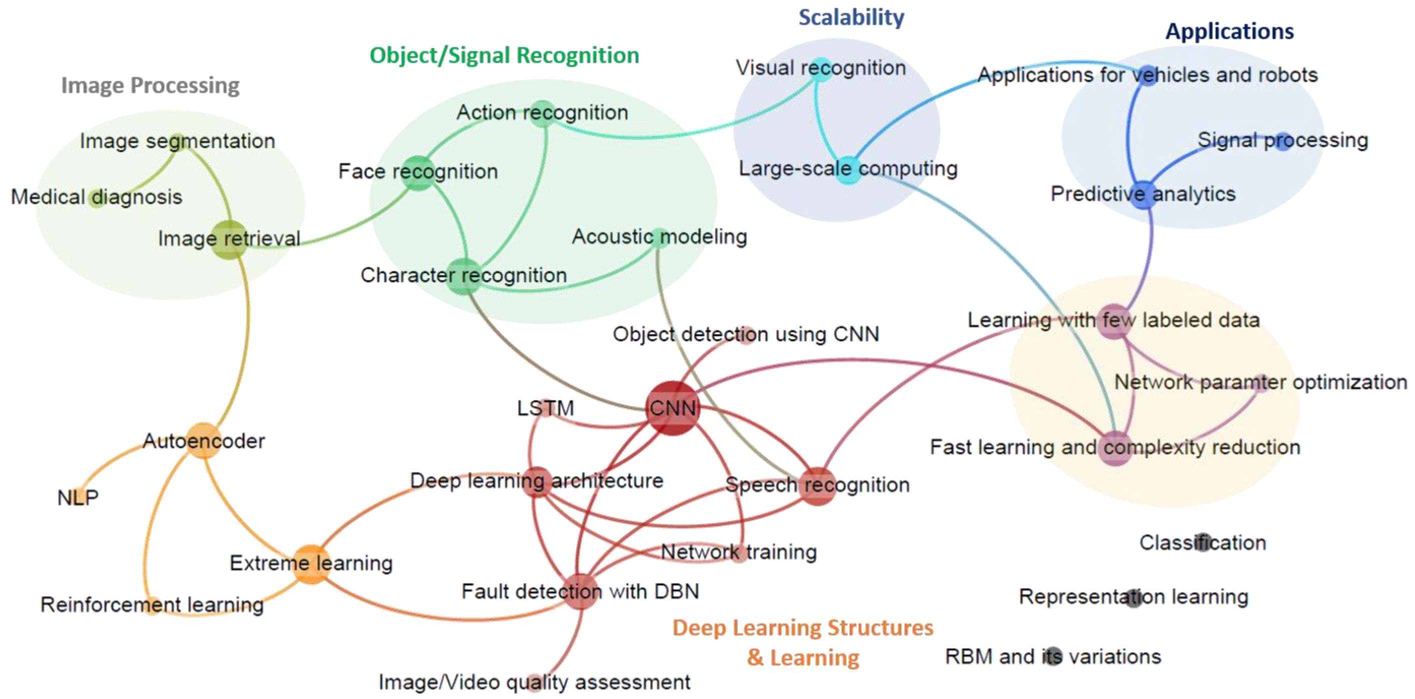


Clustering: Hierarchical Clustering

Pilsung Kang

School of Industrial Management Engineering

Korea University

AGENDA

01 Clustering: Overview

02 K-Means Clustering

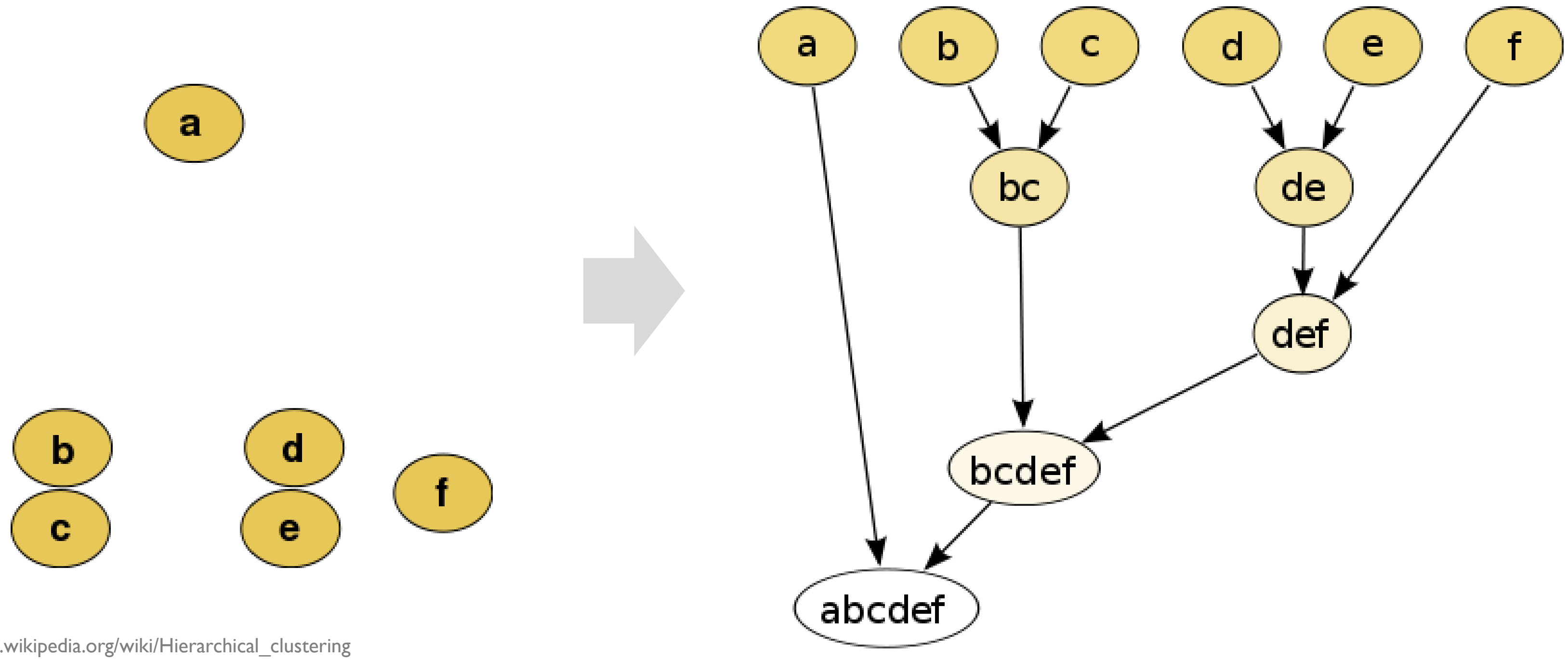
03 Hierarchical Clustering

04 Density-based Clustering: DBSCAN

04 R Exercise

Hierarchical Clustering

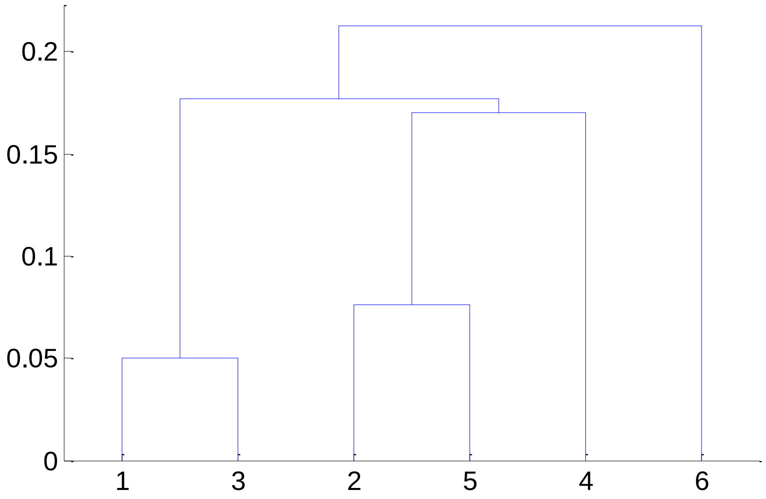
- Hierarchical clustering
  - ✓ Produces a set of nested clusters organized as a hierarchical tree
  - ✓ Can be visualized as a dendrogram
    - A tree like diagram that records the sequences of merges or splits

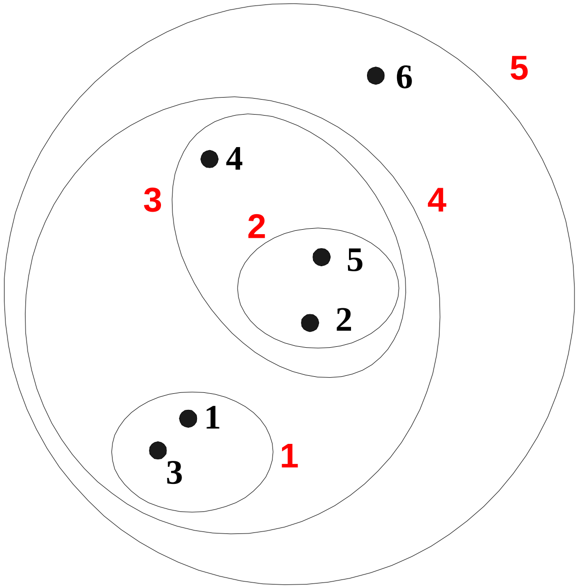


https://en.wikipedia.org/wiki/Hierarchical_clustering

Hierarchical Clustering

- Hierarchical clustering
  - ✓ Produces a set of nested clusters organized as a hierarchical tree
  - ✓ Can be visualized as a dendrogram
    - A tree like diagram that records the sequences of merges or splits



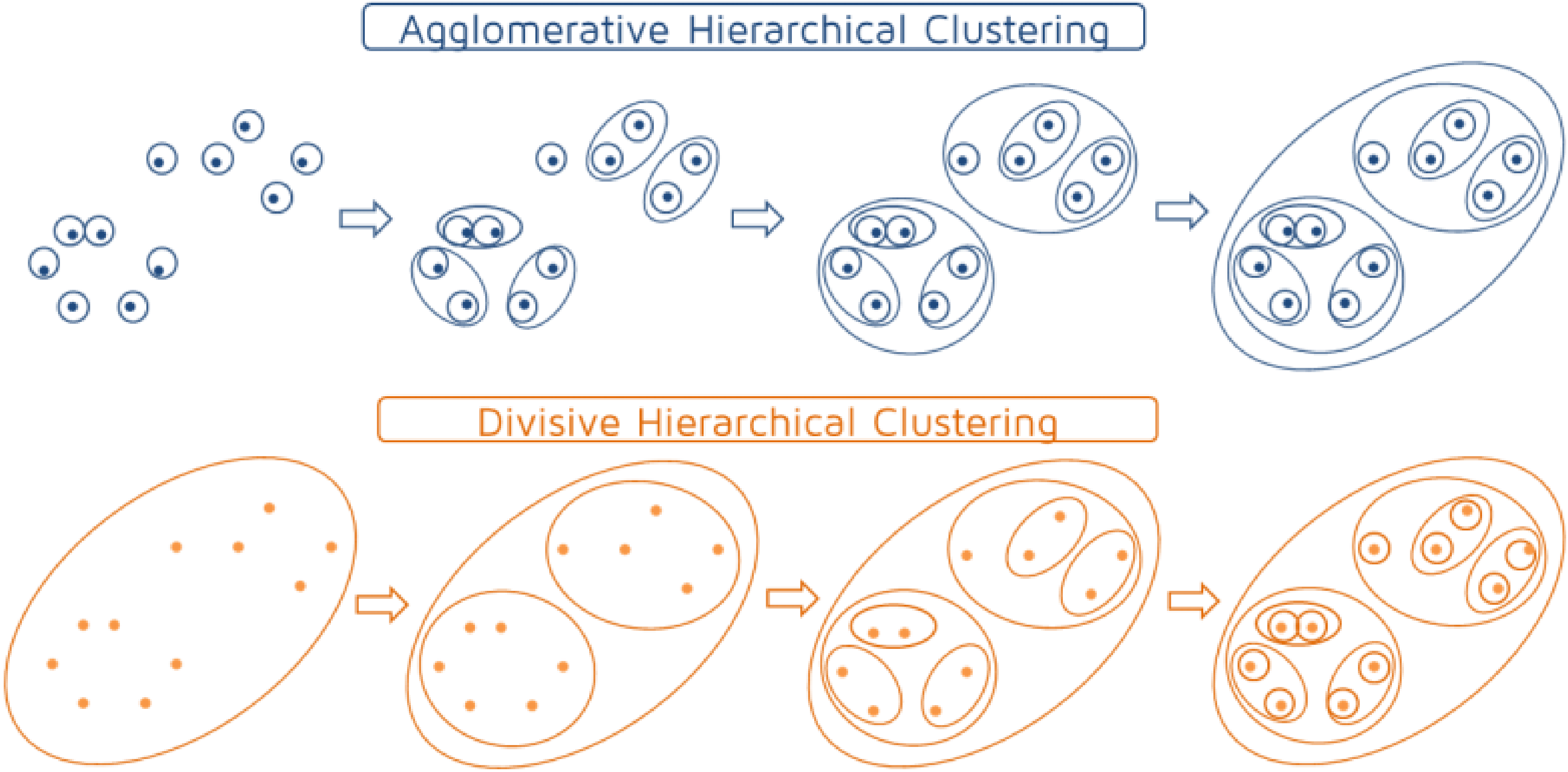


Hierarchical Clustering

- Strengths of Hierarchical clustering
  - ✓ Do not have to assume any particular number of clusters
    - ▪ Any desired number of clusters can be obtained by **'cutting'** the dendrogram at the proper level
  - ✓ May correspond to meaningful taxonomies
- Two main types of hierarchical clustering
  - ✓ Agglomerative clustering
    - ▪ Start with the points as individual clusters
    - ▪ At each step, merge the closest pair of clusters until only one cluster left
  - ✓ Divisive clustering
    - ▪ Start with one, all-inclusive cluster
    - ▪ At each step, split a cluster until each cluster contains a point

Hierarchical Clustering

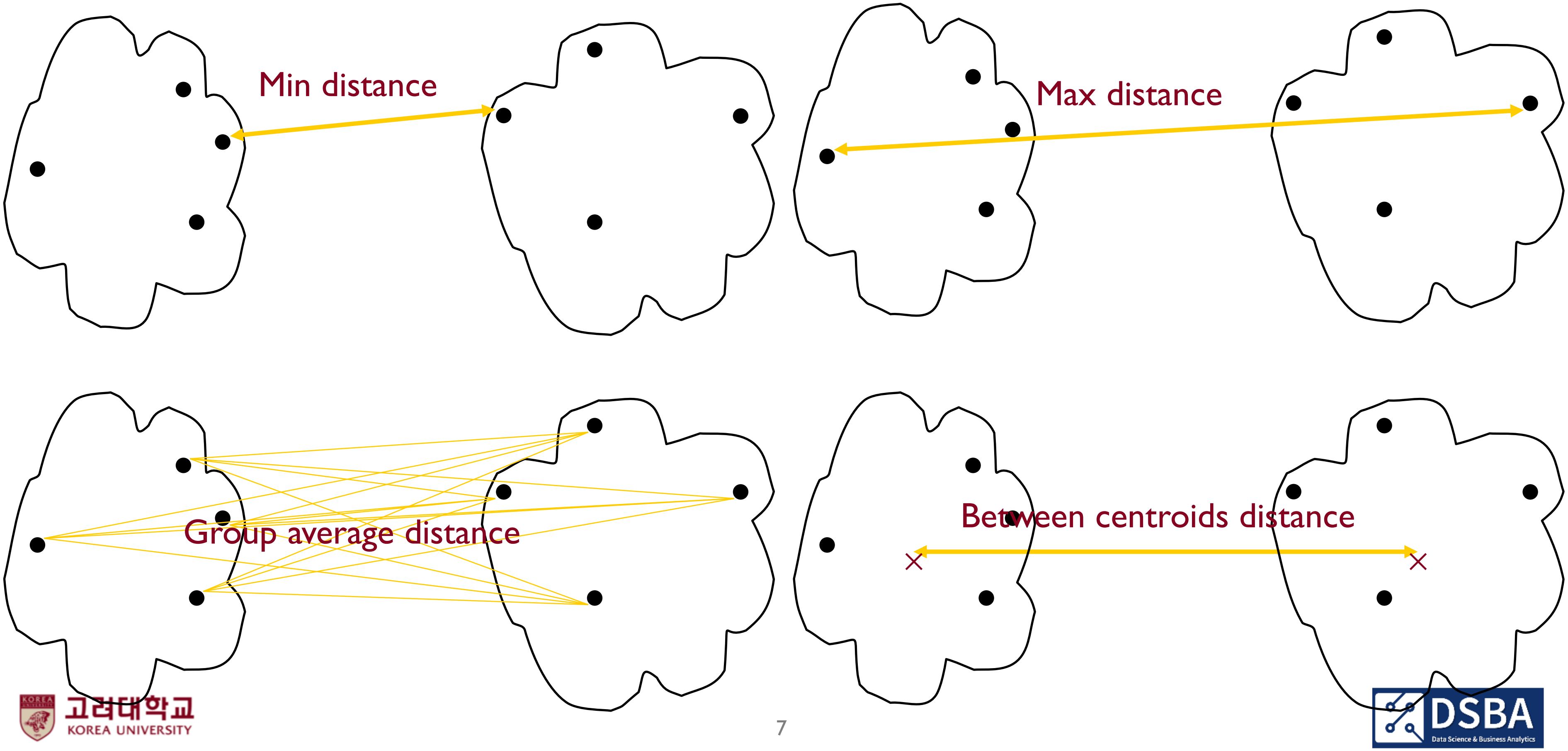
- Strengths of Hierarchical clustering
  - ✓ Agglomerative clustering vs. Divisive clustering


Agglomerative Hierarchical Clustering
Divisive Hierarchical Clustering

https://quantdare.com/hierarchical-clustering/

Hierarchical Clustering

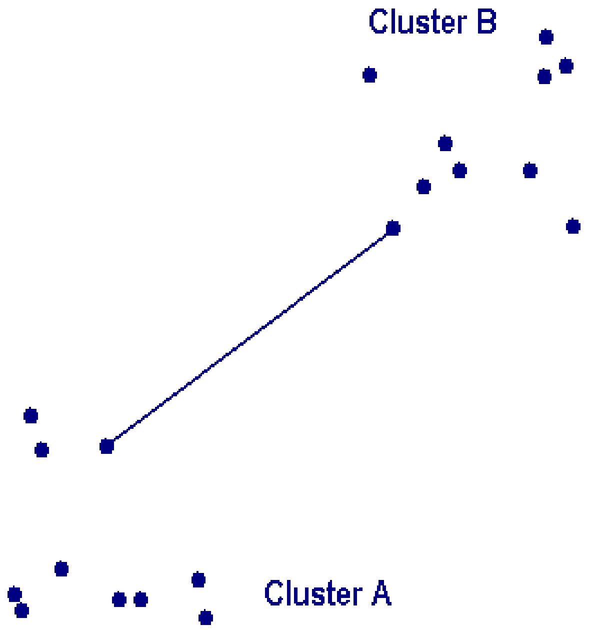
- Agglomerative clustering algorithm
  - ✓ Key operation: computation of the proximity of two clusters
    - Min, max, group average, between centroid, etc.



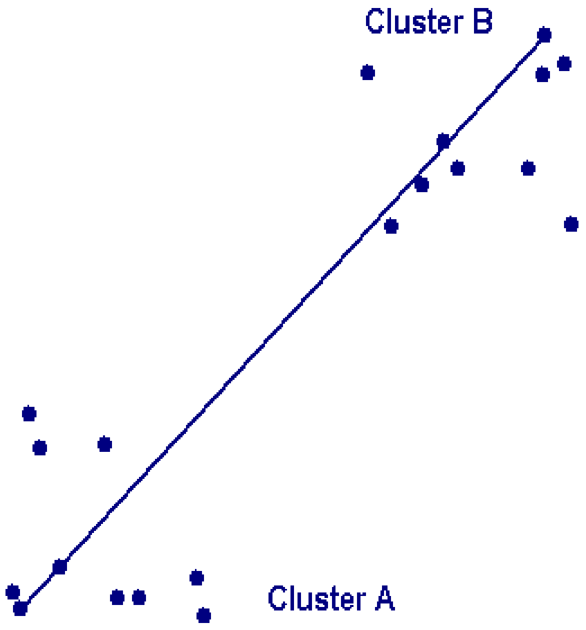
Hierarchical Clustering

- Agglomerative clustering algorithm
  - ✓ Single linkage: minimum distance between two data points in different clusters
  - ✓ Complete linkage: maximum distance between two data points in different clusters

Single linkage

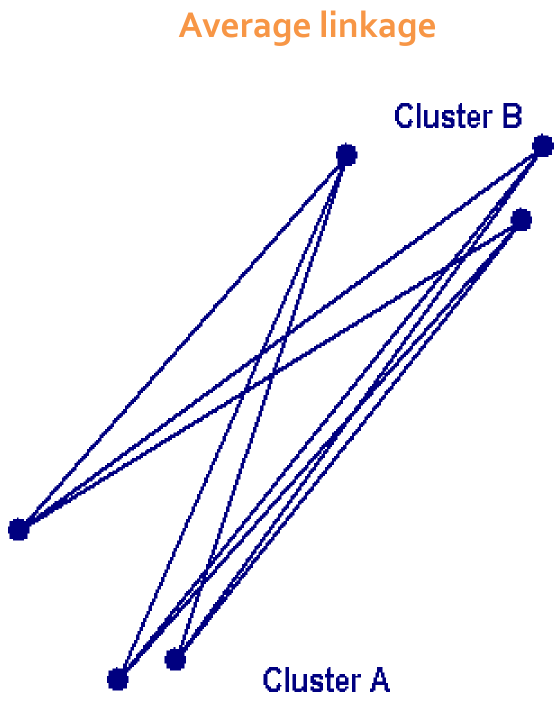


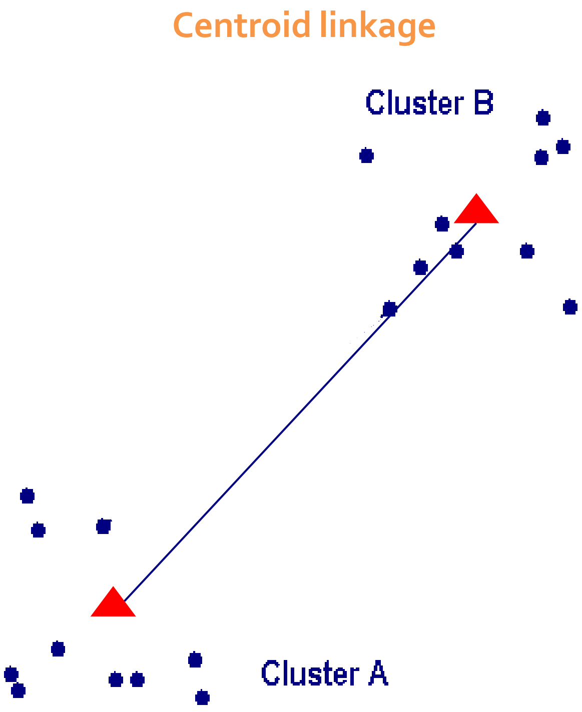
Complete linkage



Hierarchical Clustering

- Agglomerative clustering algorithm
  - ✓ Average linkage: mean distance between two data points in different clusters
  - ✓ Centroid linkage: distance between centroids in different clusters



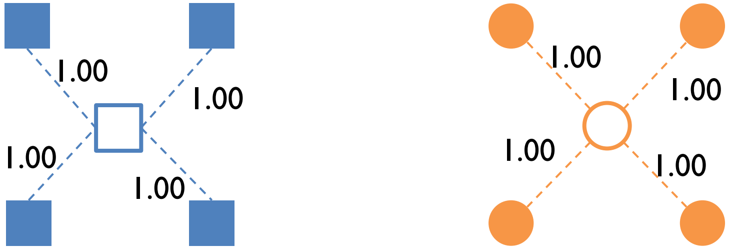


Hierarchical Clustering

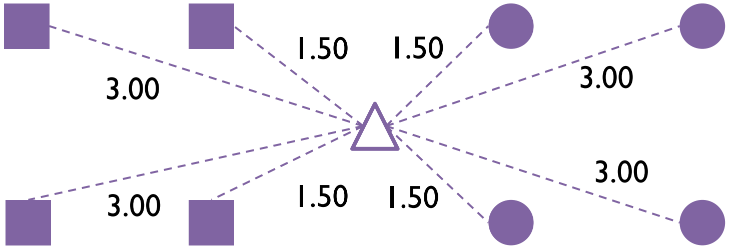
- Agglomerative clustering algorithm

  ✓ Ward method: Compare the sum of squared error (SSE) before and after the merge

  - SSE before merge: $1^2 + 1^2 + 1^2 + 1^2 + 1^2 + 1^2 + 1^2 + 1^2 = 8$



  - SSE after merge: $4 \times 1.5^2 + 4 \times 3^2 = 45$



  - Ward distance: 45-8 = 37

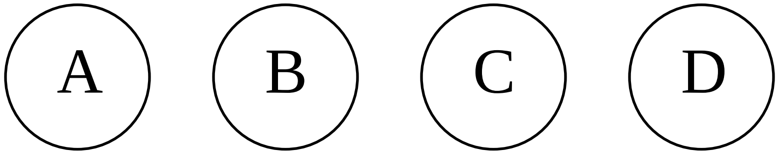
Hierarchical Clustering

- Agglomerative Clustering Procedure
  - ✓ Step 1: Assume that each data point is an individual cluster, compute the cluster distance
  - ✓ Step 2: Repeat the following procedure
    - ▪ Step 2-1: Merge the two closest clusters
    - ▪ Step 2-2: Update the cluster distance matrix
  - ✓ When all data points are merged as a single cluster, stop

Hierarchical Clustering

- Example

Initial Data Items



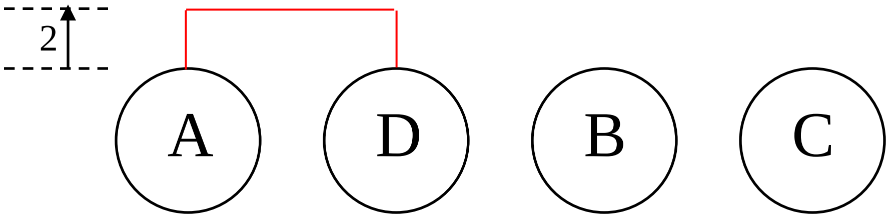
Distance Matrix

Dist	A	B	C	D
A		20	7	2
B			10	25
C				3
D				

Hierarchical Clustering

- Example

Current Clusters



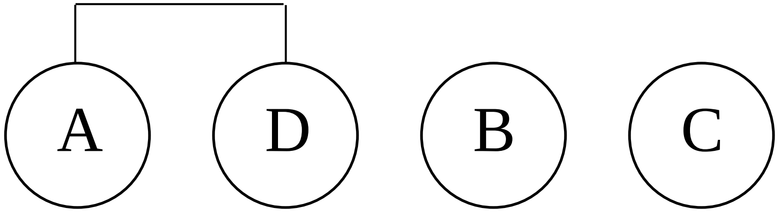
Distance Matrix

Dist	A	B	C	D
A		20	7	2
B			10	25
C				3
D				

Hierarchical Clustering

- Example

Current Clusters



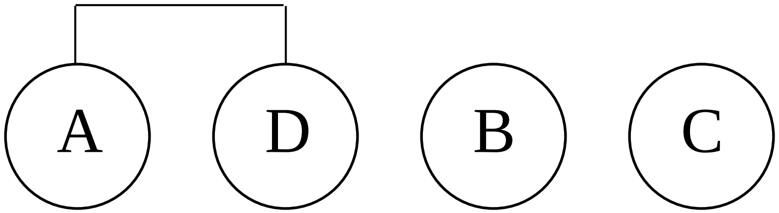
Distance Matrix

Dist	AD	B	C	
AD		20	3	
B			10	
C				

Hierarchical Clustering

- Example

Current Clusters



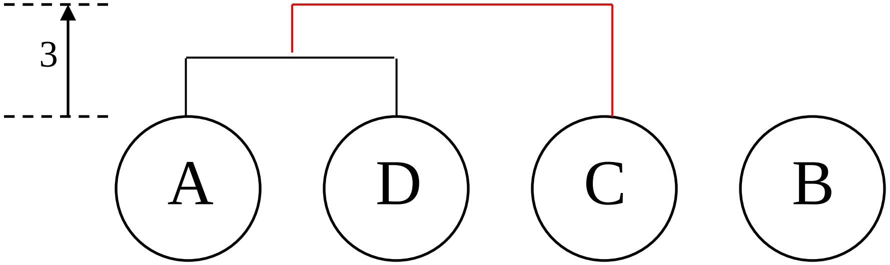
Distance Matrix

Dist	AD	B	C	
AD		20	3	
B			10	
C				

Hierarchical Clustering

- Example

Current Clusters



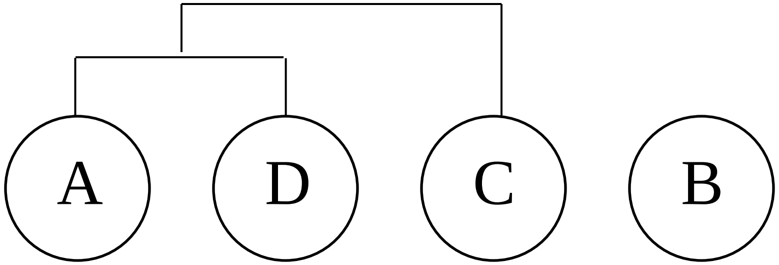
Distance Matrix

Dist	AD	B	C	
AD		20	3	
B			10	
C				

Hierarchical Clustering

- Example

Current Clusters



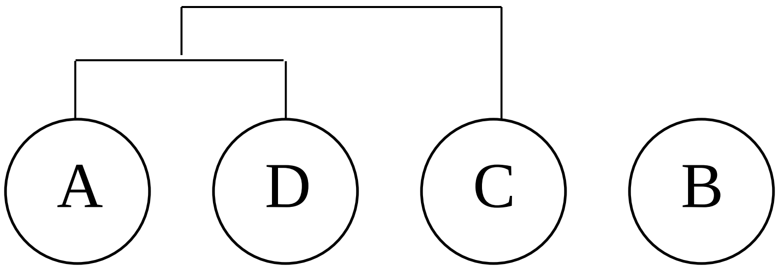
Distance Matrix

Dist	AD C	B		
AD C		10		
B				

Hierarchical Clustering

- Example

Current Clusters



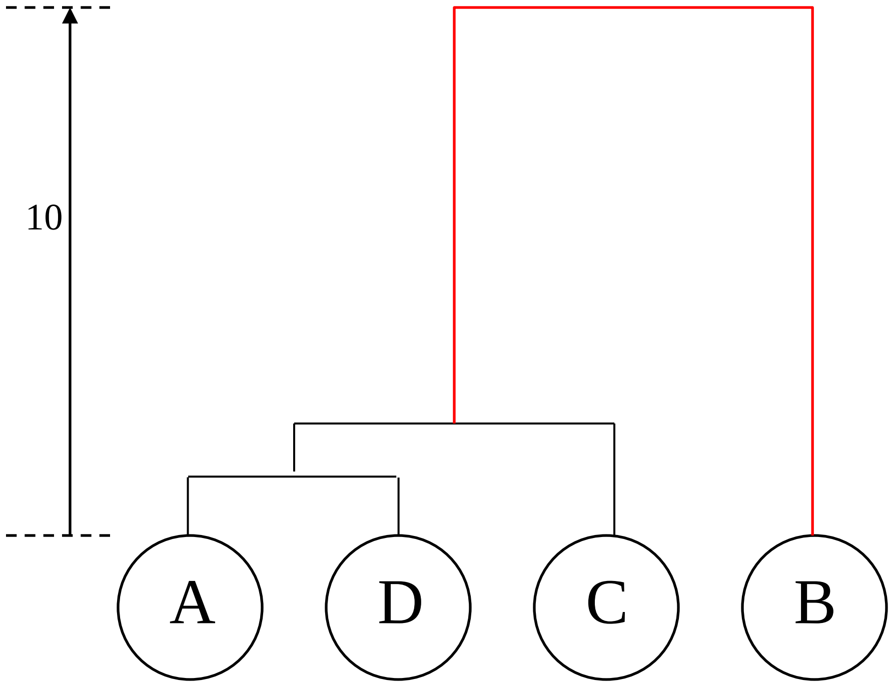
Distance Matrix

Dist	ADC	B		
ADC		10		
B				

Hierarchical Clustering

- Example

Current Clusters



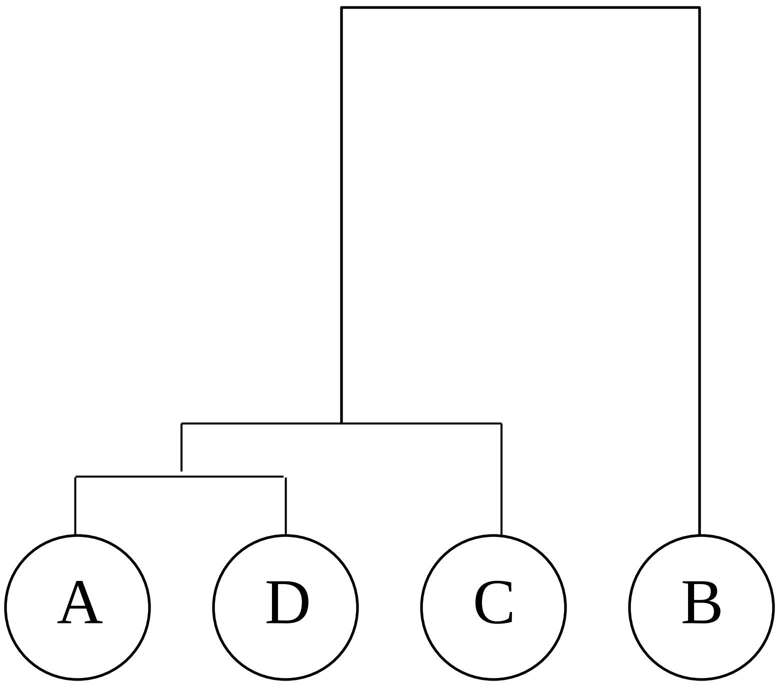
Distance Matrix

Dist	AD C	B		
AD C		10		
B				

Hierarchical Clustering

- Example

Final Result

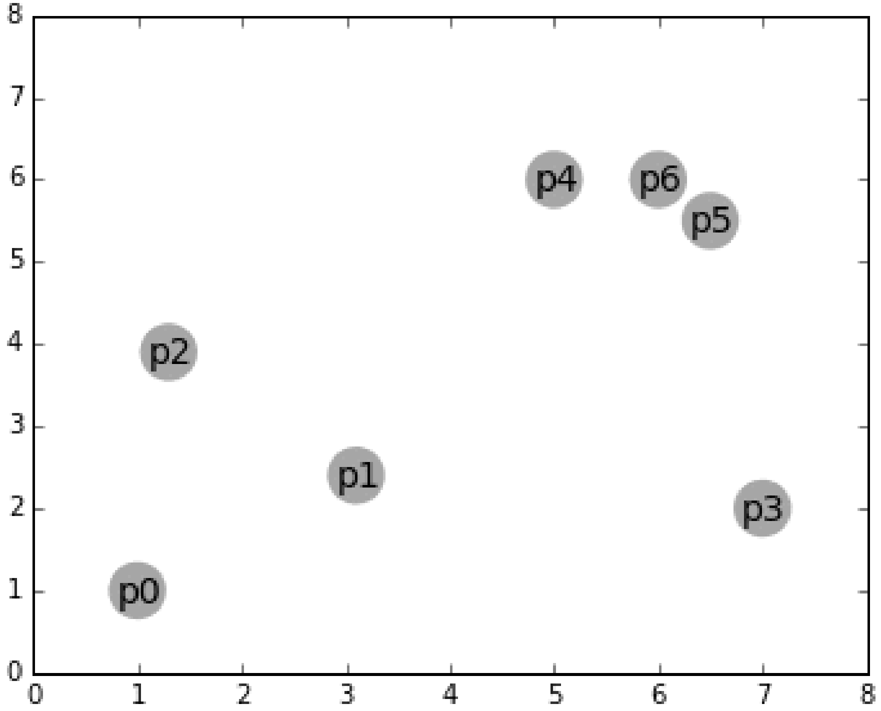


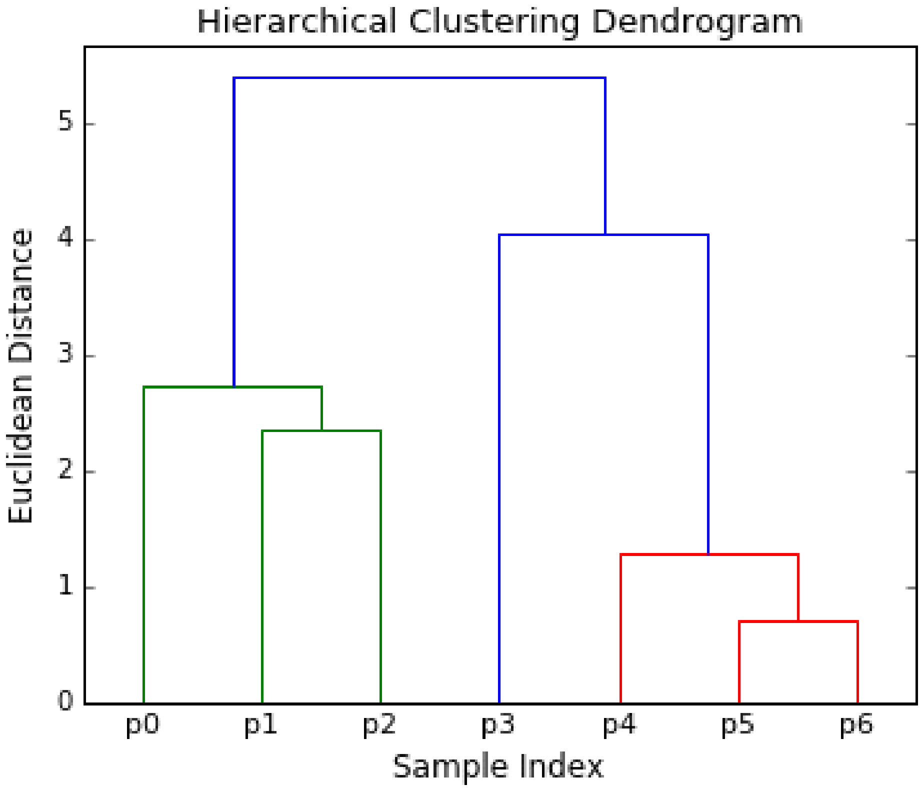
Distance Matrix

Dist	AD CB			
AD CB				

Hierarchical Clustering

- HC example





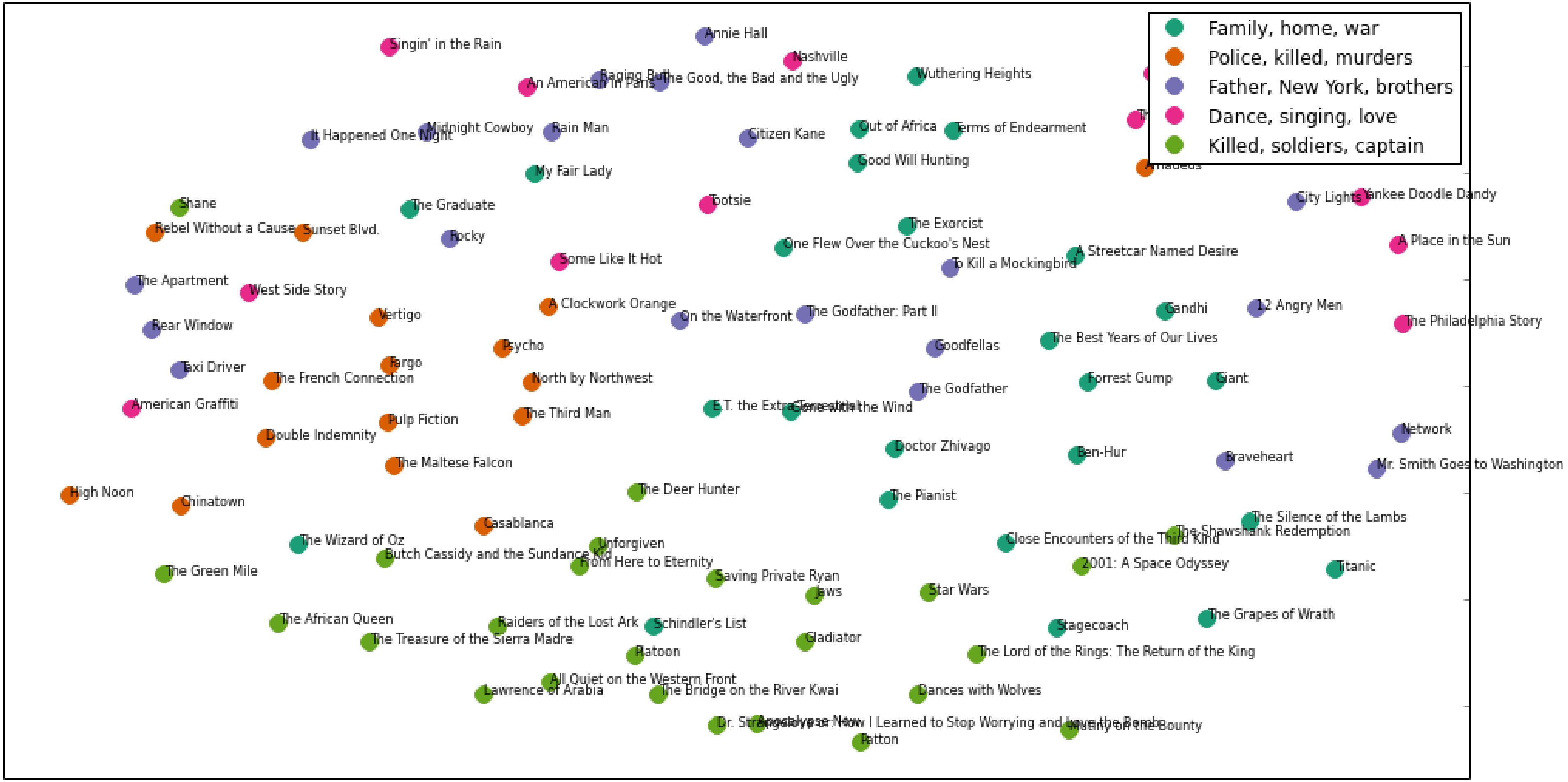
https://towardsdatascience.com/the-5-clustering-algorithms-data-scientists-need-to-know-a36d136ef68

Hierarchical Clustering

- Clustering top 100 film synopses (http://brandonrose.org/clustering)
  - ✓ Tokenizing and stemming each synopsis
  - ✓ Transforming the corpus into vector space using tf-idf
  - ✓ Calculating cosine distance between each document as a measure of similarity
  - ✓ Clustering the documents using the k-means algorithm
  - ✓ Using multidimensional scaling to reduce dimensionality within the corpus
  - ✓ Plotting the clustering output using matplotlib and mpld3
  - ✓ Conducting a hierarchical clustering on the corpus using Ward clustering
  - ✓ Plotting a Ward dendrogram
  - ✓ Topic modeling using Latent Dirichlet Allocation (LDA)

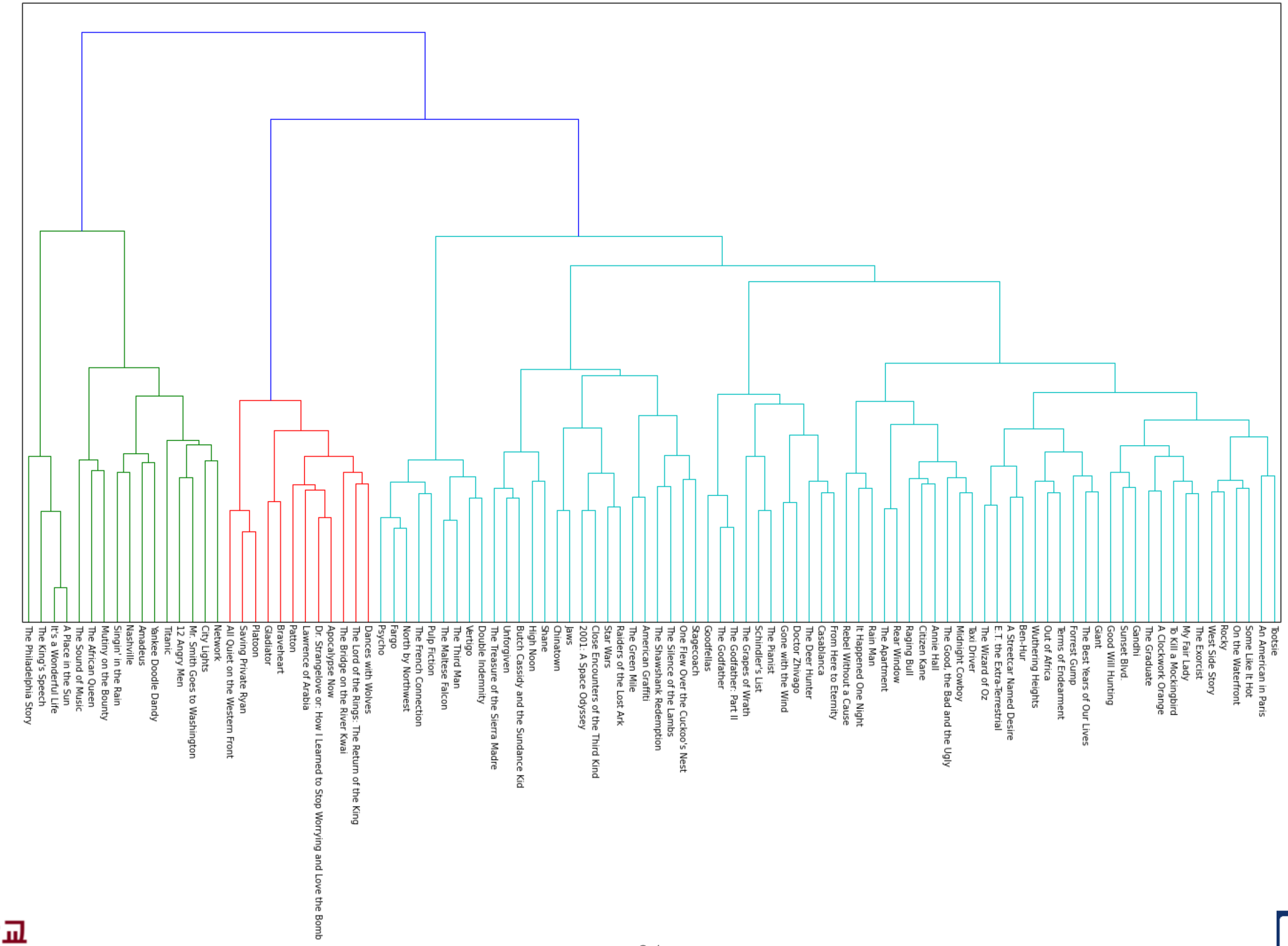
Hierarchical Clustering

- MDS result



Hierarchical Clustering

- Hierarchical clustering



ANY
questions?