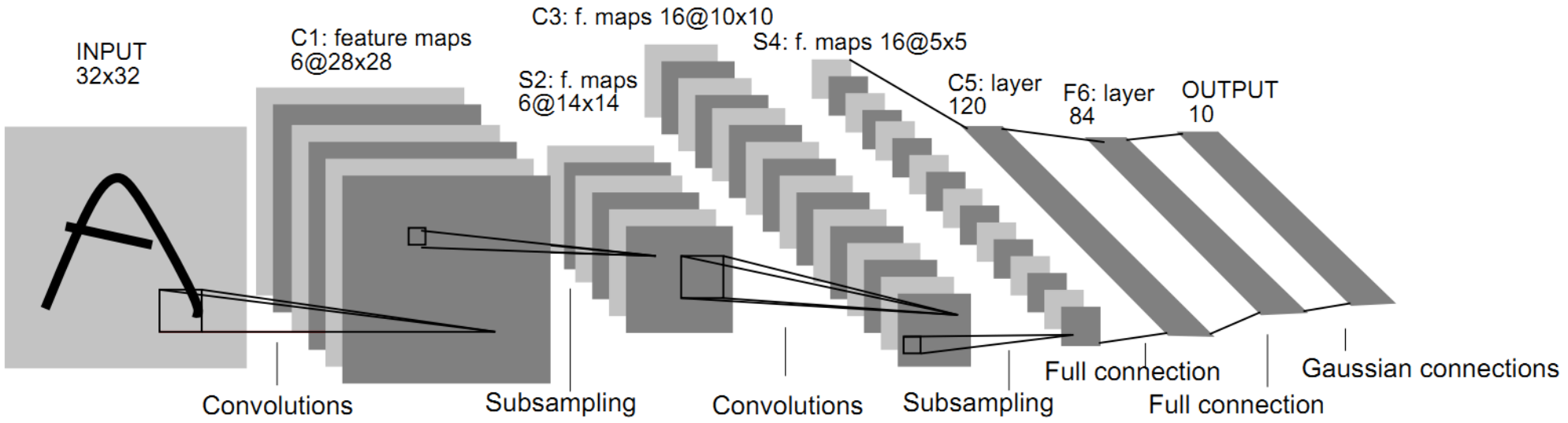

Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

LeCun, Bottou, Bengio, & Haffner. (1998)

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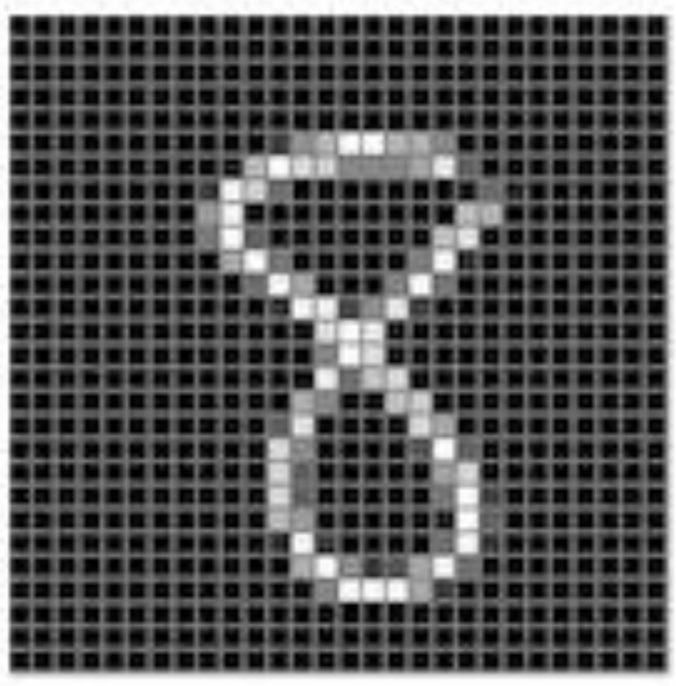
Other Neural Networks

- Convolution Operation (Dot products):

What you see:



What computer sees:

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	4	62	146	182	254	254	181	176	139	15	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	34	186	253	217	208	136	136	136	166	232	99	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	61	242	208	111	3	0	0	0	0	0	18	32	107	43	0	0	0	0	0	0
0	0	0	0	0	0	0	0	156	242	23	0	0	0	0	0	0	0	13	191	181	6	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	169	253	120	3	0	0	0	0	128	247	51	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	96	224	0	0	0	25	218	169	3	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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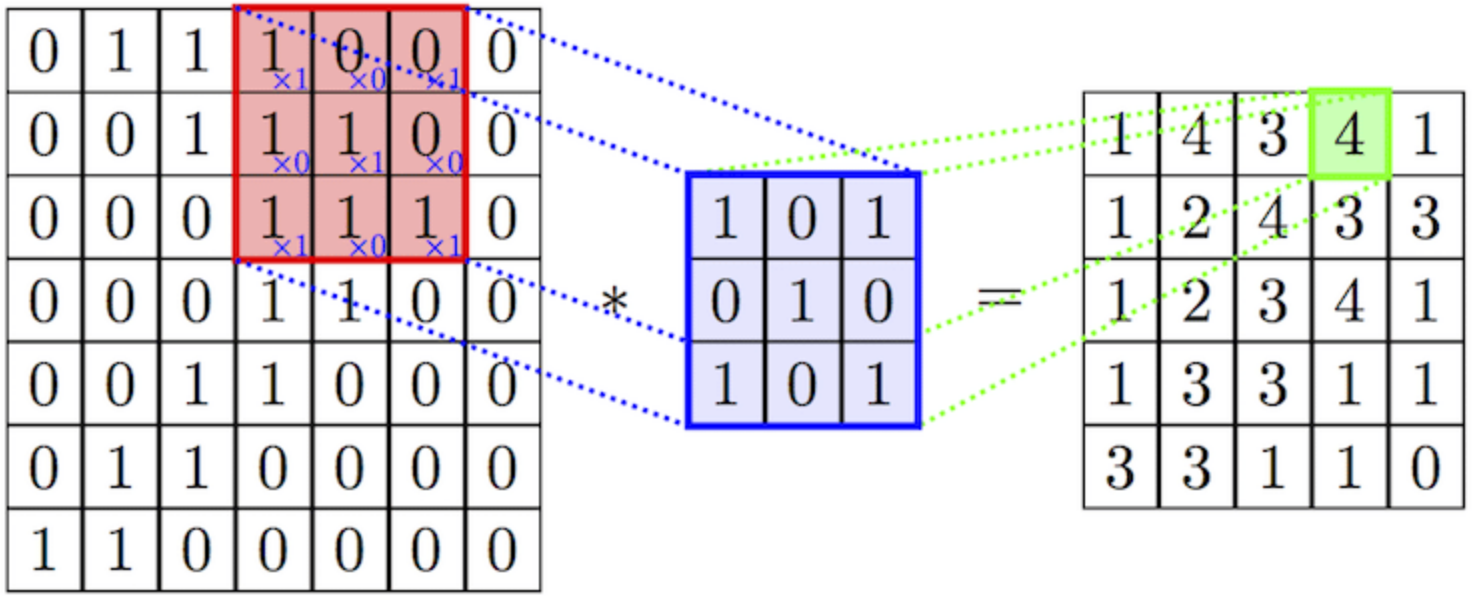
Other Neural Networks

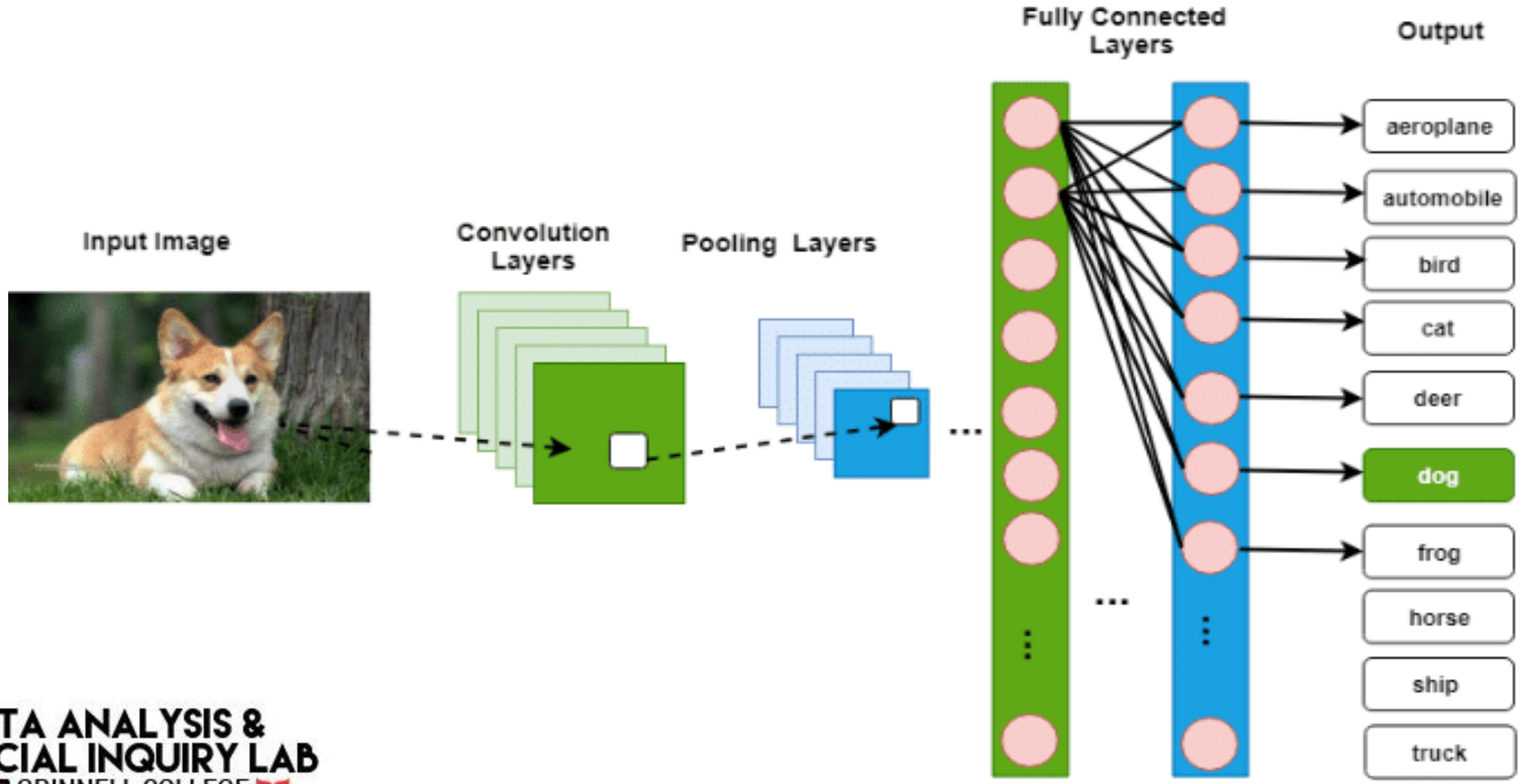
- Convolution Operation (Dot products):



Input image Convolution filter (kernel) Activation map

Other Neural Networks

- Typical CNN Structure:



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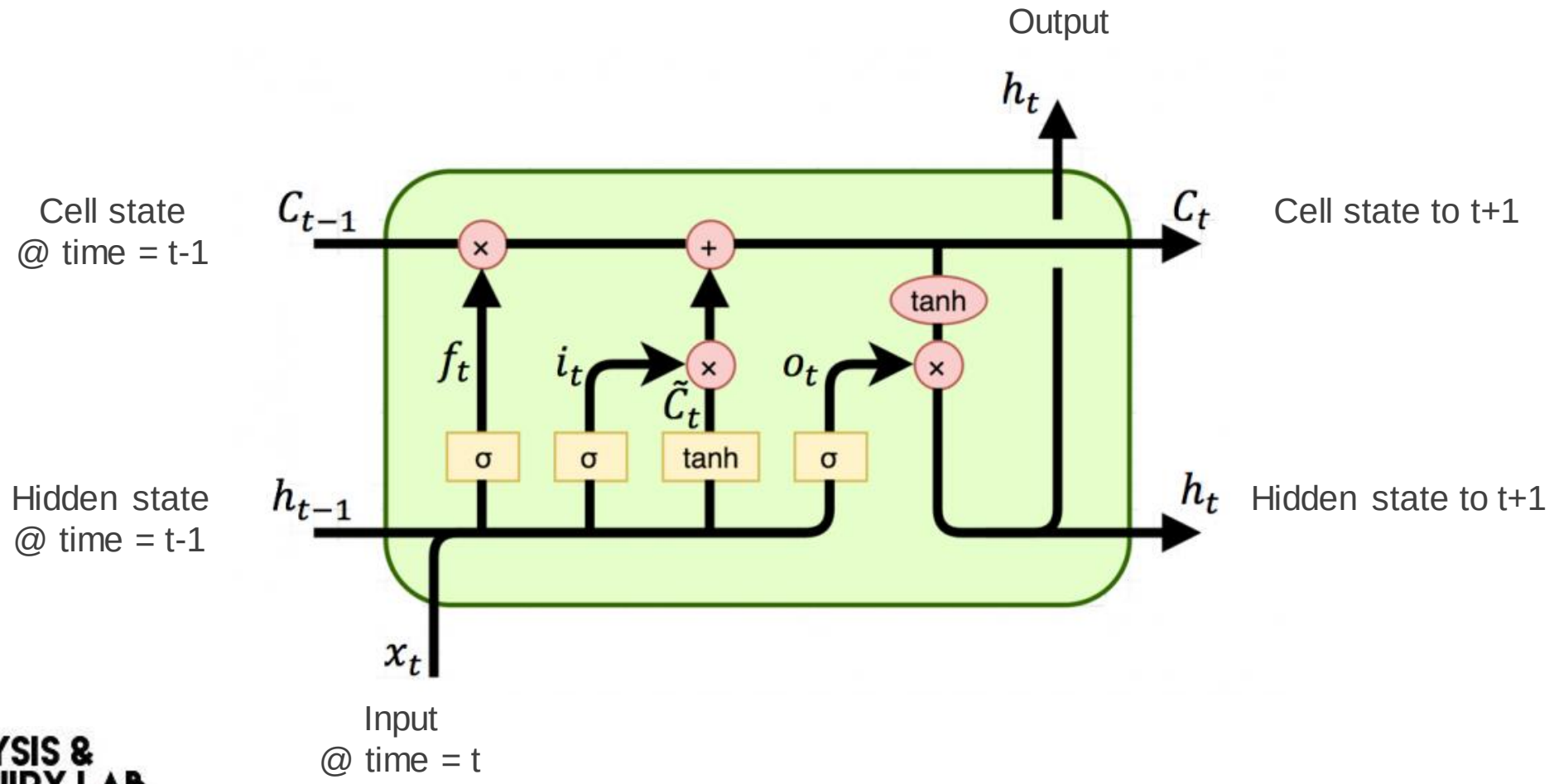
Other Neural Networks

- Long-Short-Term-Memory (LSTM)



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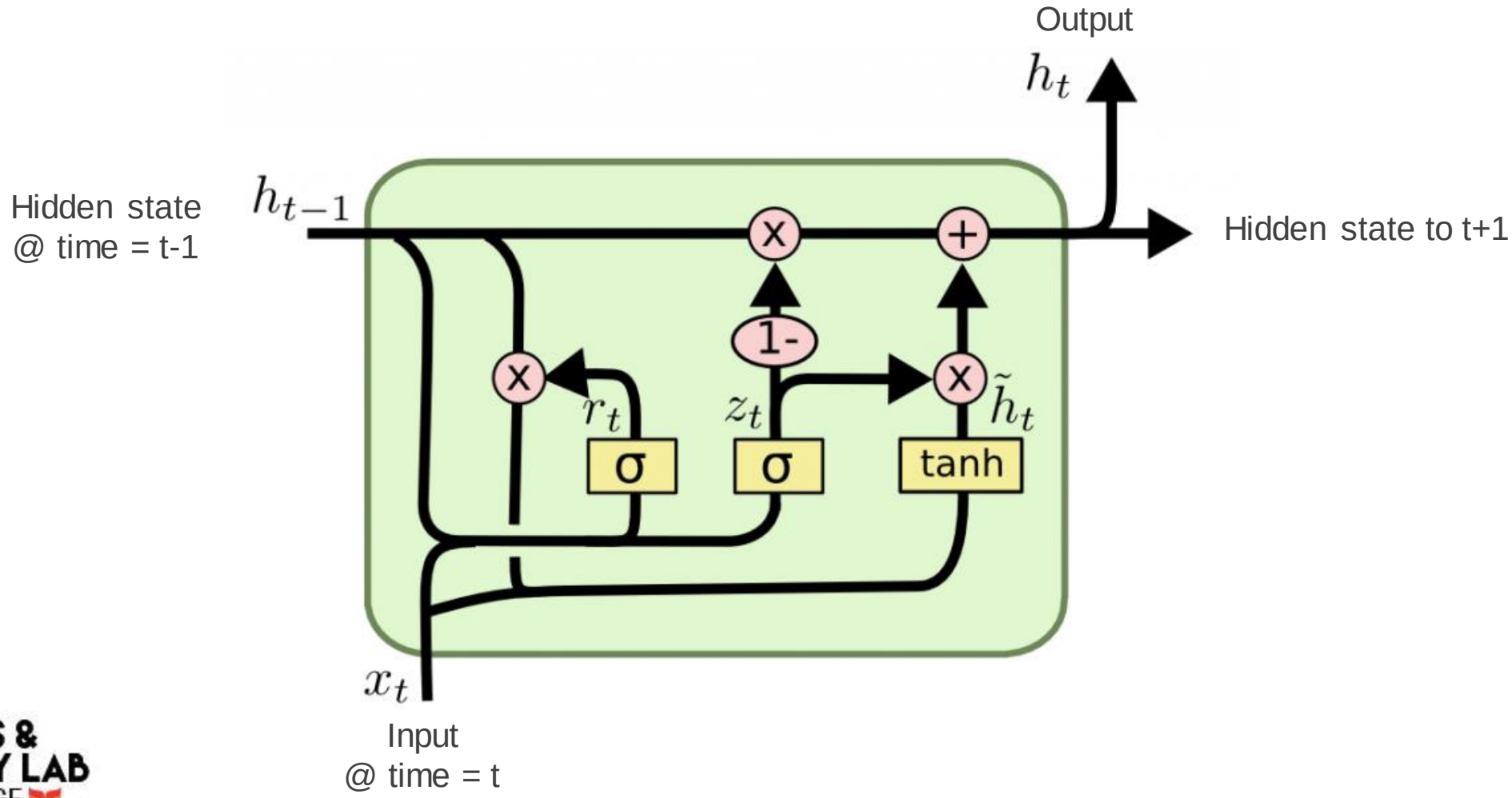
Other Neural Networks

- Gated Recurrent Unit (GRU)



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Intro to Machine Learning Part #3

AGENDA

Other Types of Neural Networks

Model Evaluation

Unsupervised Learning Basics

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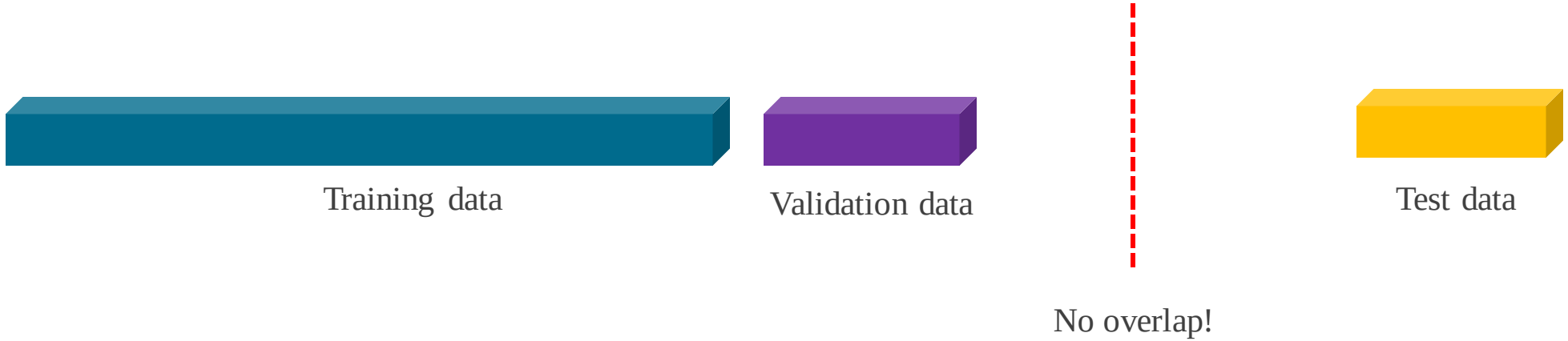
Model Evaluation

Recall: Training & Validation Dataset



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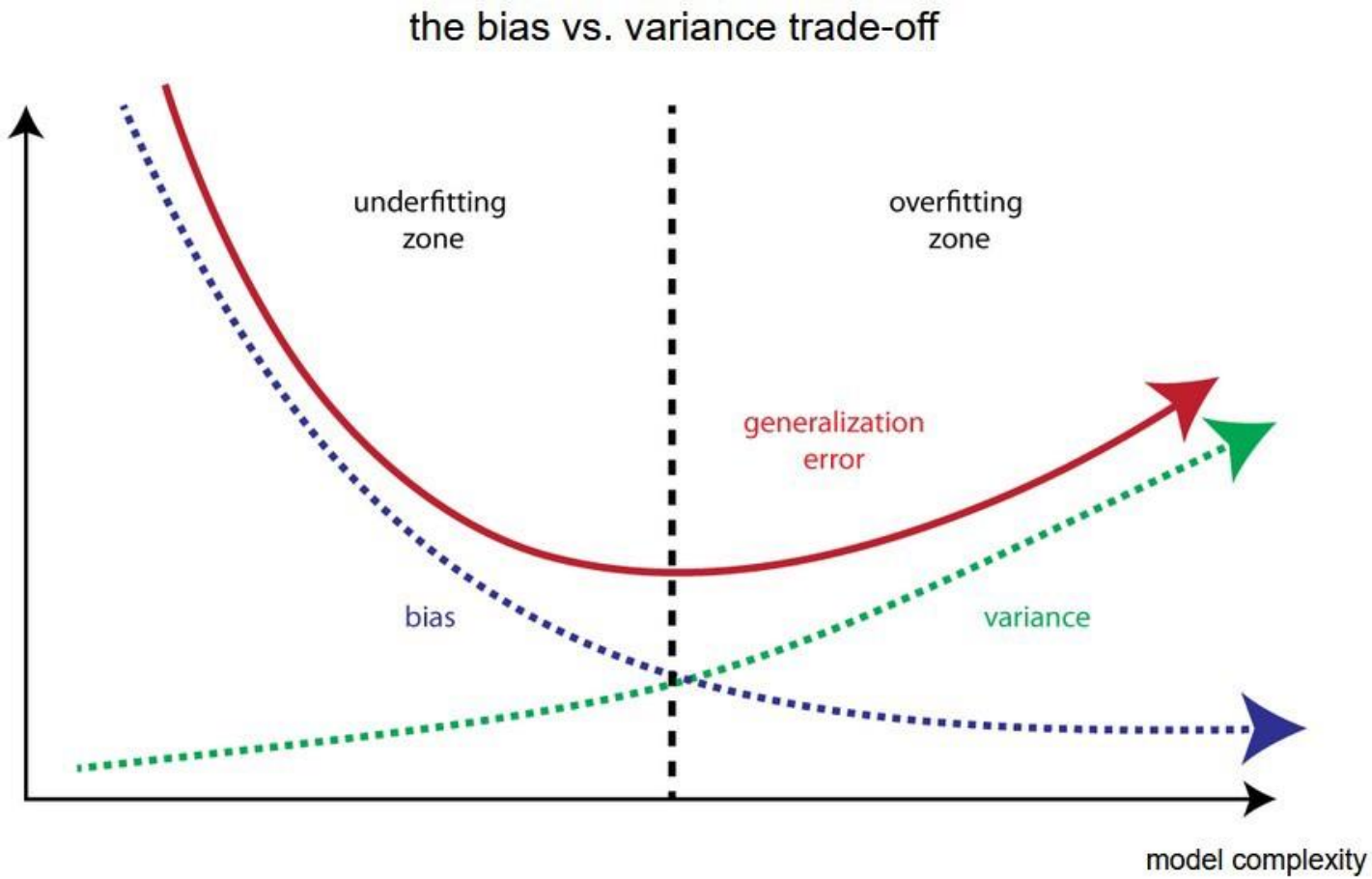
Model Evaluation

Bias Variance Trade Off:



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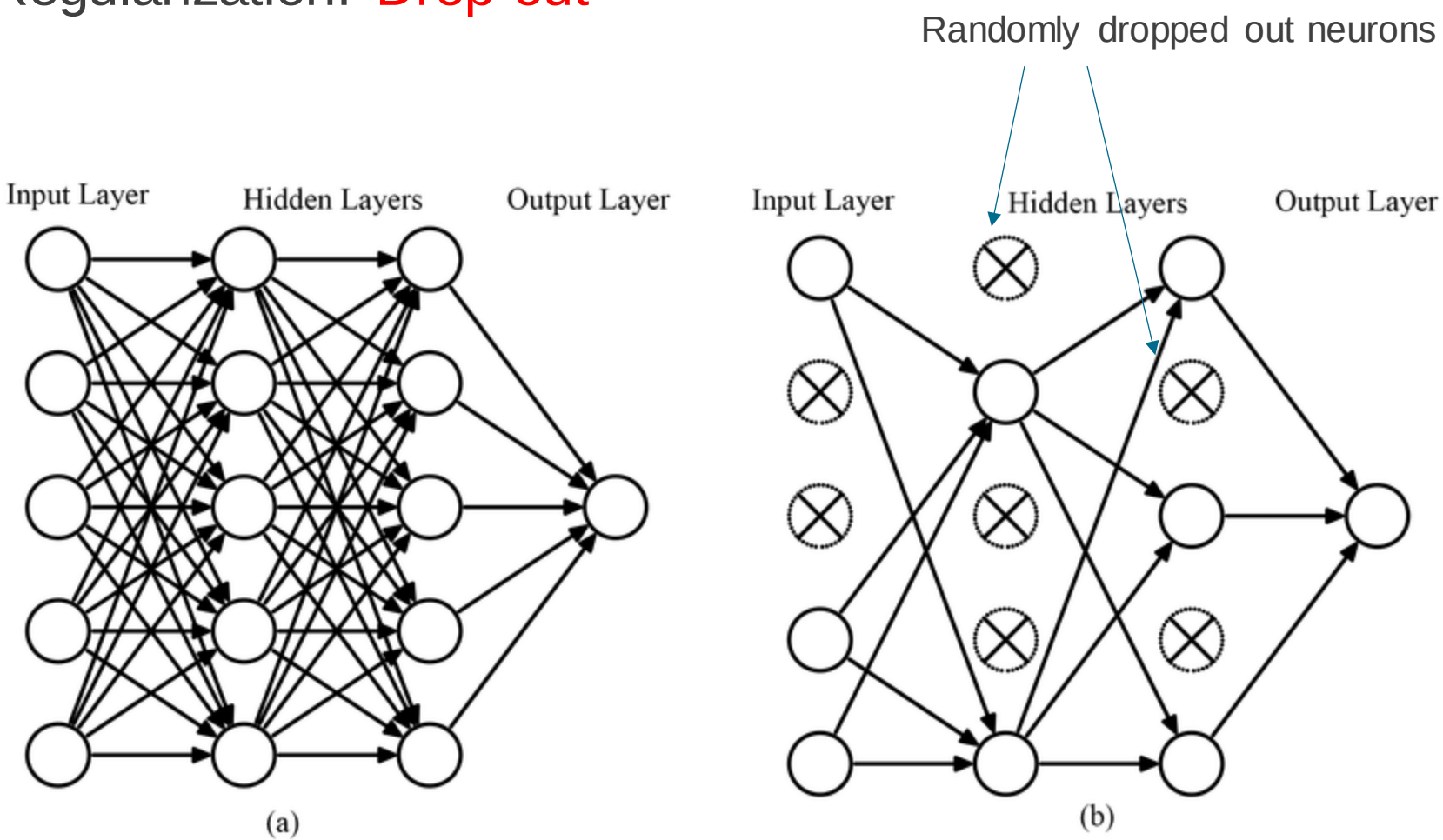
Model Evaluation

Neural Network Regularization: Drop out



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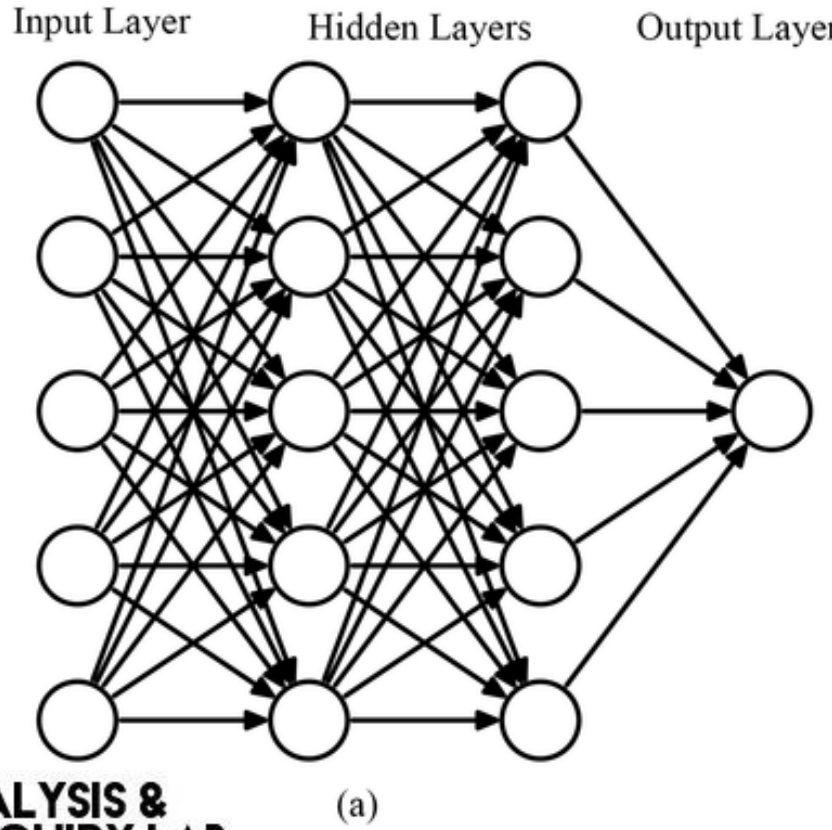
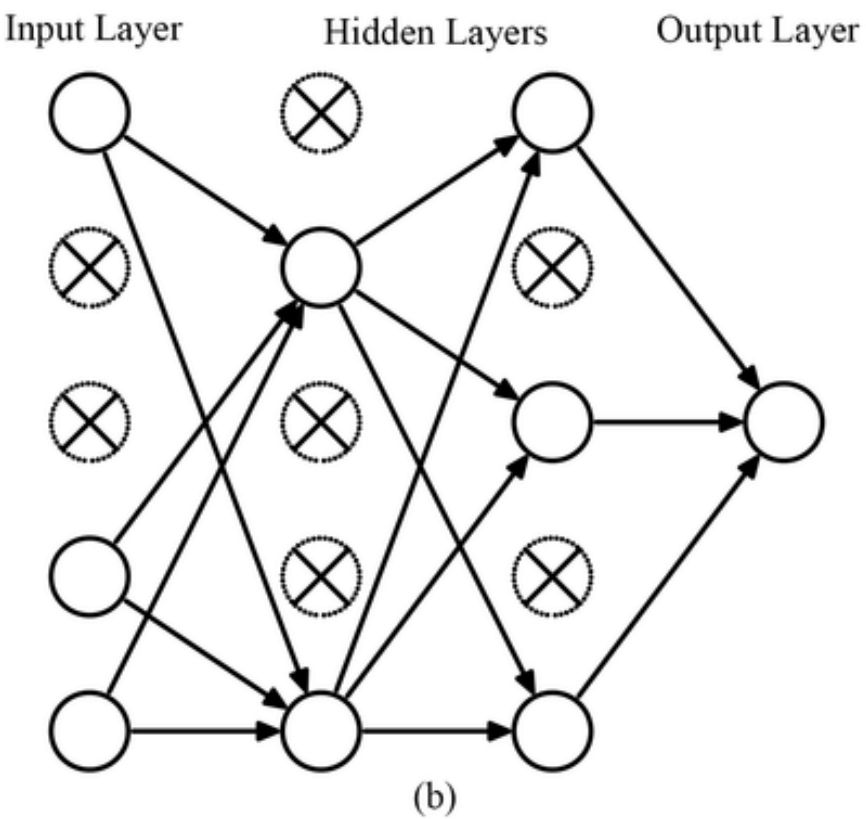
Model Evaluation

Discussion: Which neural network is better?



(a)



(b)

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Unsupervised Learning Basics

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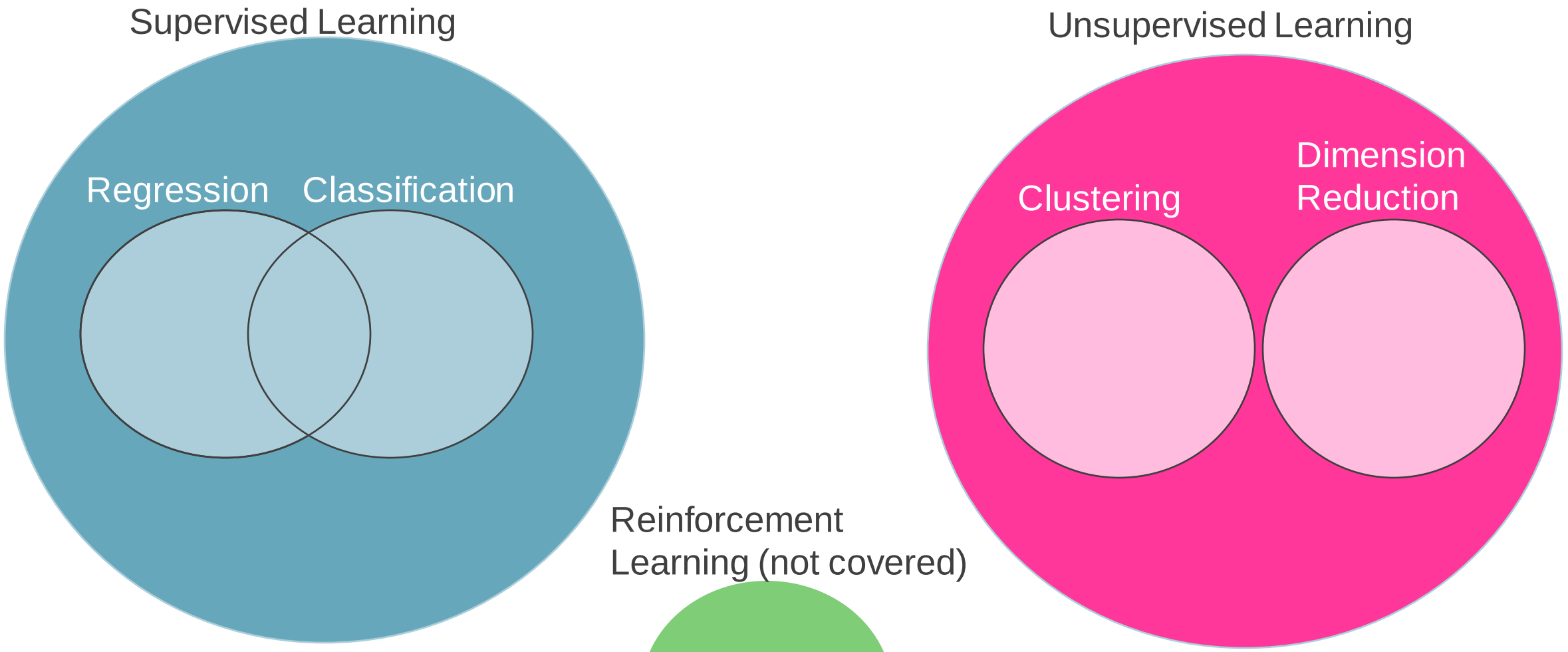
What is Machine Learning?



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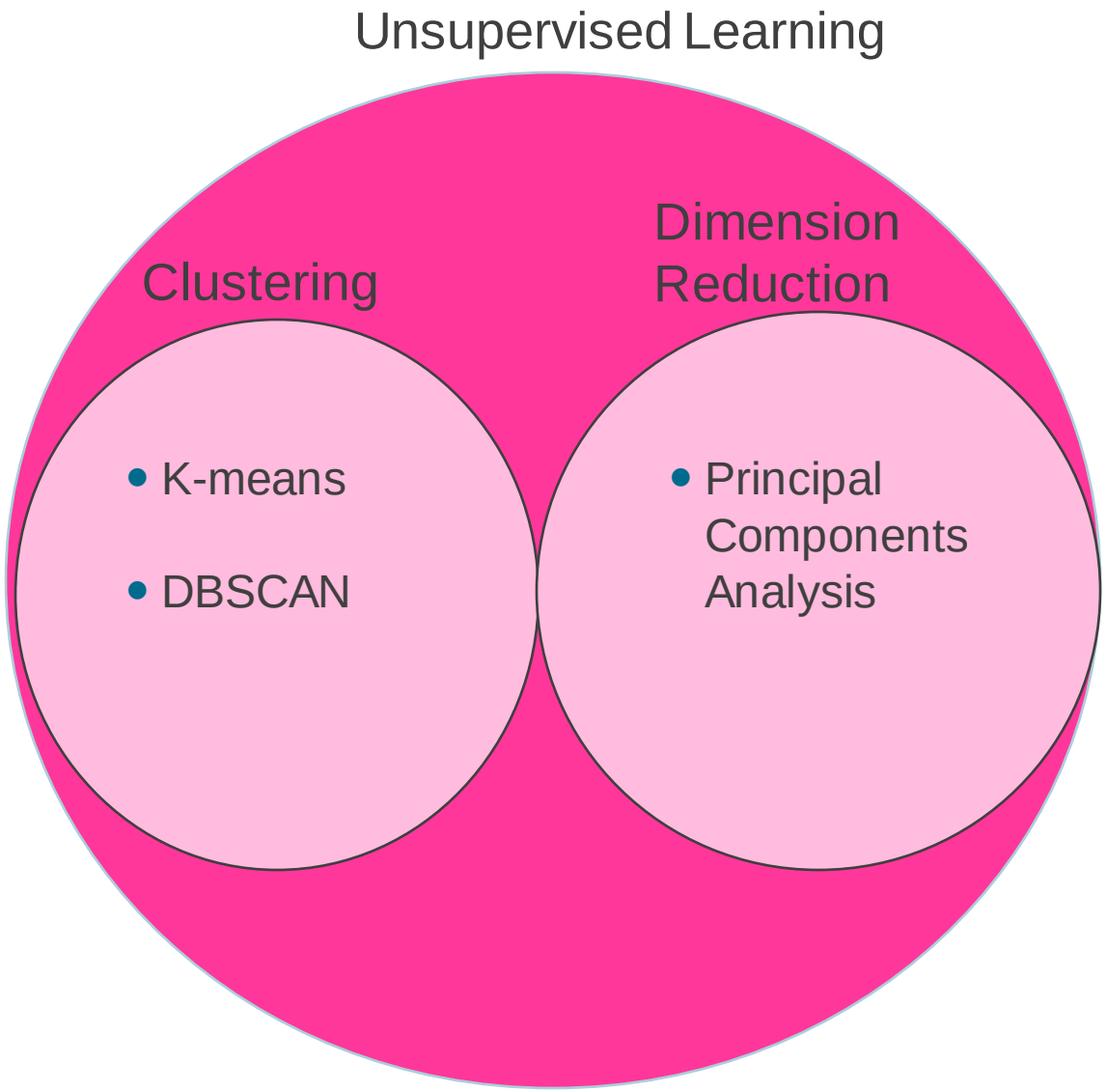
Algorithms - Unsupervised Learning



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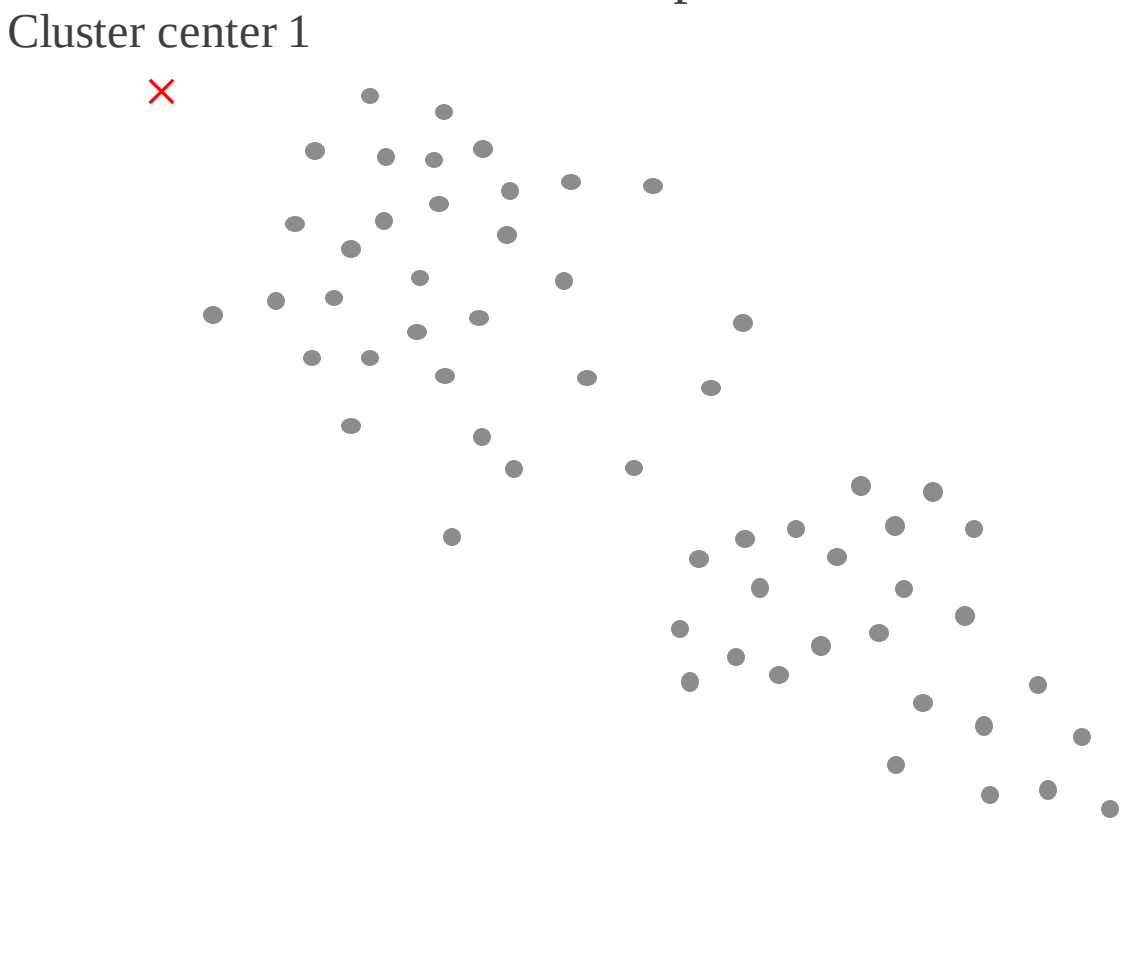
Unsupervised Learning - Clustering

- K-Mean Clustering

  Lloyd's algorithm

Step #1: Random Mean Initialization



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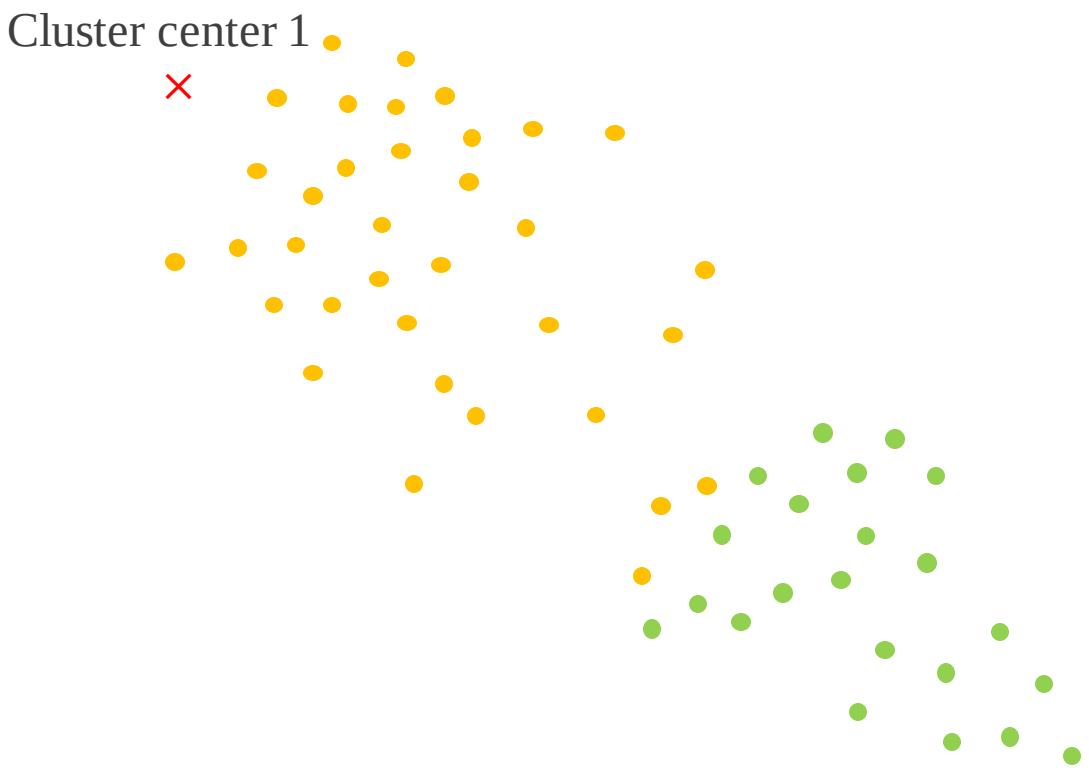
Unsupervised Learning - Clustering

- K-Mean Clustering:

  Lloyd's algorithm

Step #2: Assign class labels by distances



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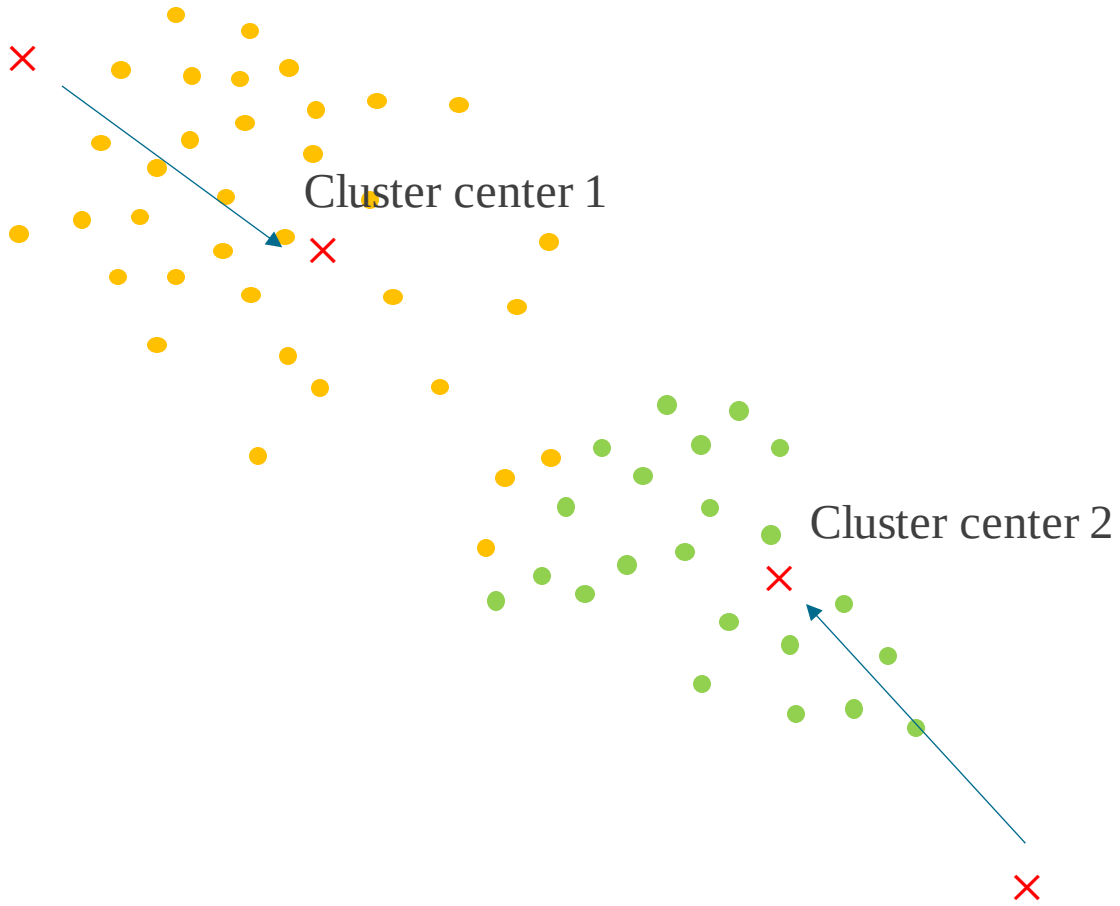
Unsupervised Learning - Clustering

- K-Mean Clustering

  Lloyd's algorithm

Step #3: Calculate cluster centers



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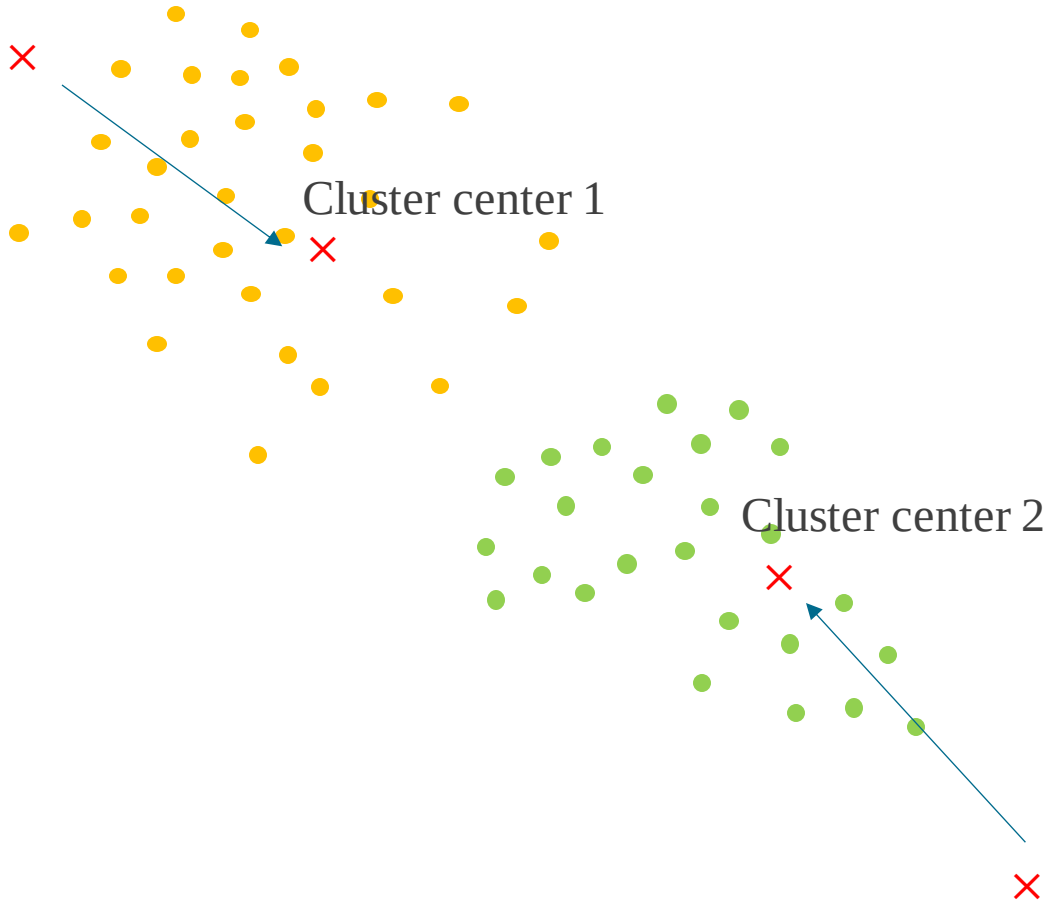
Unsupervised Learning - Clustering

- K-Mean Clustering

  Lloyd's algorithm

Step #4: Re-assign labels by distance



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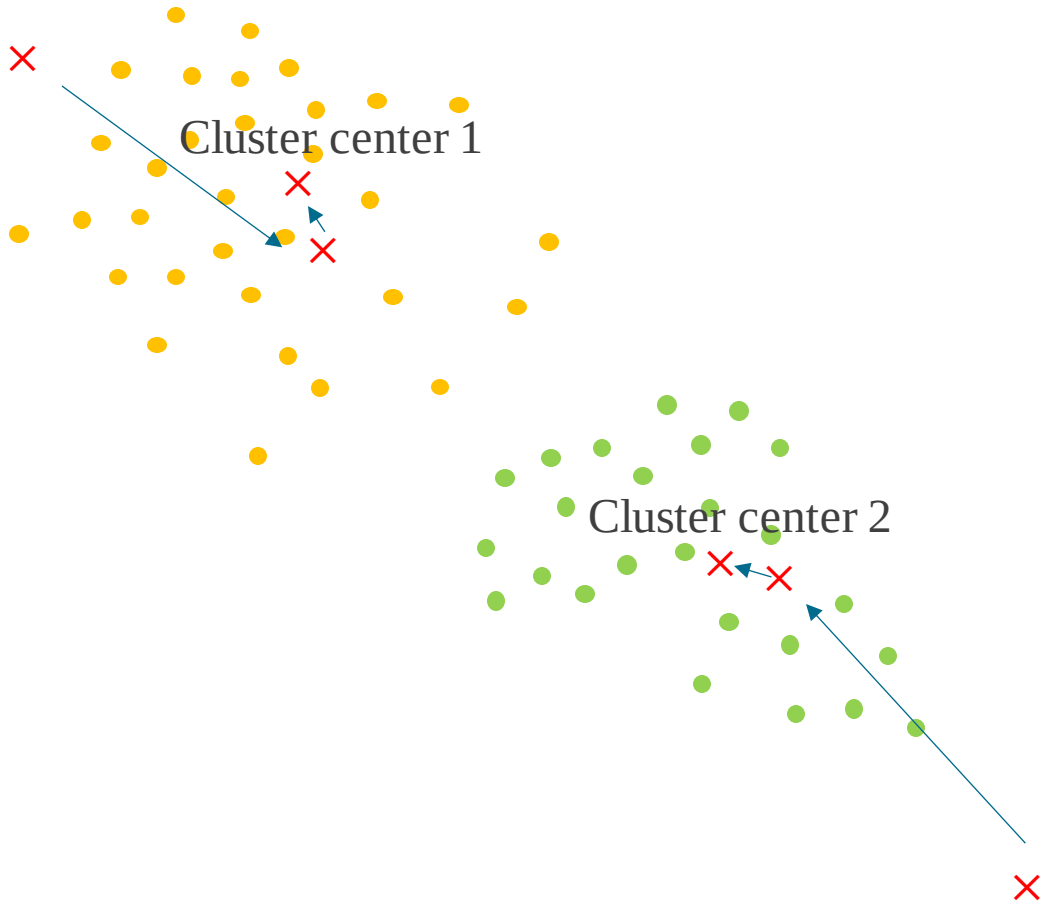
Unsupervised Learning - Clustering

- K-Mean Clustering

  Lloyd's algorithm

Step #5: Re-calculate cluster centers



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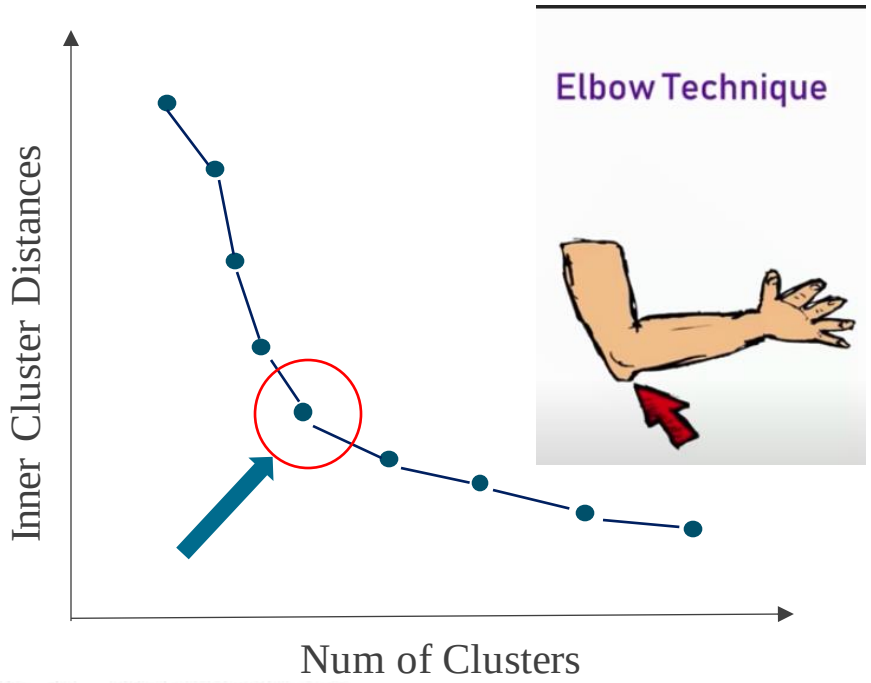
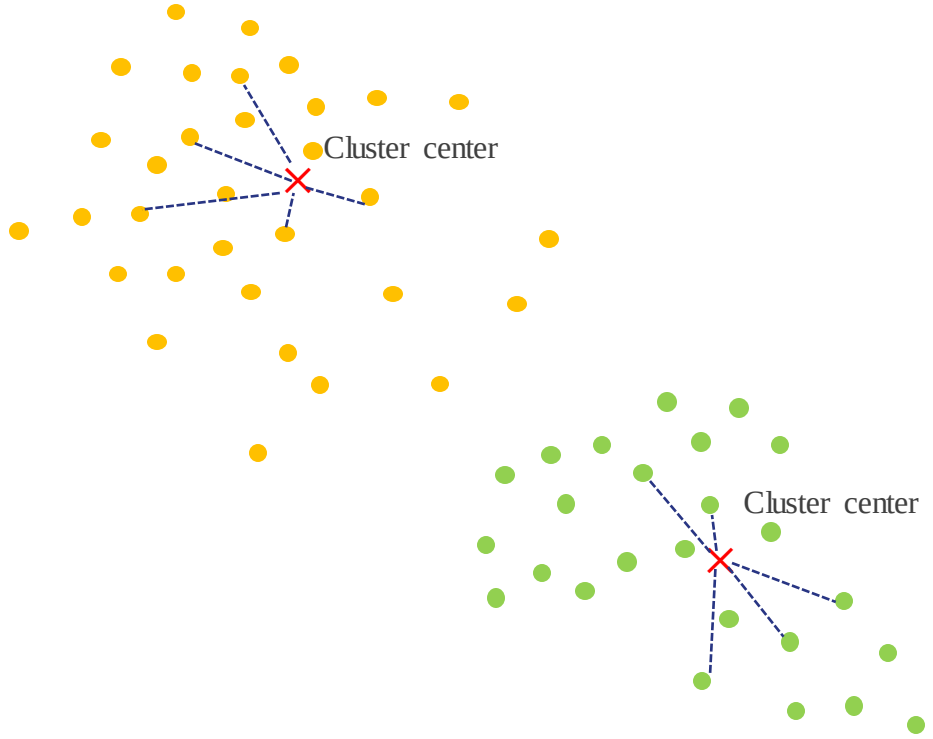
Unsupervised Learning – Clustering Evaluation

- How to measure the clustering quality?

Elbow Technique





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Unsupervised Learning – Clustering Evaluation

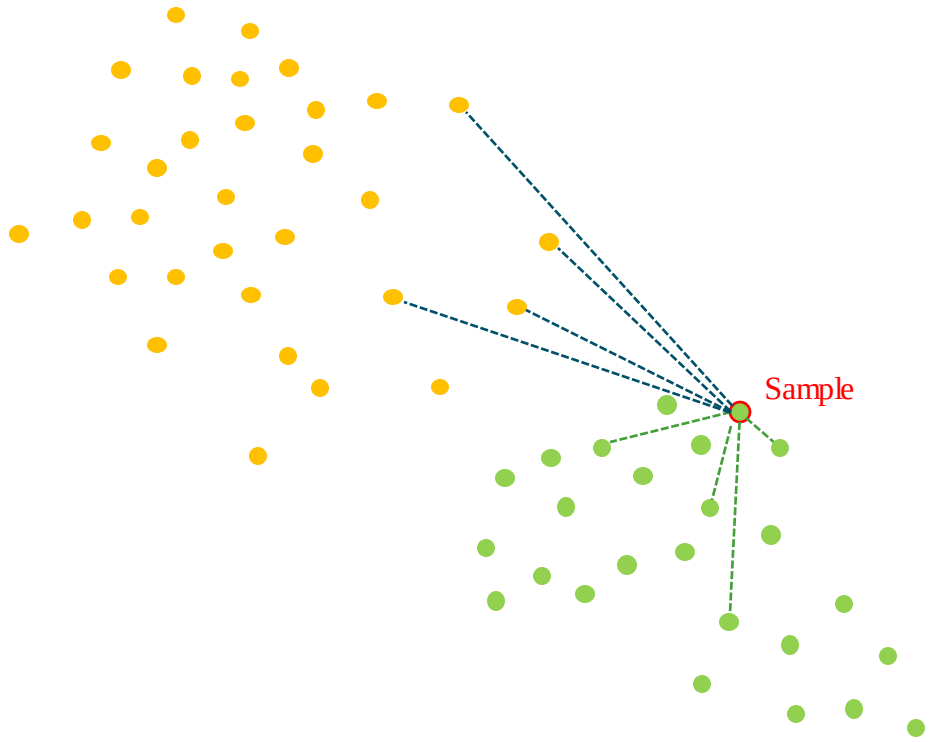
- How to measure the clustering quality?

Silhouette Coefficient:

$$s = \frac{b - a}{\max(a, b)}$$

a: The mean distance between a sample and all other points in the same cluster

b: The mean distance between a sample and all other points in the next nearest cluster



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Unsupervised Learning – Clustering Evaluation

- How to measure the clustering quality?

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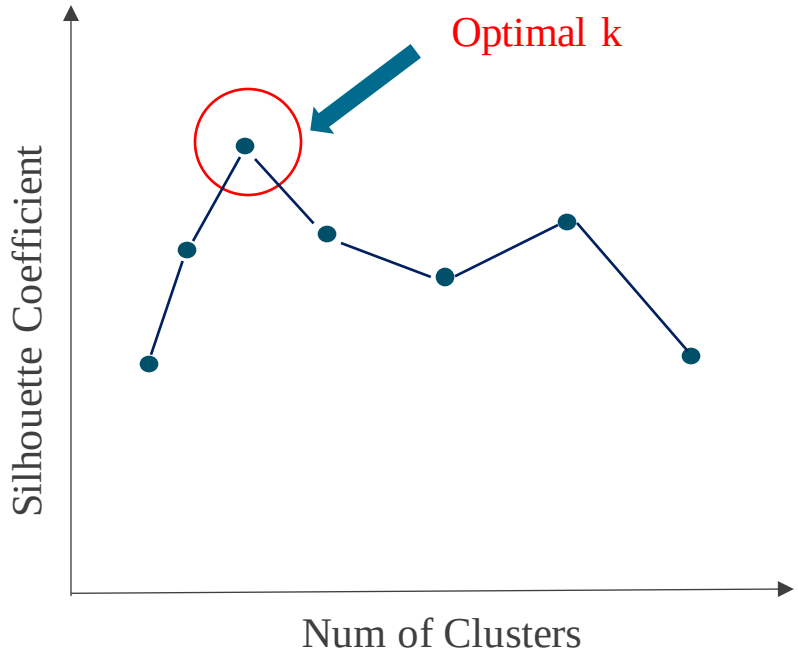

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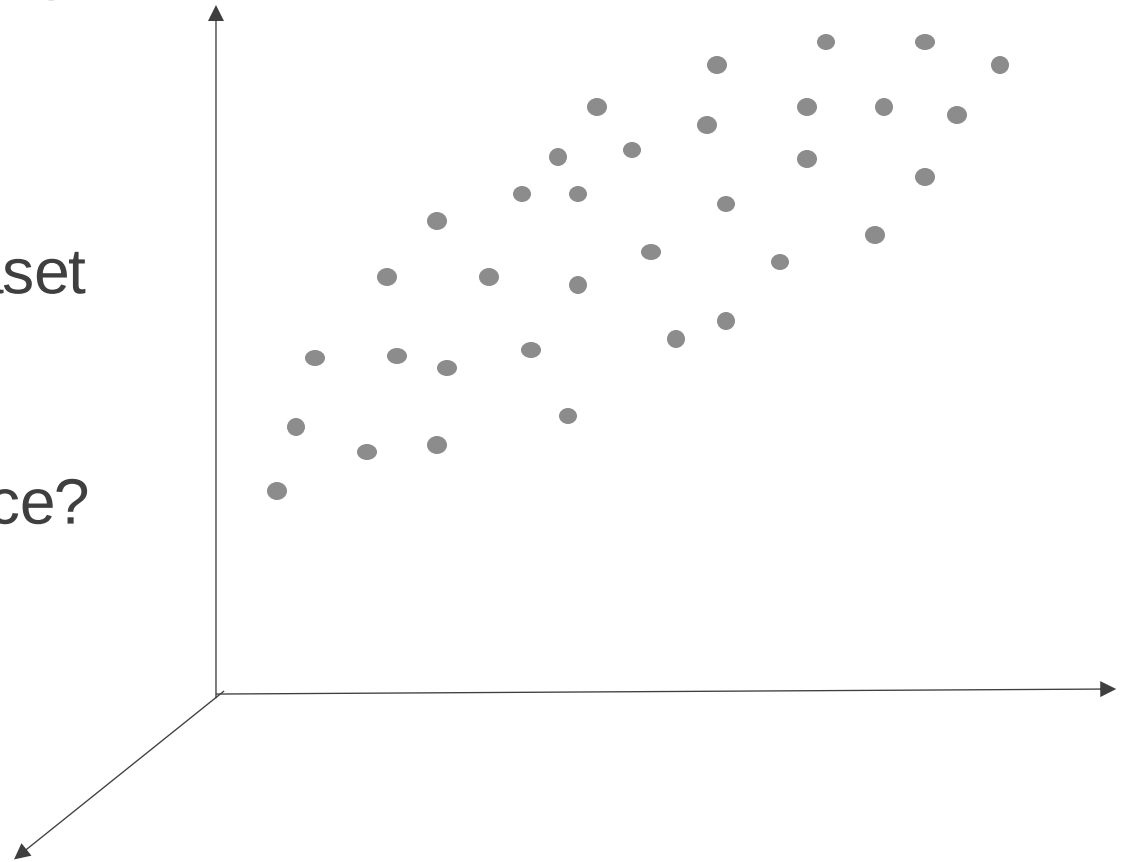
Unsupervised Learning – Dimension Reduction

- How to reduce dimensionality?
- Principal Component Analysis (PCA) most popular method

Think about a high dimensional dataset

Which direction has the most variance?



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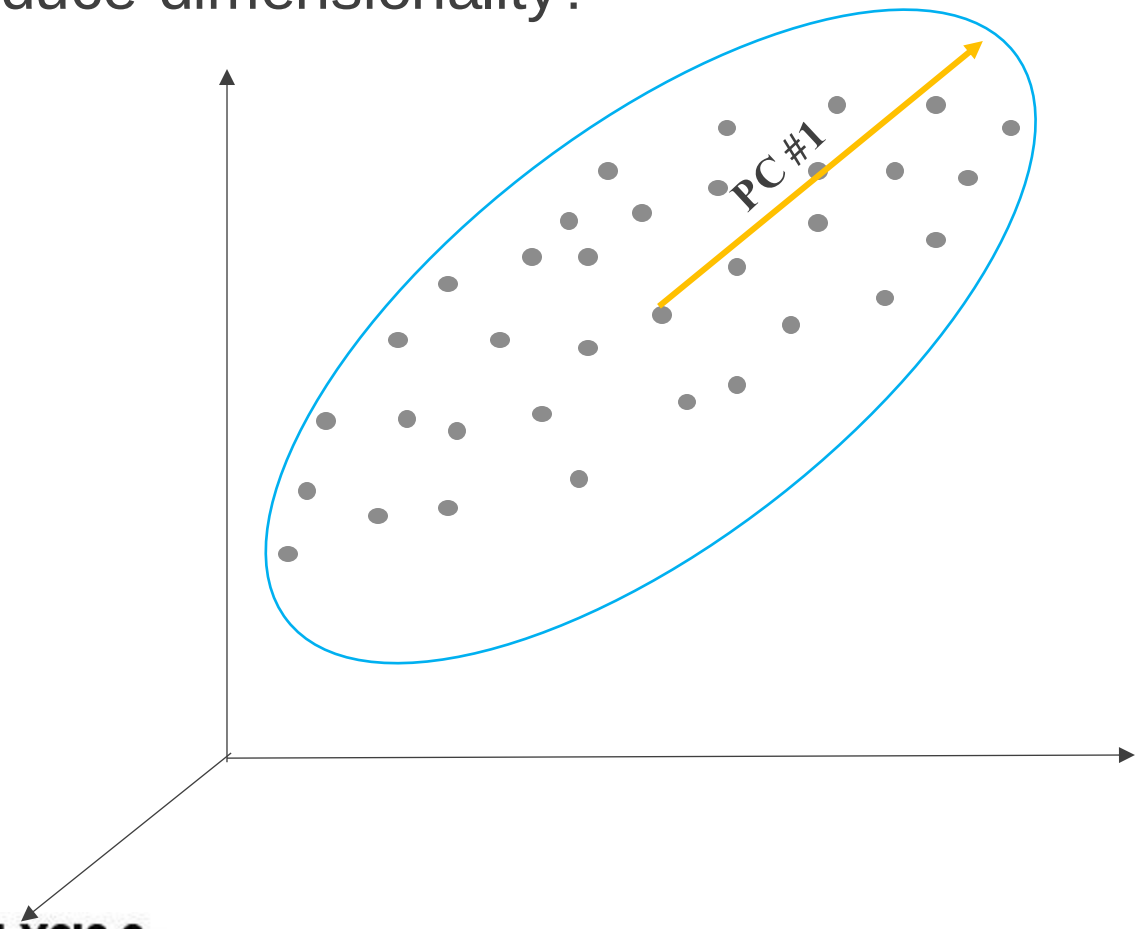
Unsupervised Learning – Dimension Reduction

- How to reduce dimensionality?



$$PC\#1 = 0.05X_1 - 0.84X_2 + \ldots + 0.11X_{200}$$

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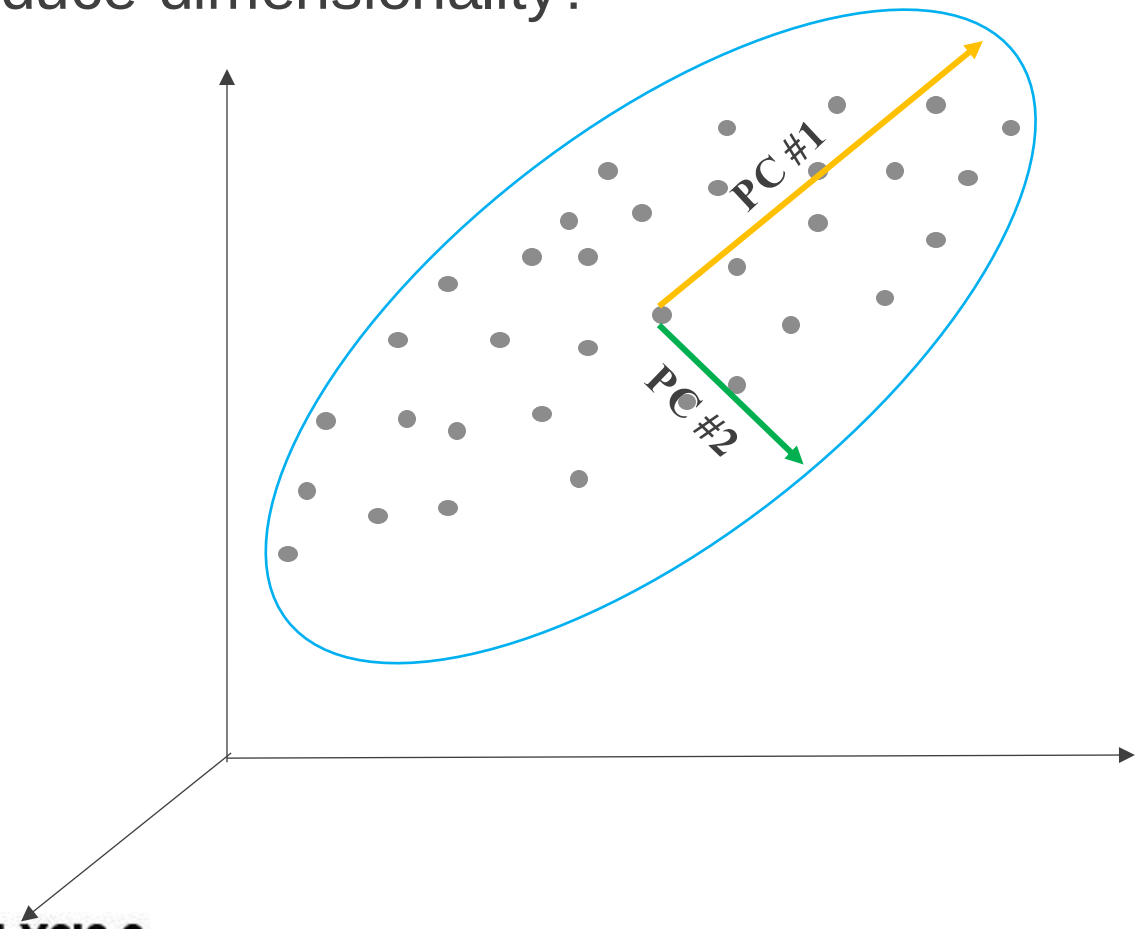
Unsupervised Learning – Dimension Reduction

- How to reduce dimensionality?



$$PC\#1 = 0.05X_1 - 0.84X_2 + \ldots + 0.11X_{200}$$
$$PC\#2 = 0.86X_1 + 0.05X_2 + \ldots - 0.47X_{200}$$

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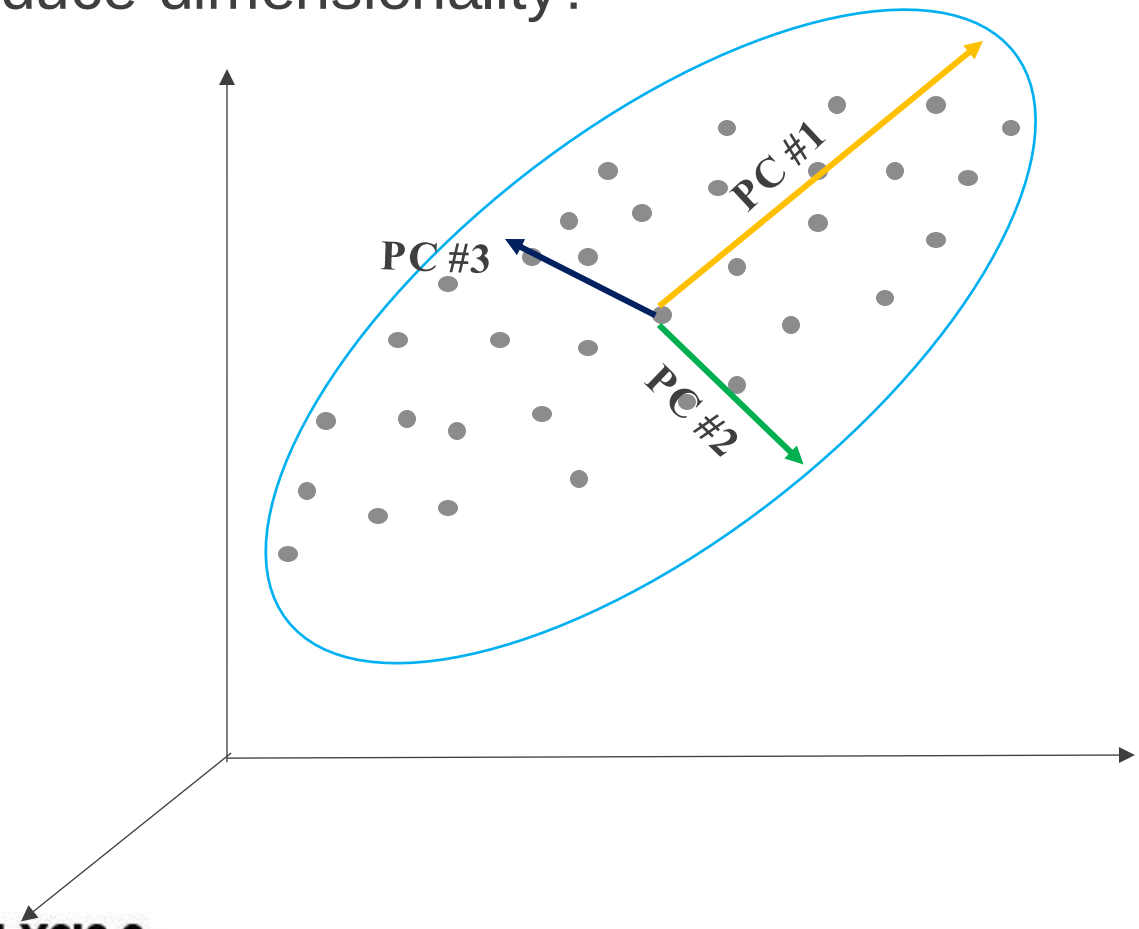
Unsupervised Learning – Dimension Reduction

- How to reduce dimensionality?



$PC\#1 = 0.05X_1 - 0.84X_2 + \ldots + 0.11X_{200}$

$PC\#2 = 0.36X_1 + 0.05X_2 + \ldots - 0.47X_{200}$

$PC\#3 = \ldots..$

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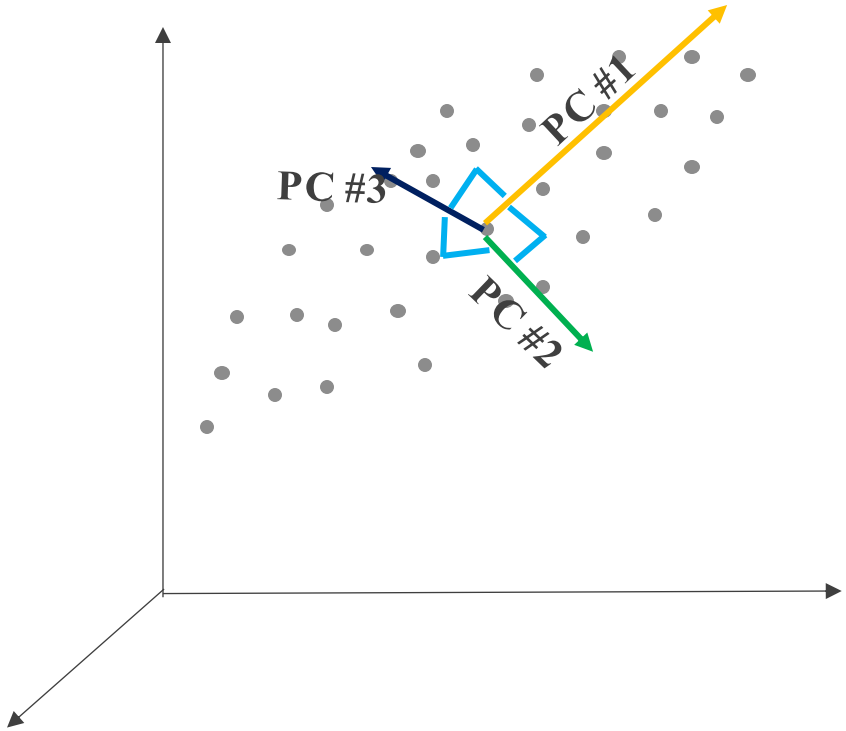
Unsupervised Learning – Dimension Reduction

- Principal components are:
  - Orthogonal (or "perpendicular") to one another
  - Linear combinations of predictor variables
- # of Principal components = # of variables
  - Keep principal components that explain most of the variation -> reduce dimensionality



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Q & A