

Ch 12.1, 12.4: Unsupervised Learning & Clustering

Lecture 32 - CMSE 381

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Dept of Computational Mathematics, Science & Engineering

Wed, Nov 19, 2025

Announcements

Last time:

- Convolutional Neural Nets

This lecture:

- Clustering (Just hierarchical clustering)

Announcements:

- No more homework!
- 11/26: Project office hours, zoom only ([link on website](#)), send a message on slack!
- Fri 11/21: Review - submit your questions
- Monday 11/24: Exam 3
 - ▶ Content since 2nd Exam (Ch 7 and on)
 - ▶ One page (8.5x11) handwritten cheat sheet
 - ▶ no-internet Calculator

21	F	10/24	Polynomial & Step Functions	7.1-7.2	HW #5 Due Sun 10/26
22	M	10/27	Step Functions; Basis functions; Start Splines	7.2-7.4	
23	W	10/29	Regression Splines	7.4	
24	F	10/31	Decision Trees	8.1	HW #6 Due Sun 11/2
25	M	11/3	Random Forests	8.2.1, 8.2.2	
26	W	11/5	Maximal Margin Classifier	9.1	
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32	W	11/19	Unsupervised learning / clustering	12.1, 12.4	
33	F	11/21	Review		HW #9 Due Sun 11/23
	M	11/24	Midterm #3		
	W	11/26	Virtual: Project Office Hours		
	F	11/28	Thanksgiving		
	M	12/1	Virtual: Project Office Hours		
	W	12/3	Virtual: Project Office Hours		
	F	12/5			Project Due
	M	12/8			
	W	12/10			
	F	12/12	No final exam		Honors Project Due

Section 1

Unsupervised learning

Supervised vs Unsupervised Learning

Supervised

Unsupervised

Some examples of unsupervised problems

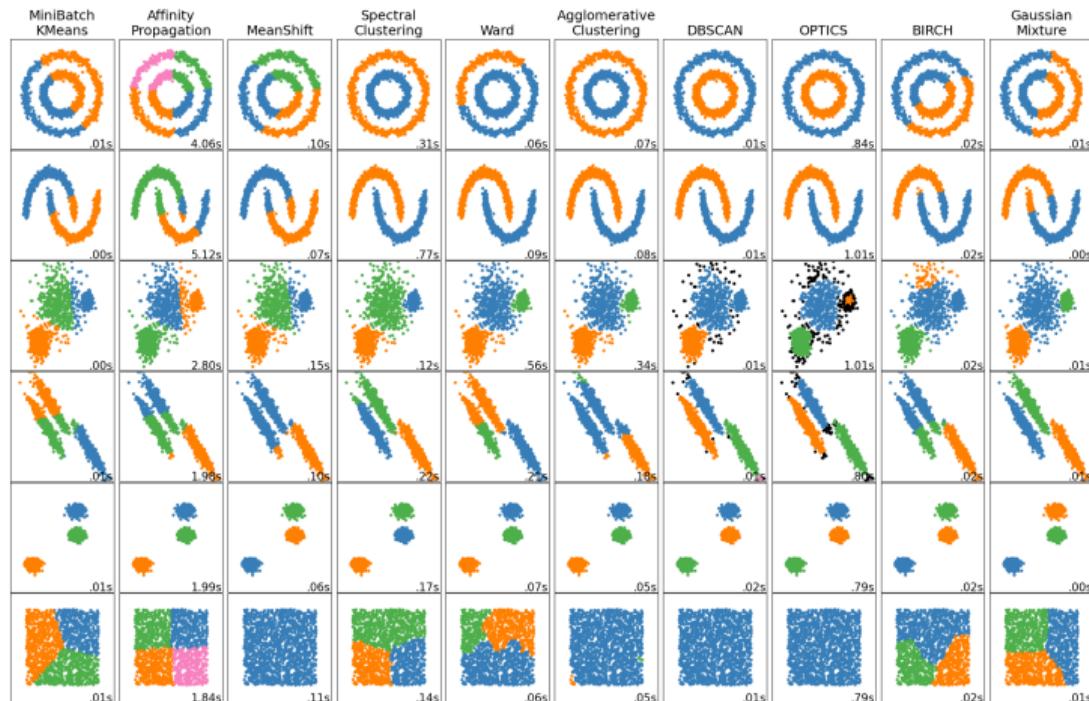
- Assay gene expression levels in 100 patients with breast cancer, looking for subgroups with similar qualities
- Online shopping: find groups of shoppers with similar browsing and purchase histories and show relevant related products.
- Search engine picking results to show

Section 2

Clustering

Big idea

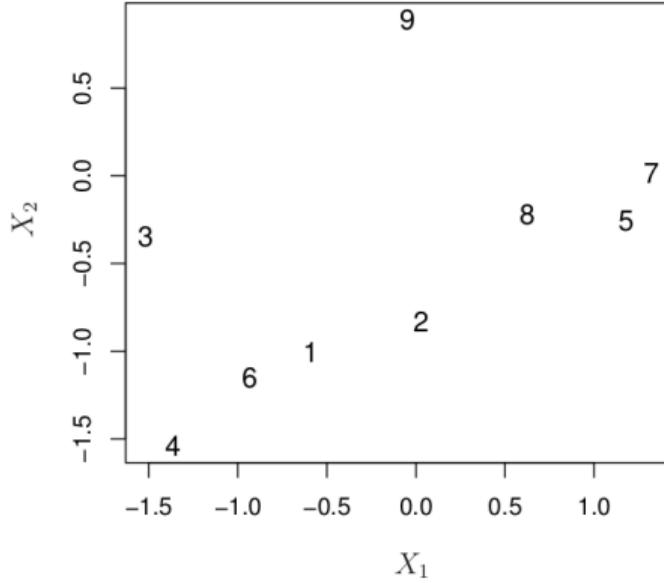
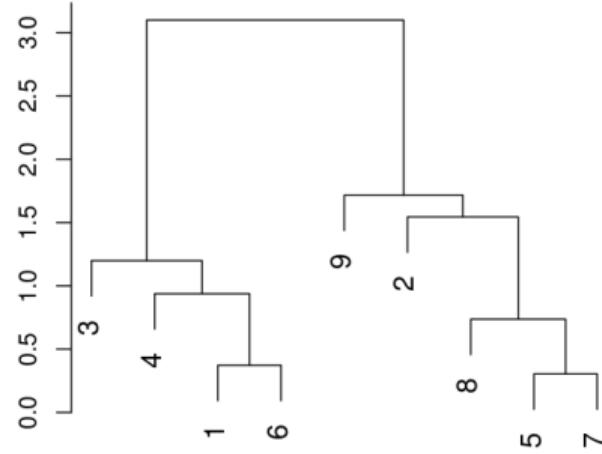
Clustering: relation between samples



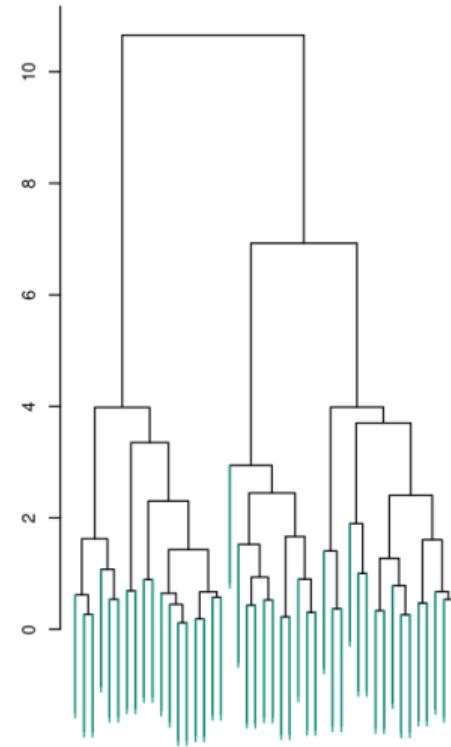
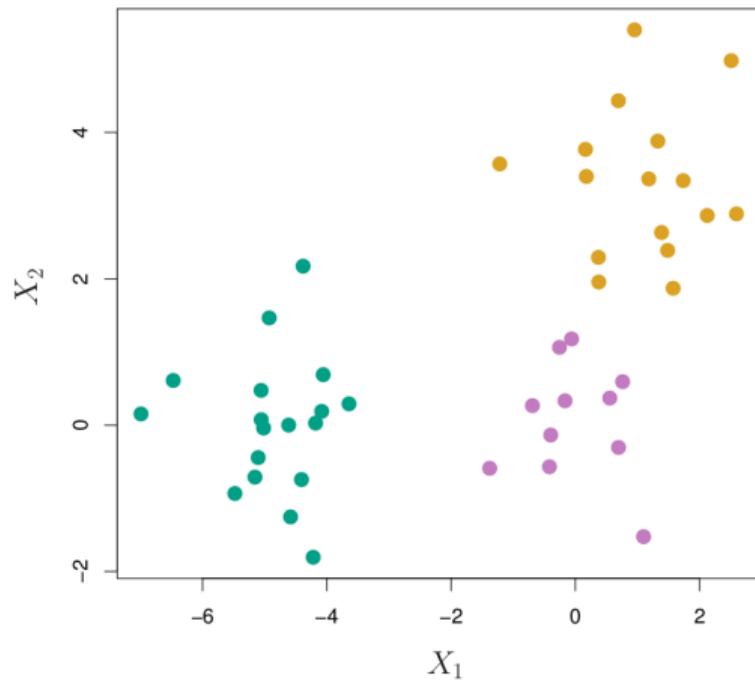
Section 3

Hierarchical Clustering

Dendrogram



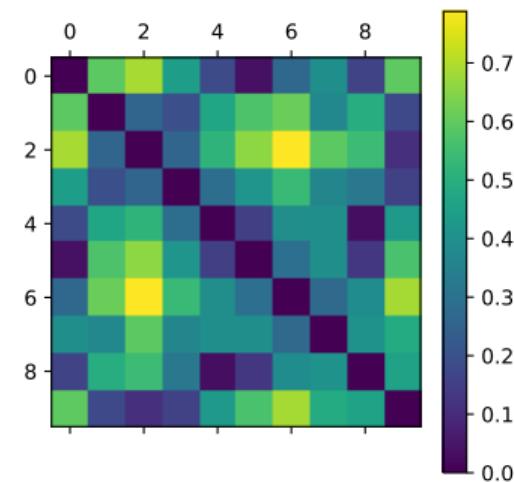
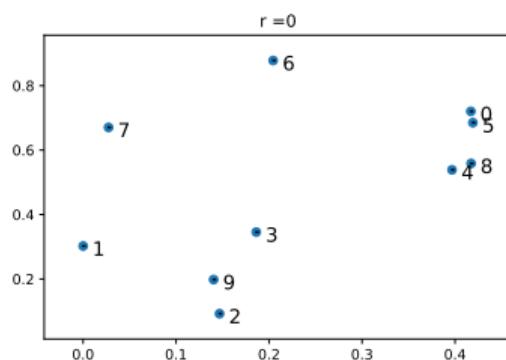
A bigger example



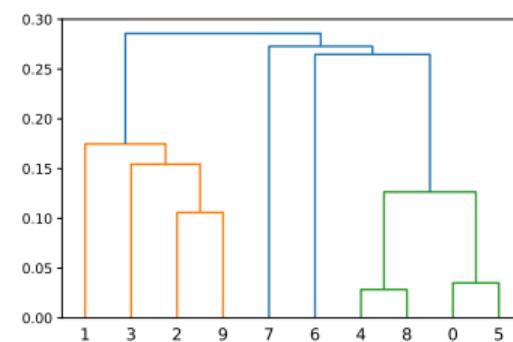
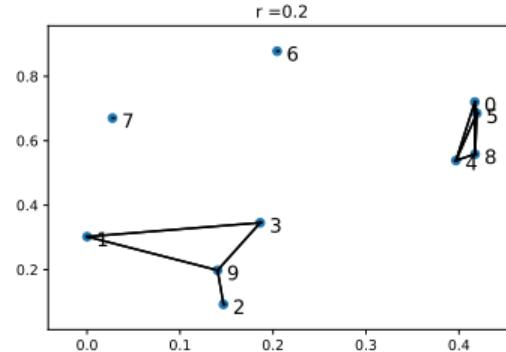
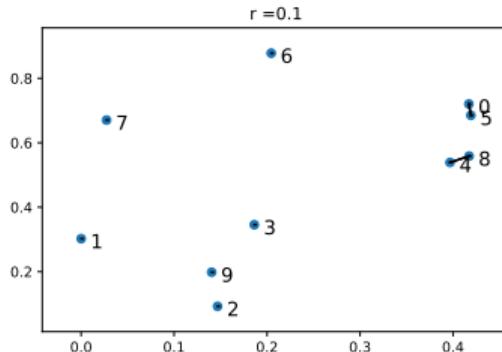
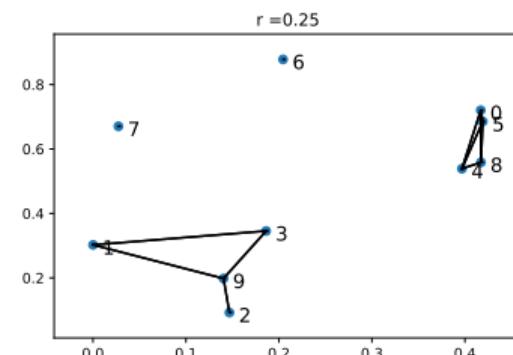
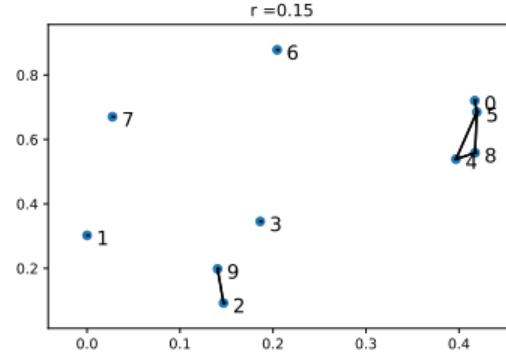
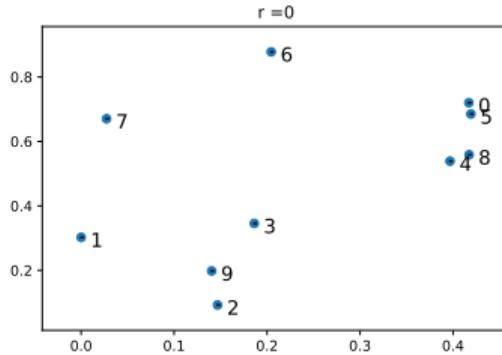
Single linkage

Distance between cluster A and cluster B :
Smallest distance between the points

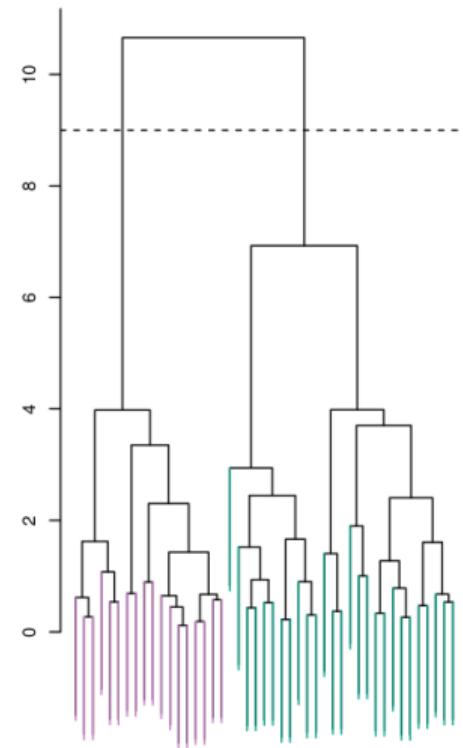
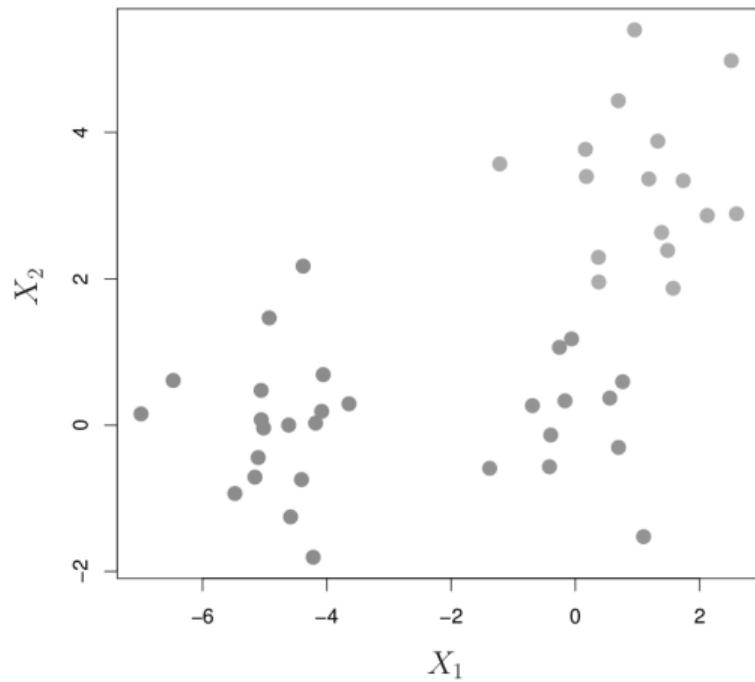
$$L(A, B) = \min_{a \in A, b \in B} \|a - b\|$$



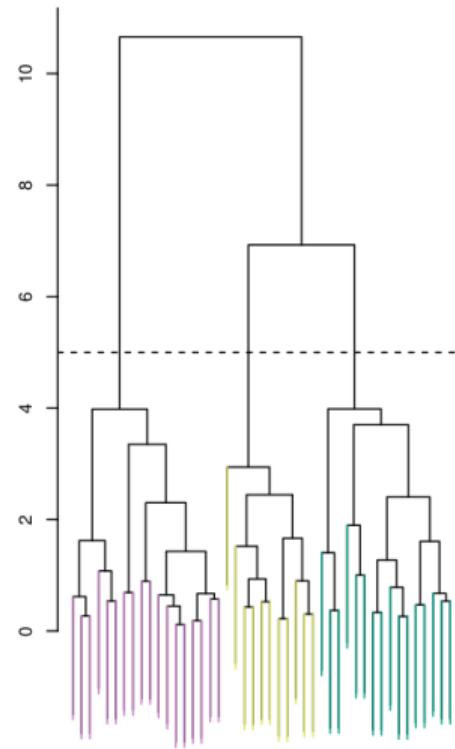
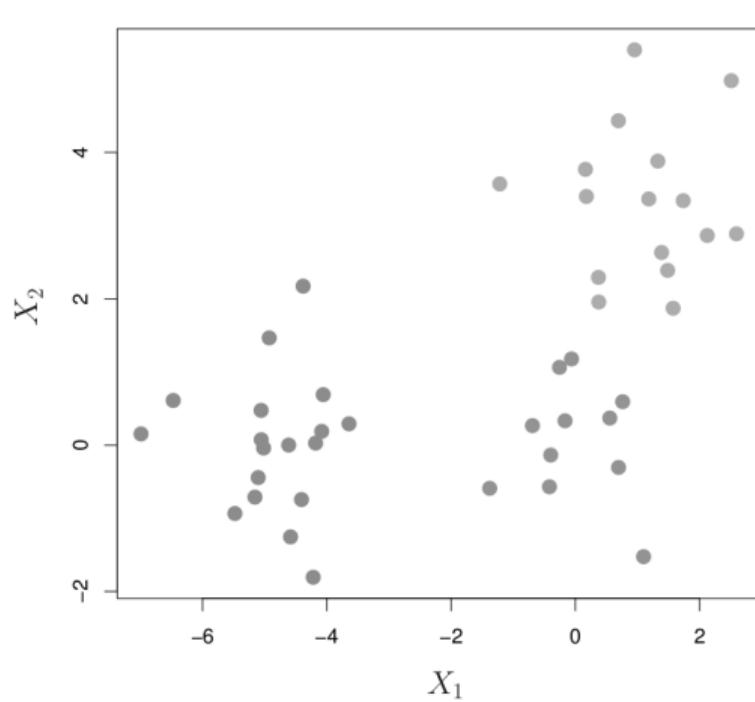
Building the dendrogram



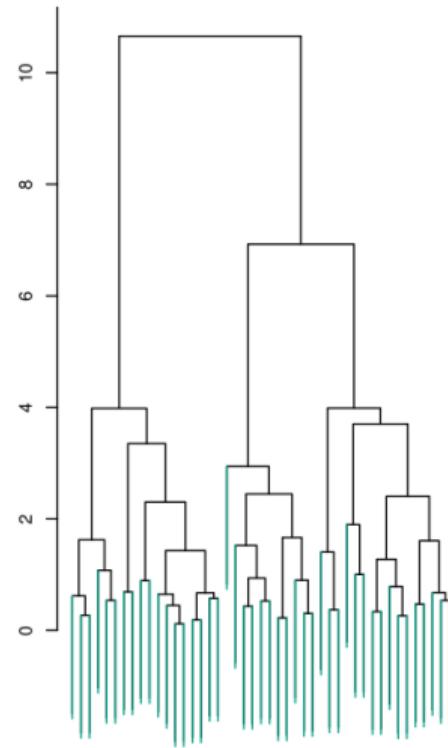
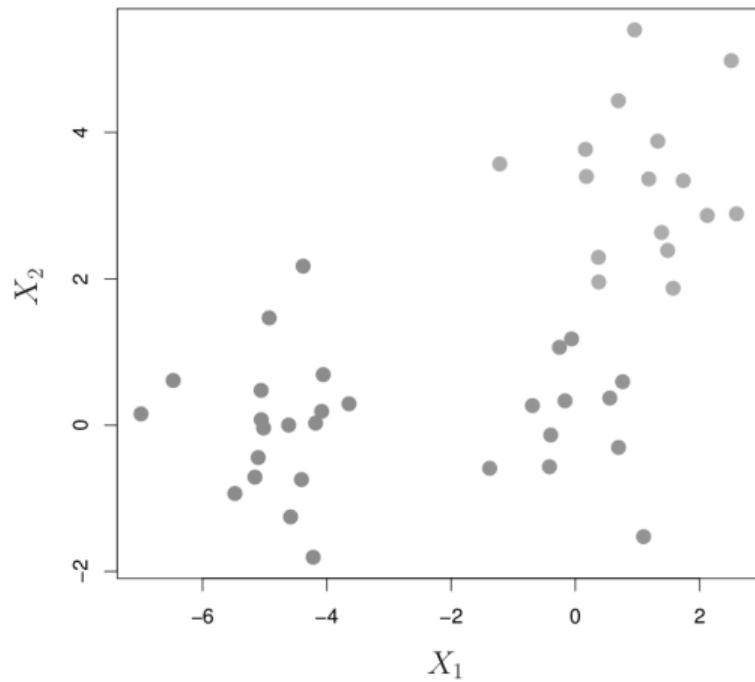
How to get clusters



How to get different clusters



Can get any number of clusters



Test your understanding: [PolIEv](#)

Linkage

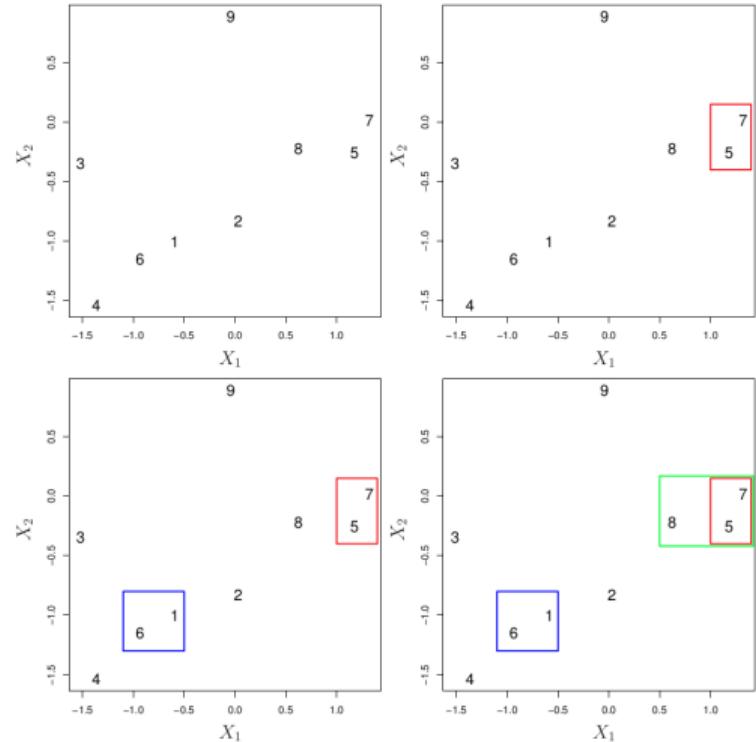
Linkage	Description
Complete	Maximal intercluster dissimilarity. Compute all pairwise dissimilarities between the observations in cluster A and the observations in cluster B, and record the <i>largest</i> of these dissimilarities.
Single	Minimal intercluster dissimilarity. Compute all pairwise dissimilarities between the observations in cluster A and the observations in cluster B, and record the <i>smallest</i> of these dissimilarities. Single linkage can result in extended, trailing clusters in which <u>single</u> observations are fused one-at-a-time.
Average	Mean intercluster dissimilarity. Compute all pairwise dissimilarities between the observations in cluster A and the observations in cluster B, and record the <i>average</i> of these dissimilarities.
Centroid	Dissimilarity between the centroid for cluster A (a mean vector of length p) and the centroid for cluster B. Centroid linkage can result in undesirable <i>inversions</i> .

Example with complete linkage

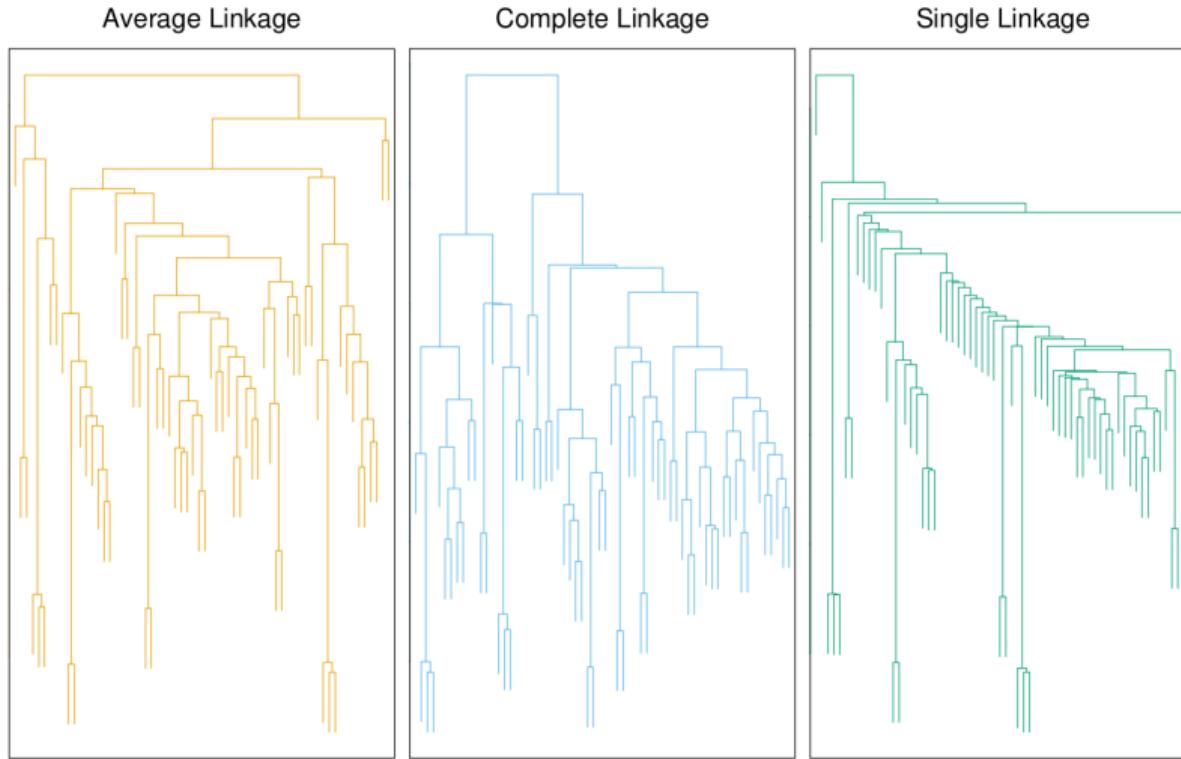


Distance between cluster A and cluster B :
Largest distance between the points

$$L(A, B) = \max_{a \in A, b \in B} \|a - b\|$$



Examples of different linkage



Dependence on dissimilarity measure

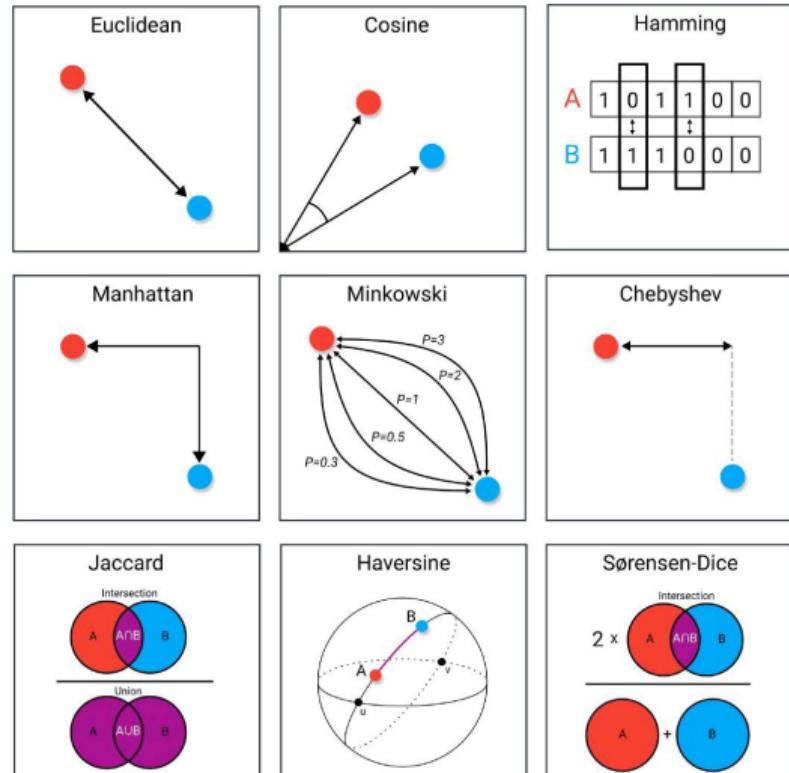


Photo Credit Link

Coding

Next time

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