Ch 12.1, 12.4: Unsupervised Learning & Clustering

Lecture 32 - CMSE 381

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Mon, April 14, 2025

Announcements

Last time:

- Convolutional Neural Nets

This lecture:

- Clustering (Just hierarchical clustering)

Announcements:

- No more homework!
- Weds: Project office hours, zoom only (link on website), send a message on slack!
- Fri 4/18: Review - submit your questions here!
- Monday 4/21: Exam 3
  - Content since 2nd Exam (Ch 7 and on)
  - One page (8.5x11) handwritten cheat sheet
  - no-internet Calculator

	M	3/17	**Midterm #2**		Sun 3/16
21	W	3/19	Polynomial & Step Functions	7.1-7.2	
22	F	3/21	Step Functions; Basis functions; Start Splines	7.2-7.4	
23	M	3/24	Regression Splines	7.4	
24	W	3/26	Decision Trees	8.1	HW #6 Due Wed 3/26
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26	M	3/31	Maximal Margin Classifier	9.1	
27	W	4/2	SVC	9.2	
28	F	4/4	SVM	9.3, 9.4	HW #8 Due Sun 4/6
29	M	4/7	Single Layer NN	10.1	
30	W	4/9	Multi Layer NN	10.2	
31	F	4/11	CNN	10.3	HW #9 Due Sun 4/13
32	M	4/14	Unsupervised learning / clustering	12.1, 12.4	
33	W	4/16	Virtual: Project Office Hours		
	F	4/18	***Review***		
	M	4/21	**Midterm #3**		
	W	4/23			
	F	4/25			**Project Due**

Section 1

Unsupervised learning

Supervised vs Unsupervised Learning

Supervised

Unsupervised

Some examples of unsupervised problems

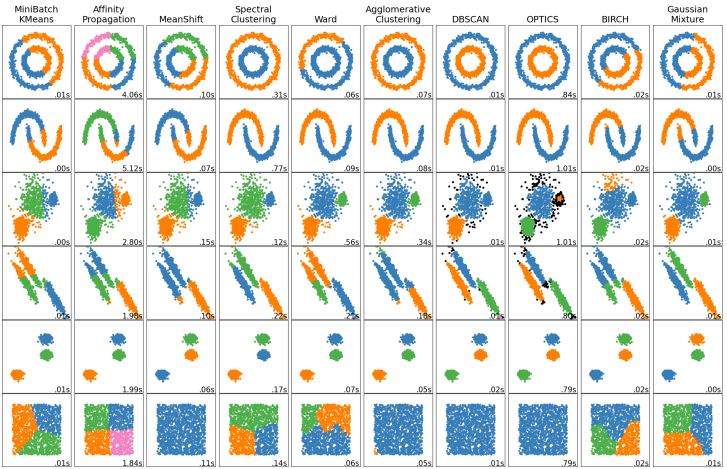
- Assay gene expression levels in 100 patients with breast cancer, looking for subgroups with similar qualities
- Online shopping: find groups of shoppers with similar browsing and purchase histories and show relevant related products.
- Search engine picking results to show

Section 2

Clustering

Big idea

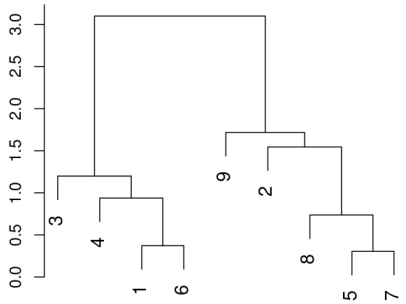
Clustering: relation between samples



Section 3

Hierarchical Clustering

Dendrogram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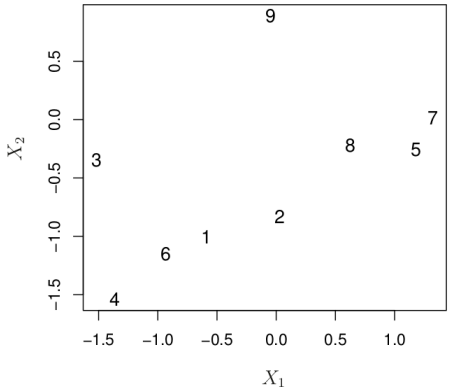
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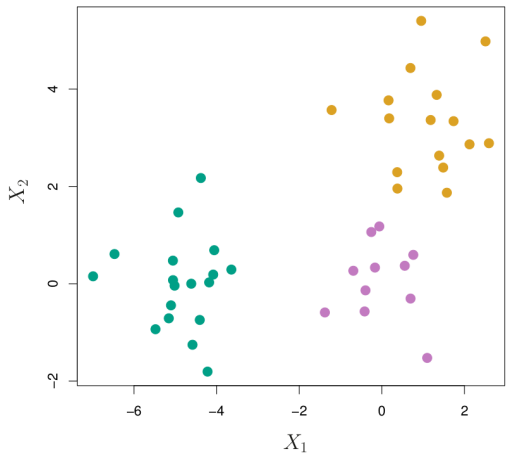
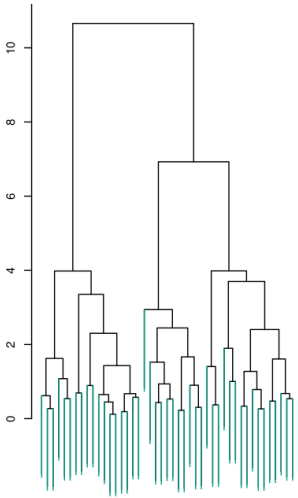
1.0
X_2
X_1

A bigger example

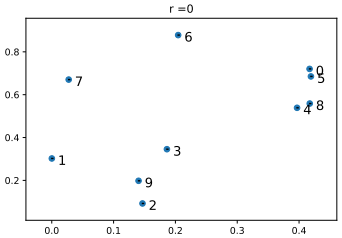


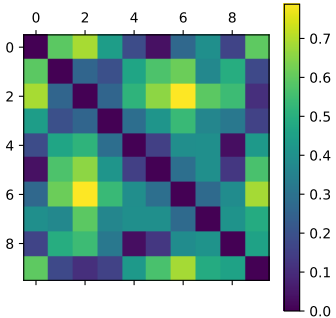


Single linkage

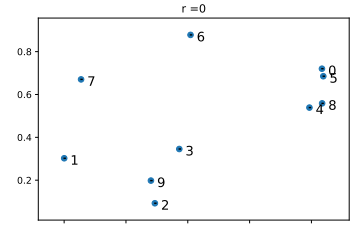
Distance between cluster A and cluster B:
Smallest distance between the points

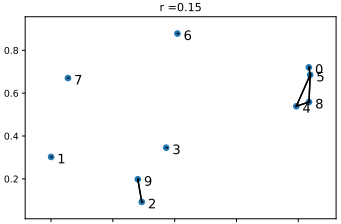
$$L(A, B) = \min_{a \in A, b \in B} \|a - b\|$$

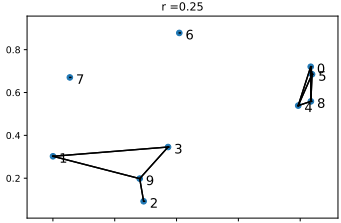


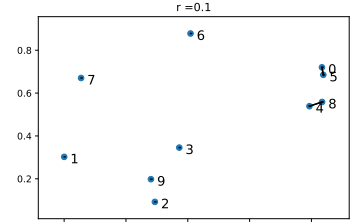


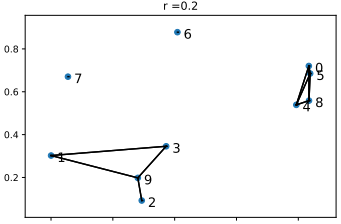
Building the dendrogram

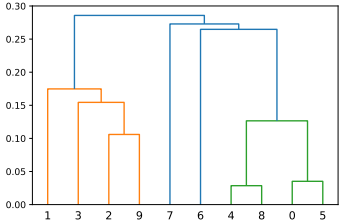




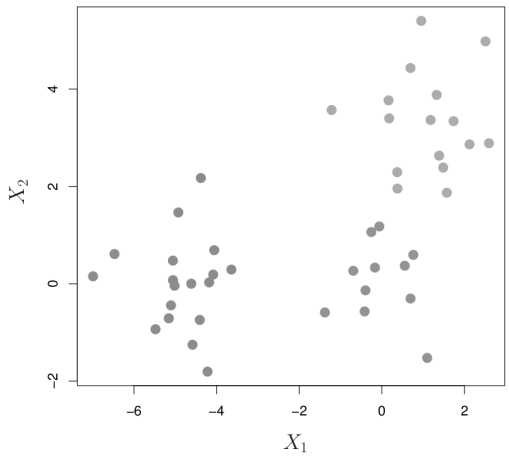


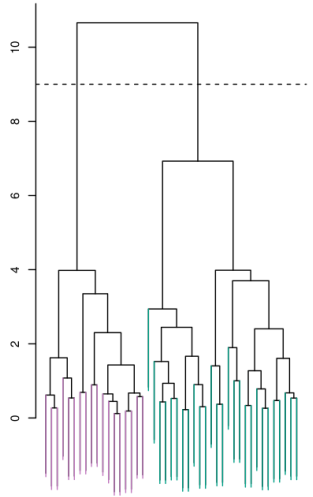




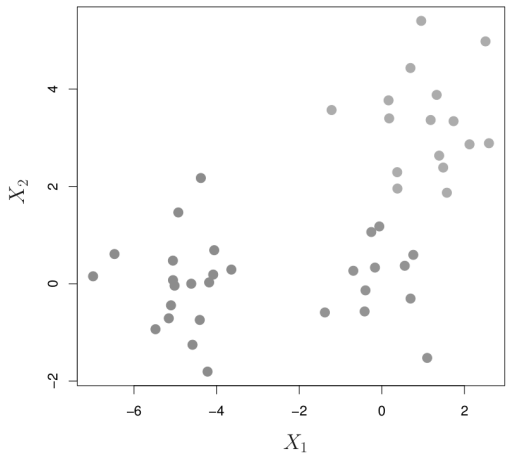


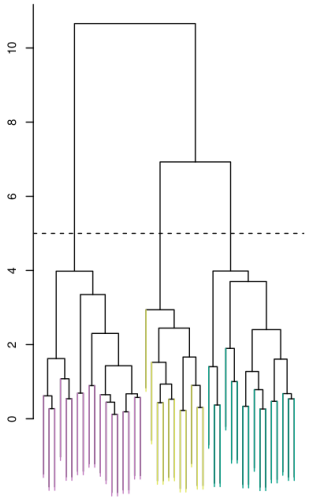
How to get clusters



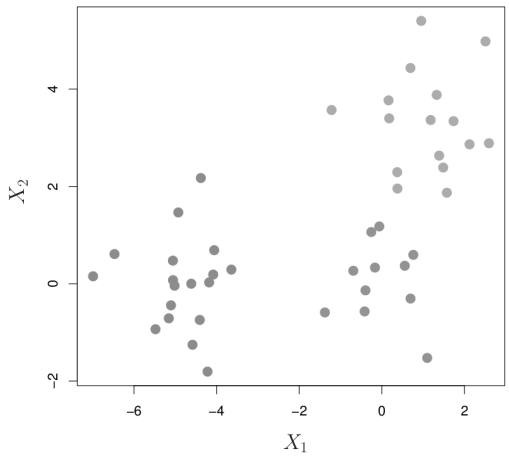


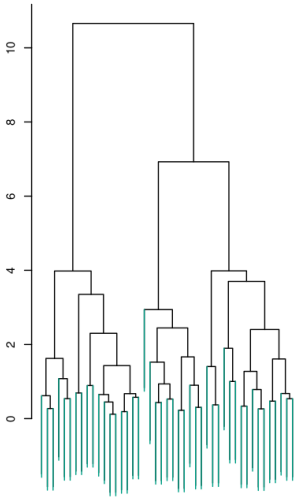
How to get different clusters





Can get any number of clusters



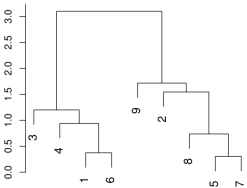


Test your understanding: PollEv

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 *largest* 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 *smallest* of these dissimilarities. Single linkage can result in extended, trailing clusters in which single 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 *average* 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 *inversions*.

Example with complete linkage



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

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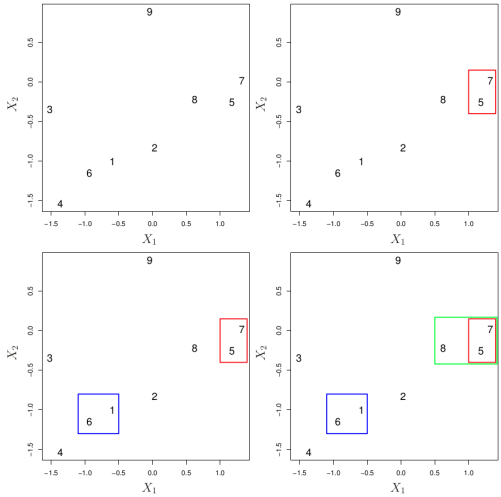
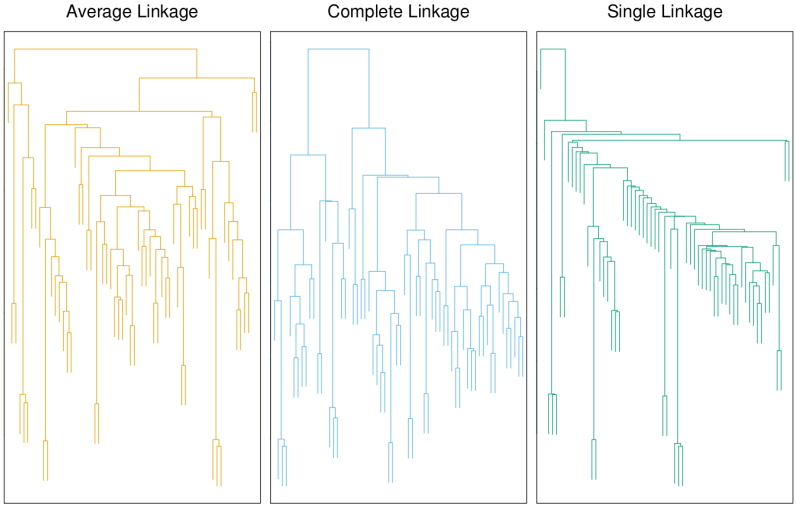


Examples of different linkage



Dependence on dissimilarity measure

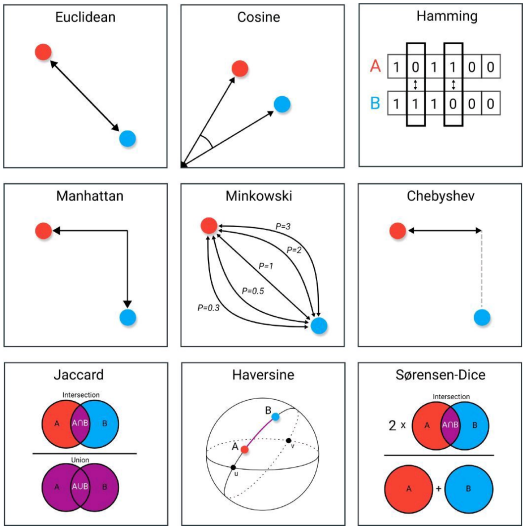


Photo Credit Link

Coding

Next time

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Q of the Day: What is the difference between single and complete linkage?