CS 383: Machine Learning

Prof Adam Poliak

Fall 2024

12/03/2024

Lecture 29

Announcements – Remaining Assignments

HW07: due Wednesday 11/27

HW08: due Thursday 12/12

Just the Pytorch & Word2Vec notebook

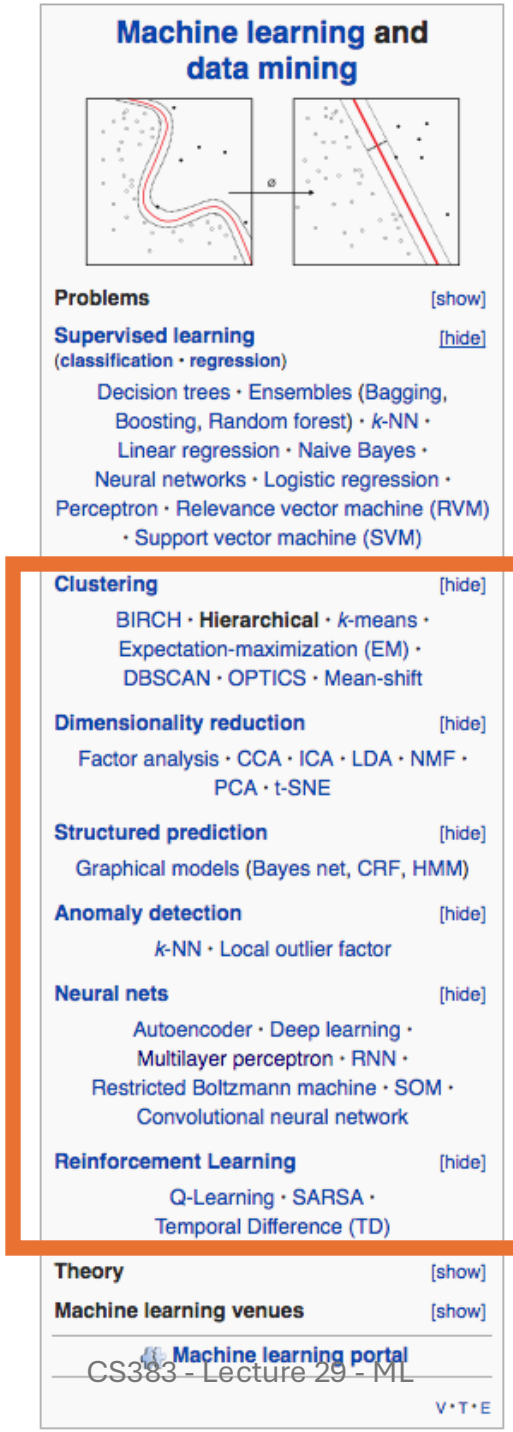
No Project Presentations – due end of finals period

Midterm: Wednesday 12/11

Outline

Unsupervised learning

Supervised Learning:
makes use of examples where we know the underlying "truth" (label/output)



Unsupervised Learning:
Learn underlying structure or features without labeled training data

Image: wikipedia

Unsupervised learning: 3 main areas

1) Clustering: group data points into clusters based on features only

2) Dimensionality reduction: remove feature correlation, compress data, visualize data

3) Structured prediction: model latent variables (example: Hidden Markov Models)

Unsupervised Algorithms

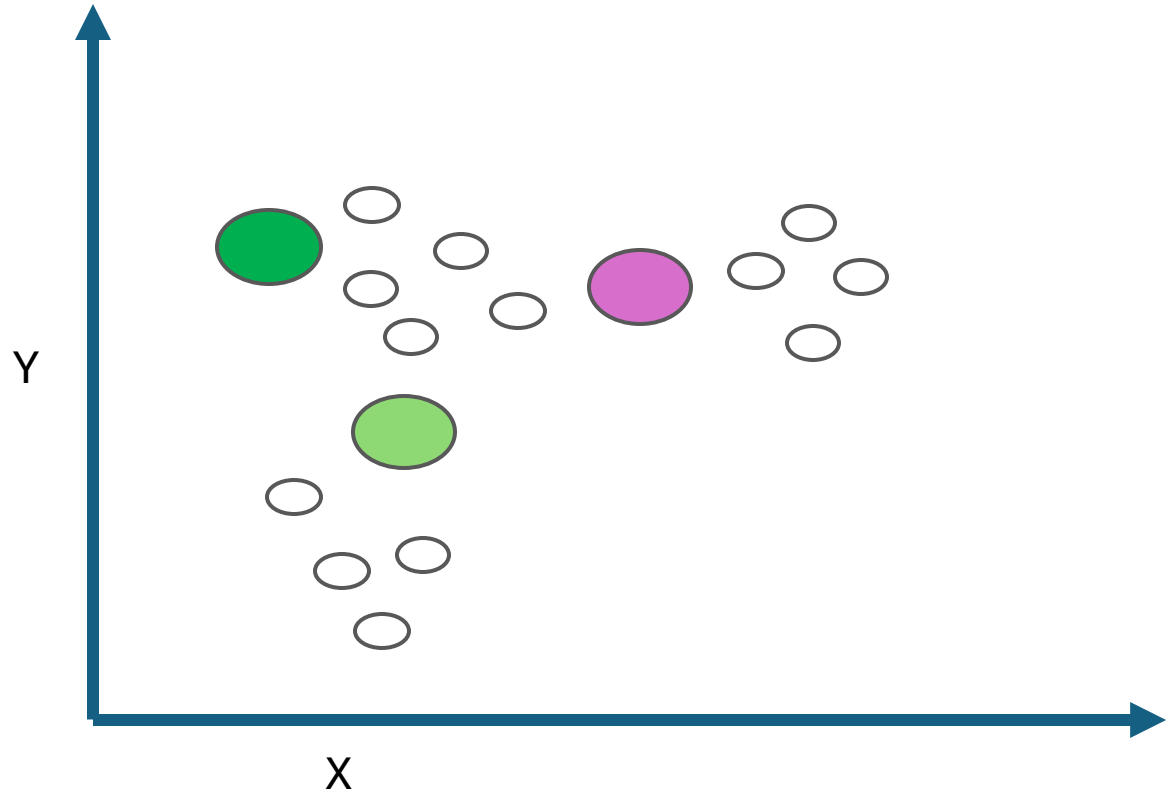
- K-means
- Gaussian Mixture Models (GMM)
- Principle Component Analysis (PCA)

K-means Algorithms

1. Initialize: Randomly pick K points as cluster centers

Randomly pick K points as centers

- Example: 2D point patterns



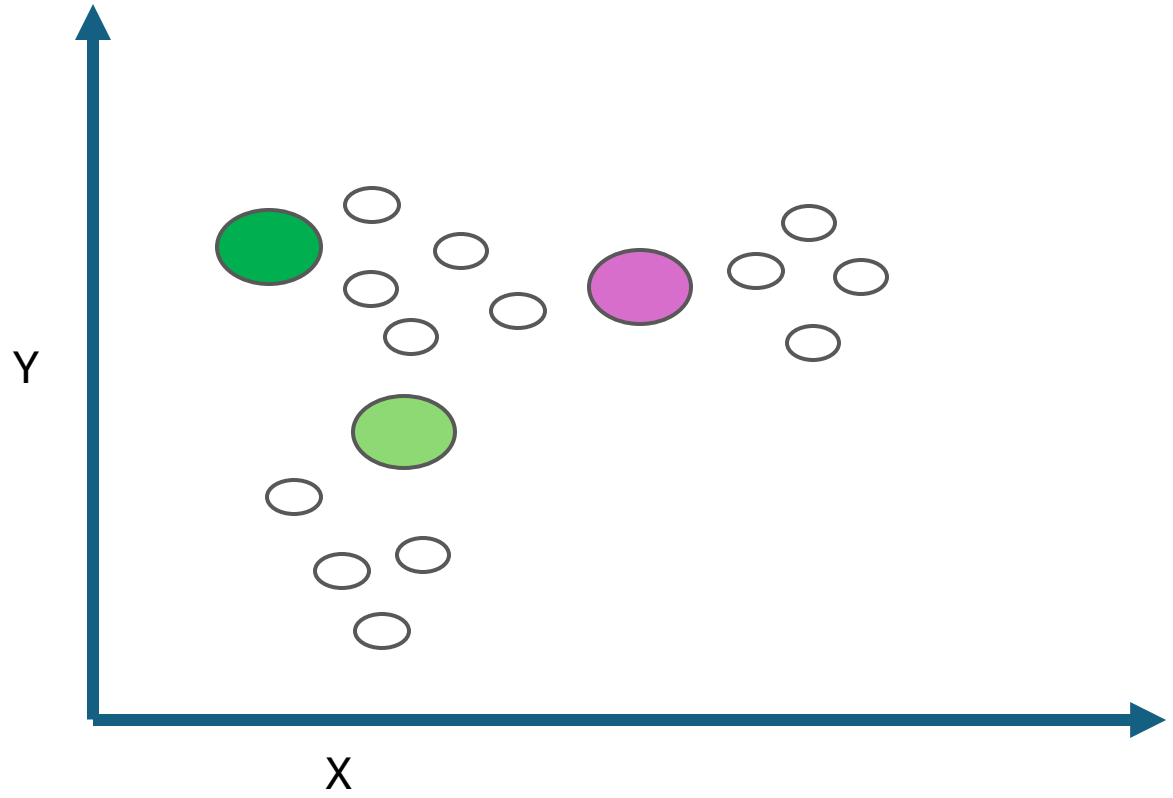
K-means Algorithms

1. Initialize: Randomly pick K points as cluster centers

2. Assign data points to each cluster
    1. Based on distance between point and cluster's center

Assign data points to each cluster

- Example: 2D point patterns



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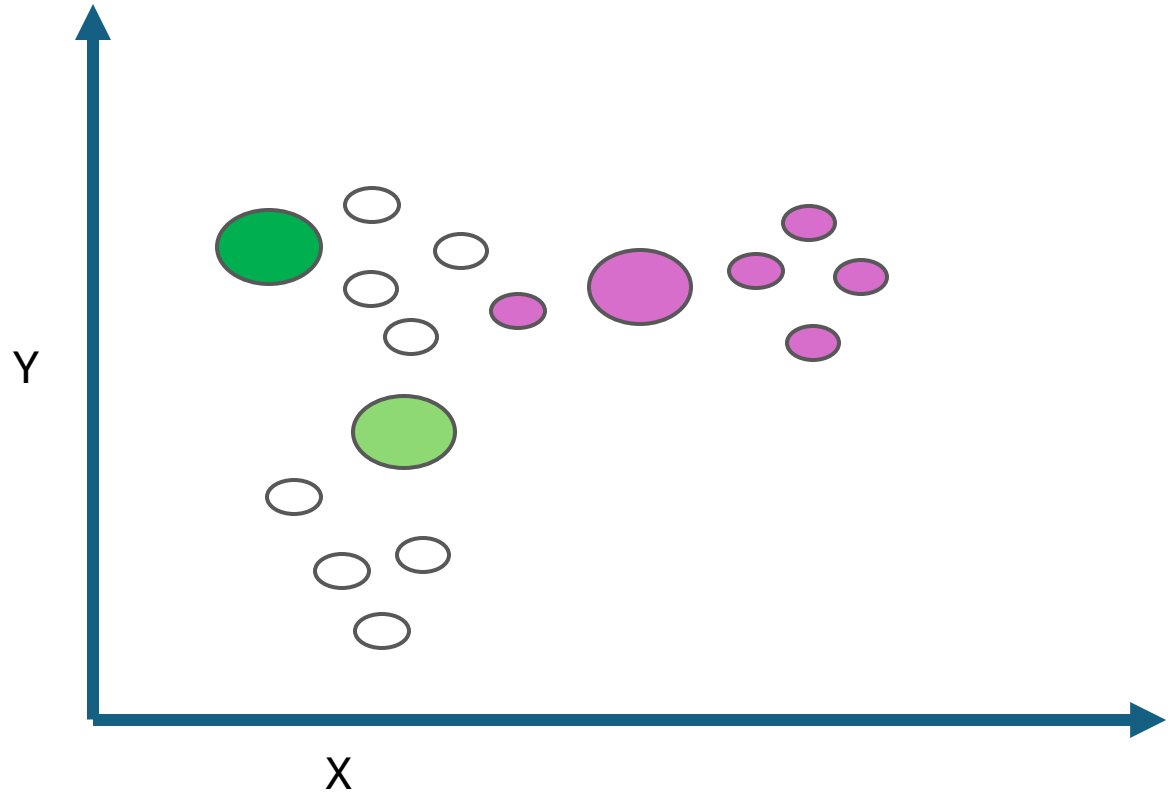

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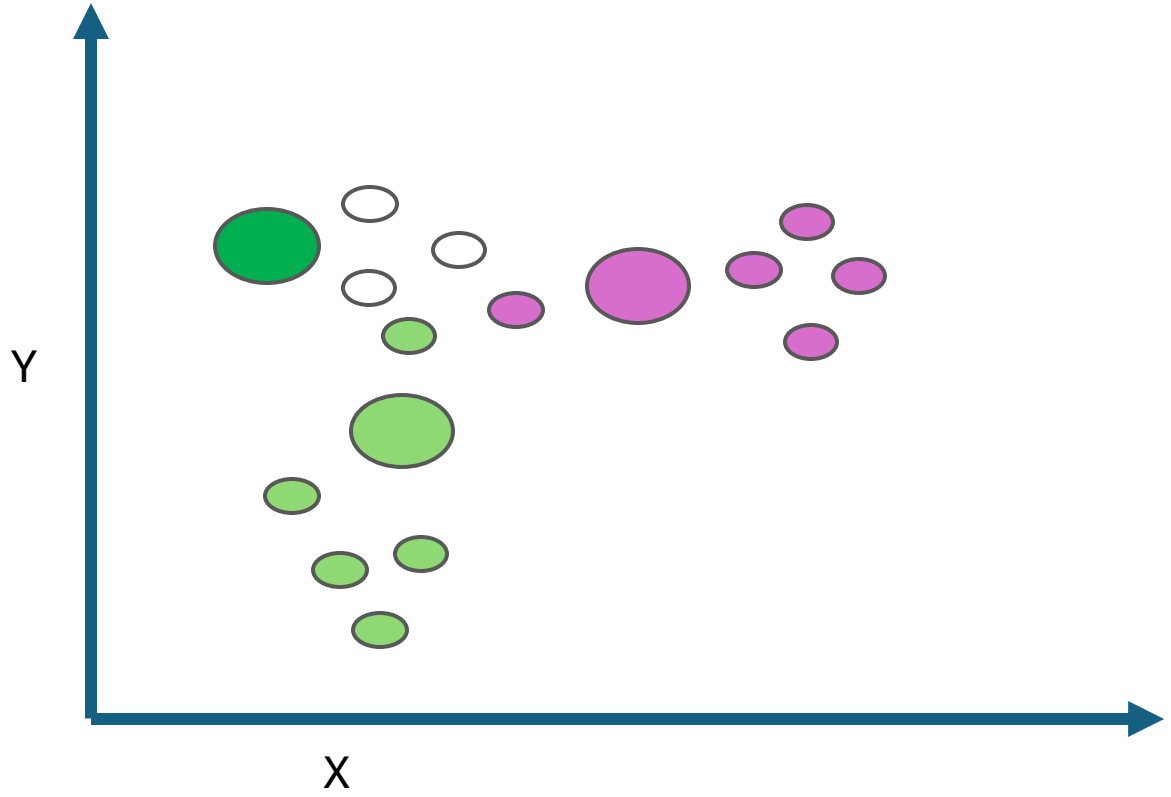

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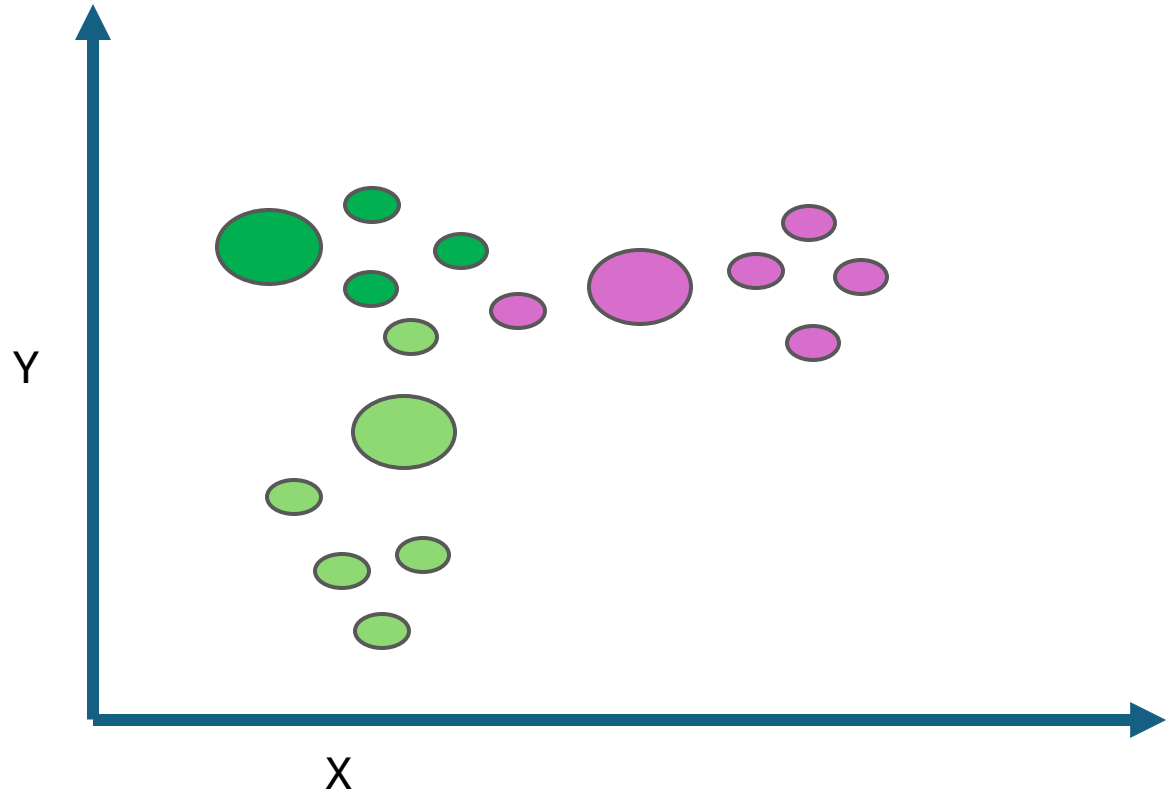

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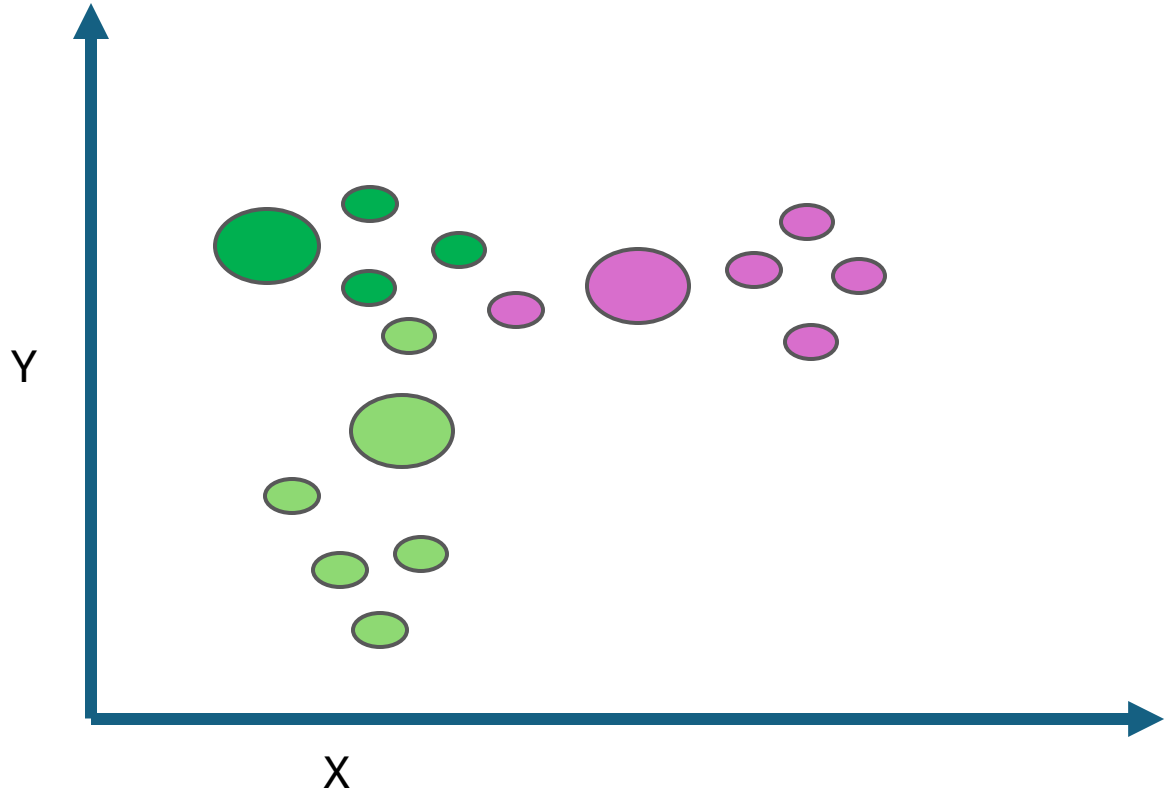
Update Centers

- Example: 2D point patterns



Update Centers

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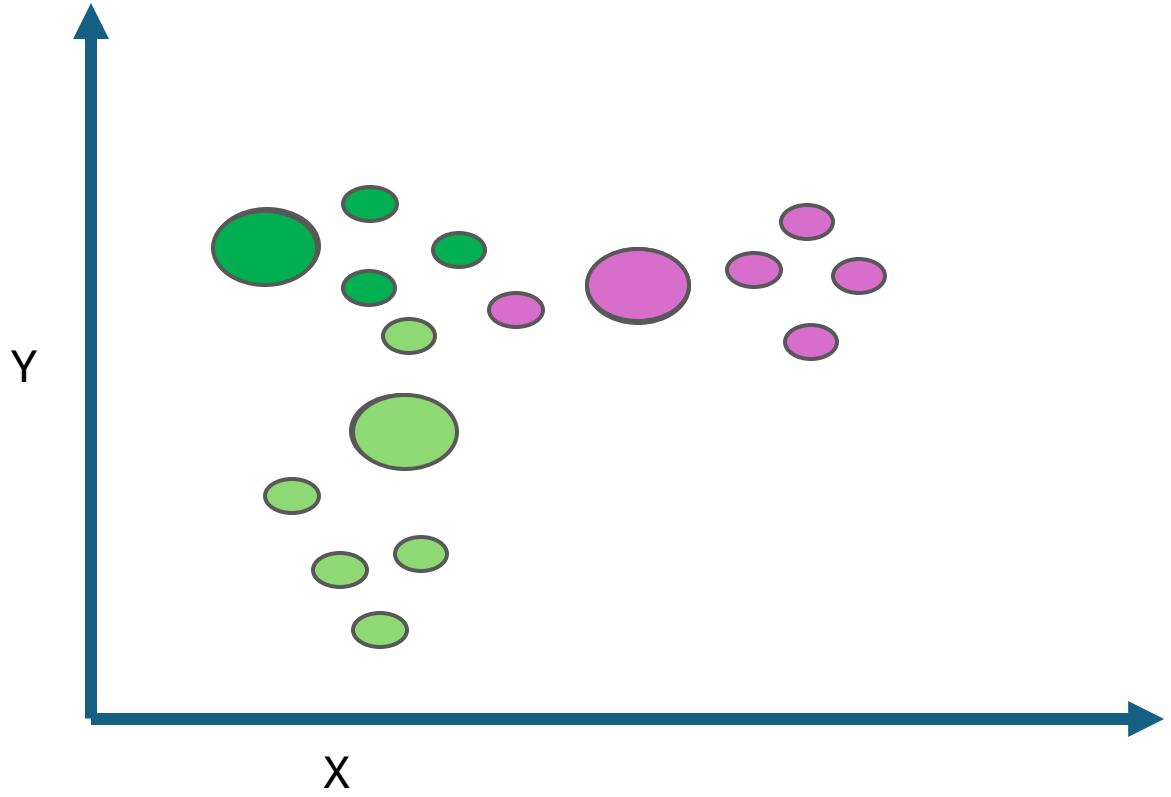
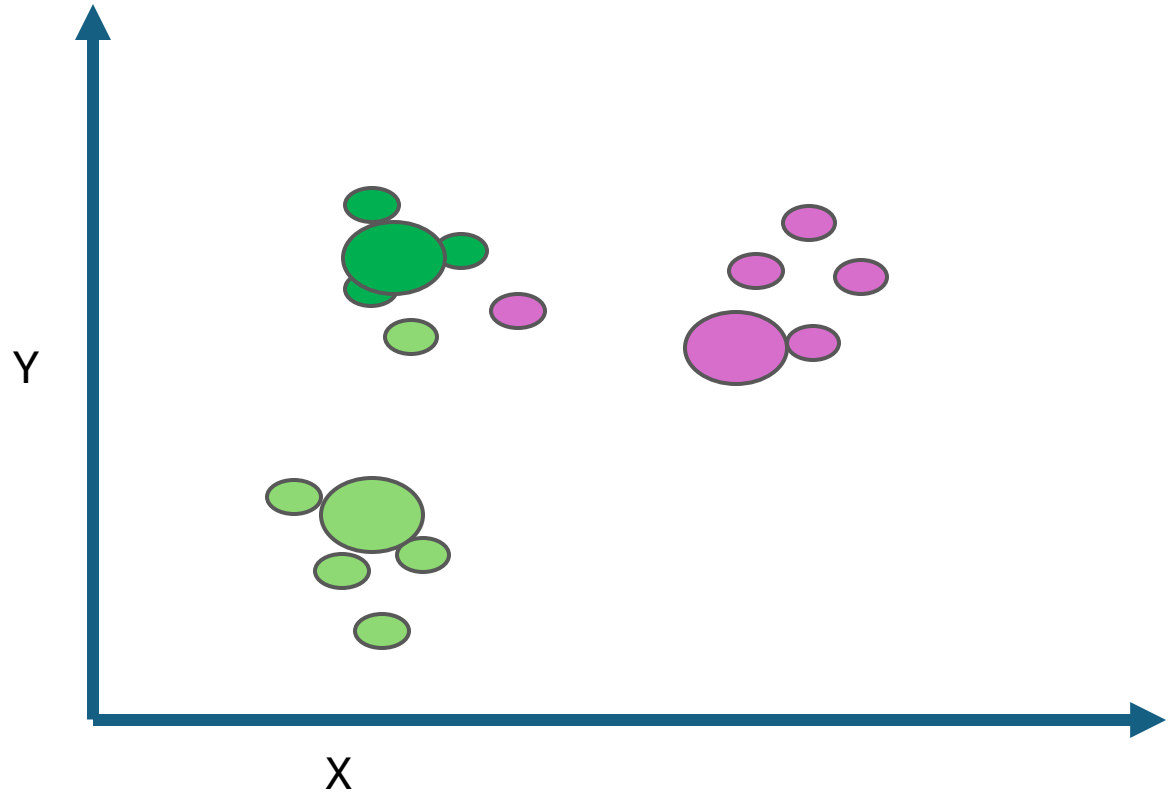


Updated Centers

- Example: 2D point patterns



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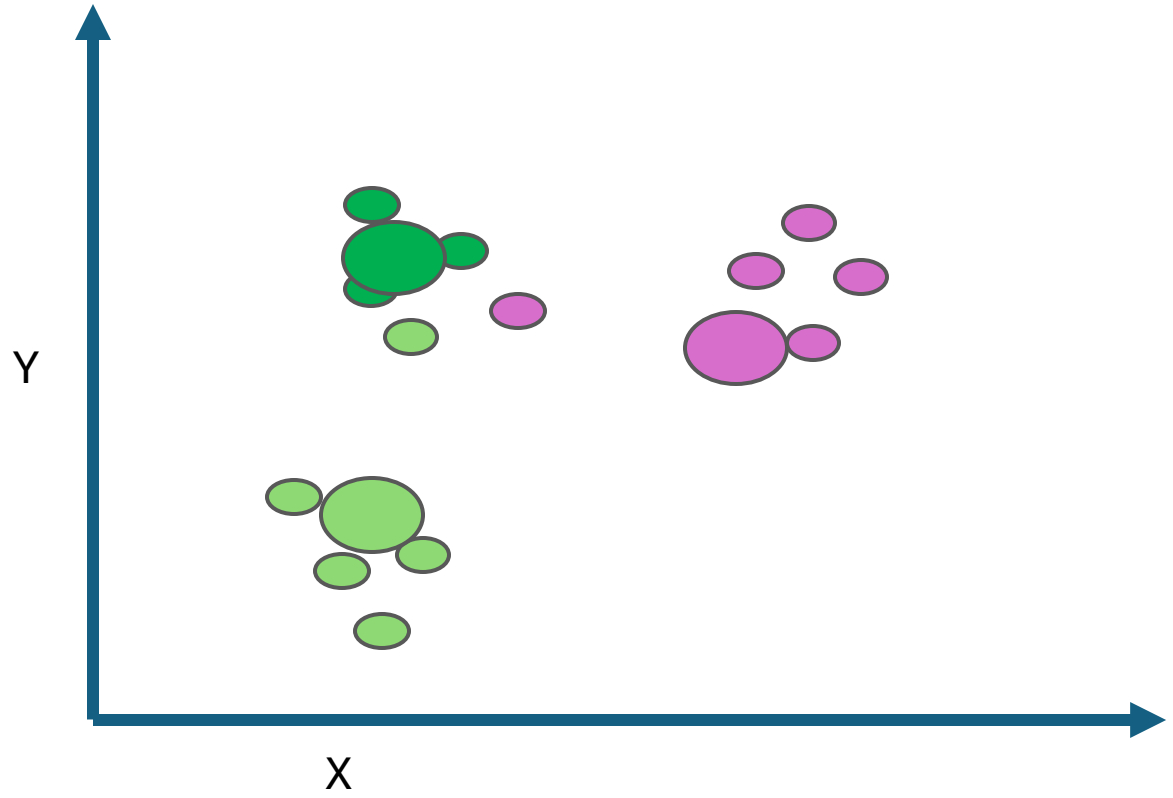
4. Repeat 2 & 3 until the assignments stop changing

Reassign data points to each cluster

- Example: 2D point patterns



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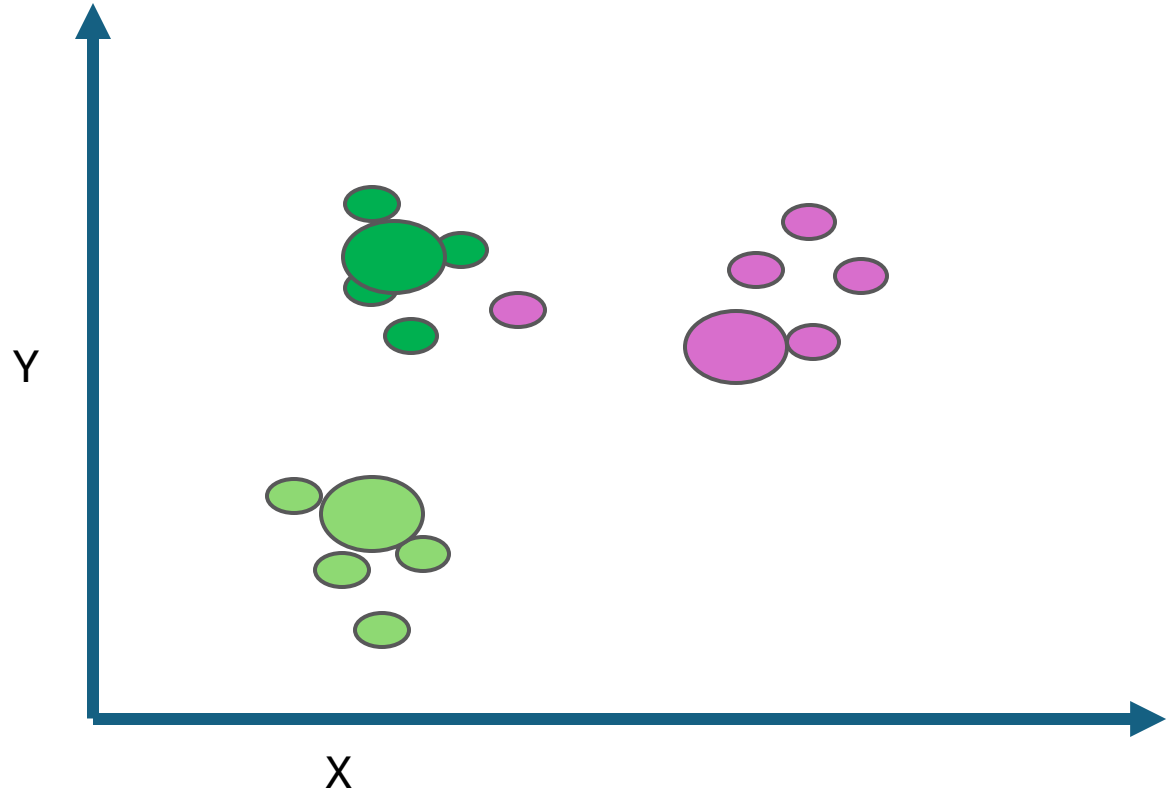

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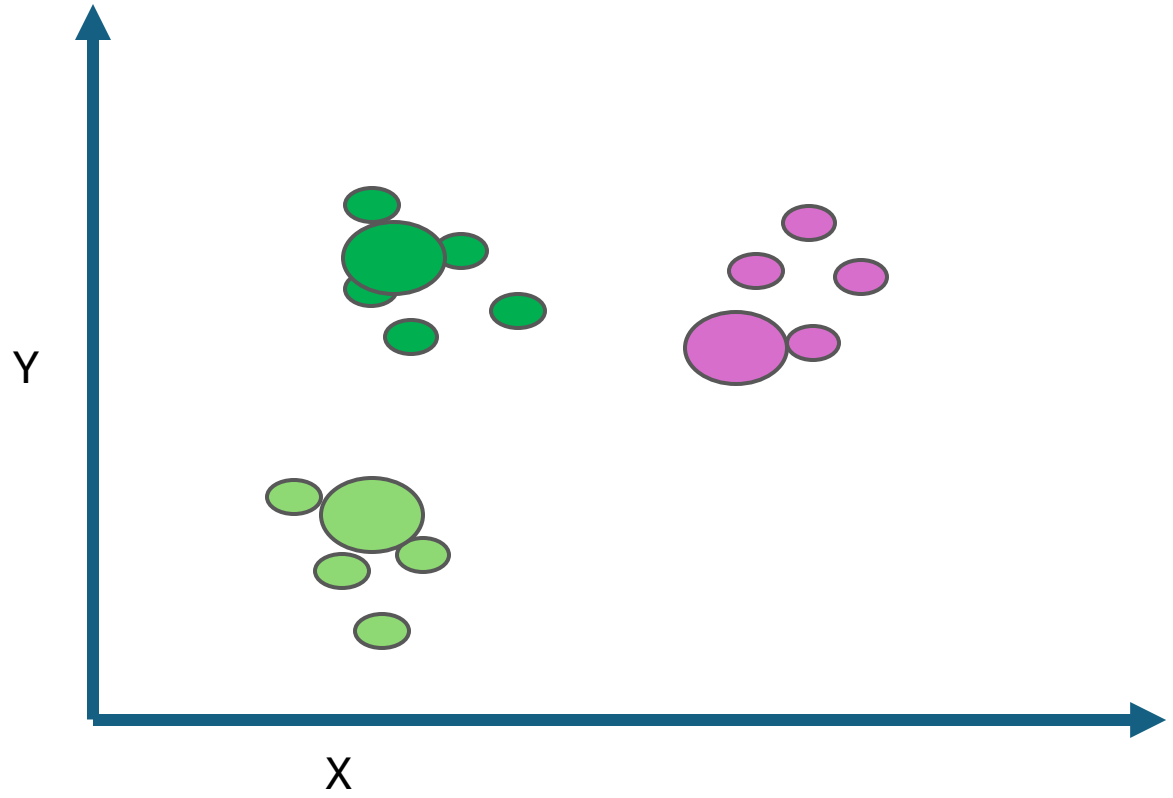

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Goal of K-means

Find k clusters e $= \{e_1, e_2, e_3, \ldots, e_k\}$ s.t. we minimize $J(e)$

$$\sum_{k=1}^{K} \sum_{i \in e_k} ||\overrightarrow{x_i} - \overrightarrow{\mu_k}||^2 = J(e)$$

Expectation Maximization Algorithm

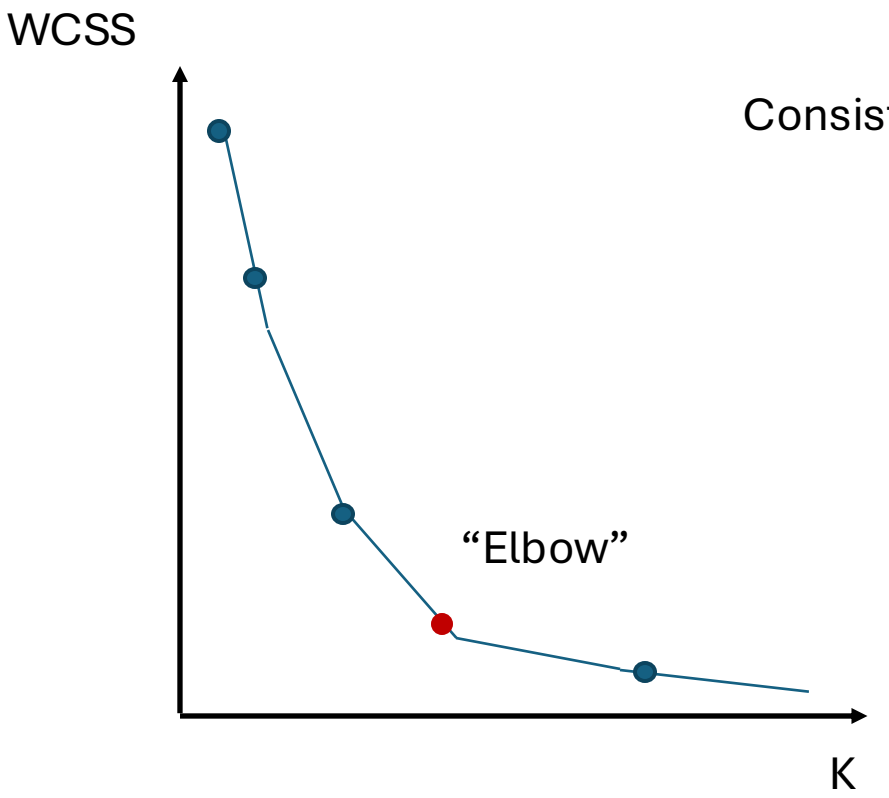
Expectation step:

- Assign members (data points) to each clusters

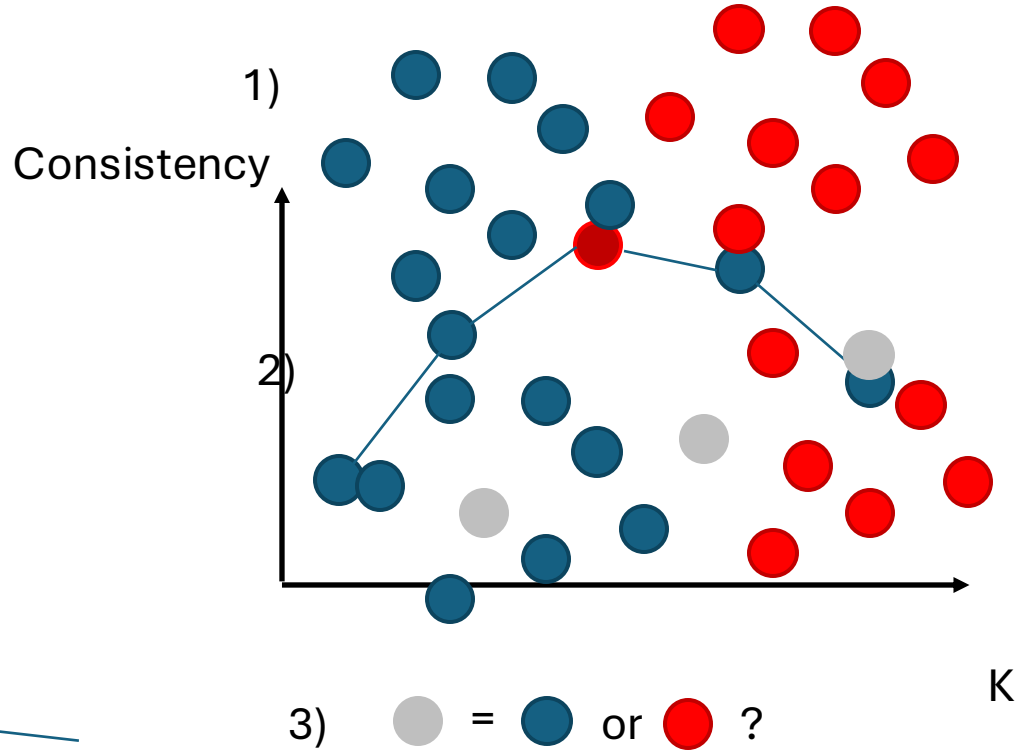
Maximization step:

- Recompute the means as the average of all members in a cluster

Choosing number of clusters



Elbow method



Cross-validation

Many other approaches: silhouette, gap statistics, Calinsky criterion etc…

Issues with k-means

Not generative:

- Cant use it to generate a new datapoint

Lack of uncertainty

- Doesn’t account for sizes of clusters or variance of clusters

Gaussian Mixture Models (GMM)