



Unsupervised Learning

Sammie Omranian

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Unsupervised Learning

- Unsupervised learning involves training a model to find patterns in a dataset without pre-labeled responses.

Supervised vs. Unsupervised Learning

- Supervised Learning: Labeled data, goal is to predict outcomes.
- Unsupervised Learning: Unlabeled data, goal is to find hidden patterns.

Unsupervised Learning

Three common unsupervised learning algorithms:

- Clustering: Grouping similar items.
- Hierarchical Clustering: to build a hierarchy of clusters
- Dimensionality Reduction: Simplifying data without losing important information.

Clustering

- Clustering is a data mining technique which groups unlabeled data based on their similarities or differences.
- Clustering algorithms are used to process raw, unclassified data objects into groups represented by structures or patterns in the information.
- Clustering algorithms can be categorized into a few types, specifically
 - Exclusive
 - Hierarchical

Clustering

Clustering in market segmentation



Cluster 1: High income/high property value

Cluster 2: Middle income/middle property value

Cluster 3: High income/low property value

K-means clustering

- The **K-means clustering** algorithm is an example of exclusive clustering.
- K-Means clustering aims to group n data points into k clusters in which each observation belongs to the cluster with the nearest mean.
- A larger K value will be indicative of smaller groupings whereas a smaller K value will have larger groupings and less granularity.
- K-means clustering is commonly used in market segmentation, document clustering, and image segmentation.

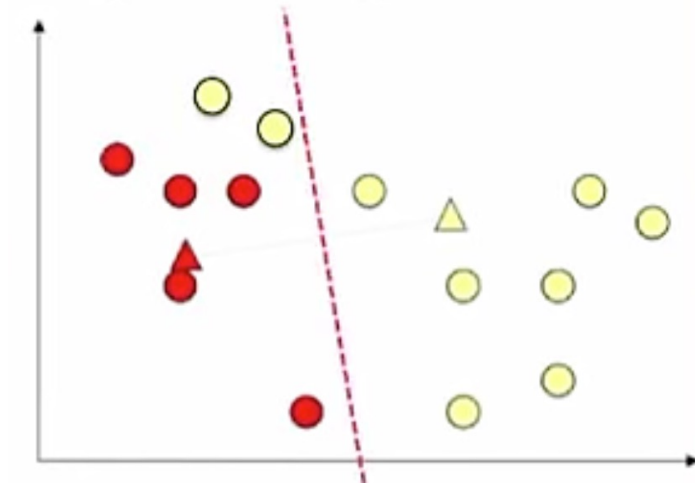
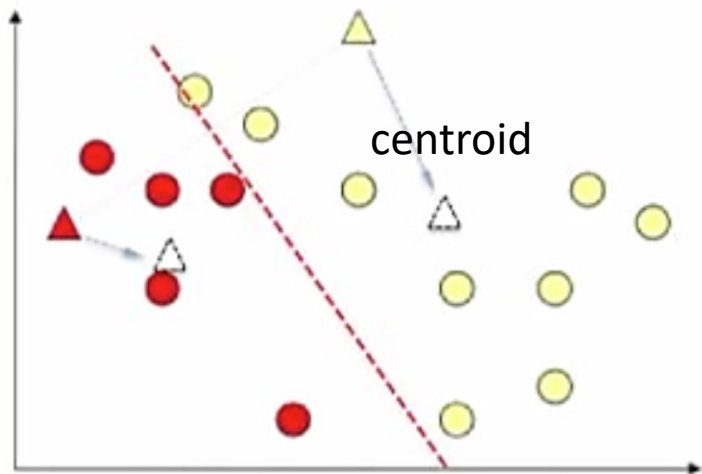
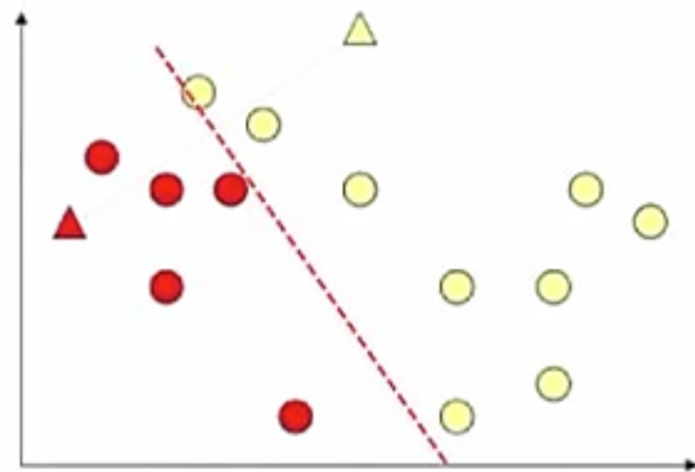
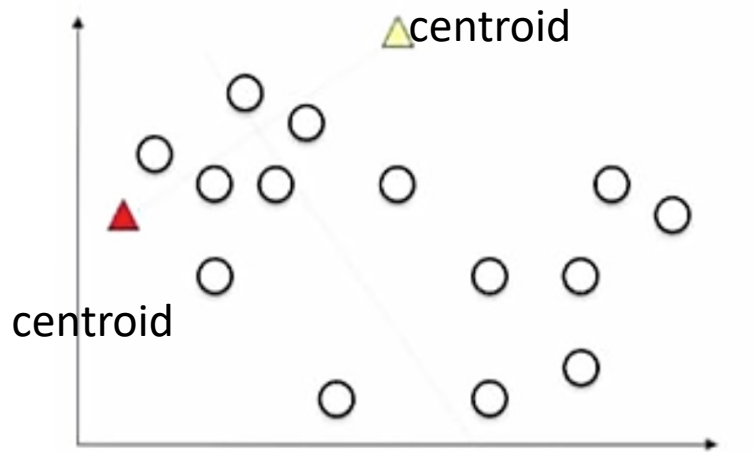
K-means clustering

- input k , set of points x_1, x_2, \dots, x_n
- starts by placing K points (centroids: c_1, c_2, \dots, c_k) at random locations in space.
- repeat until convergence:
 - for each point x_i :
 - find nearest centroid c_j
 - assign the point x_i to cluster j

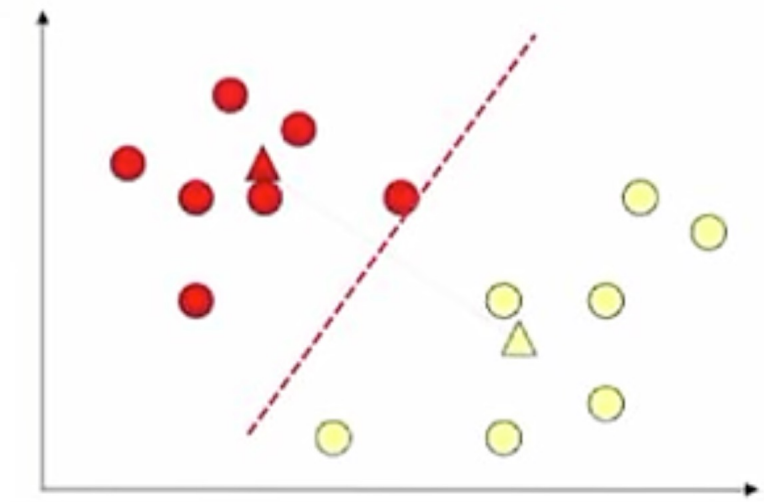
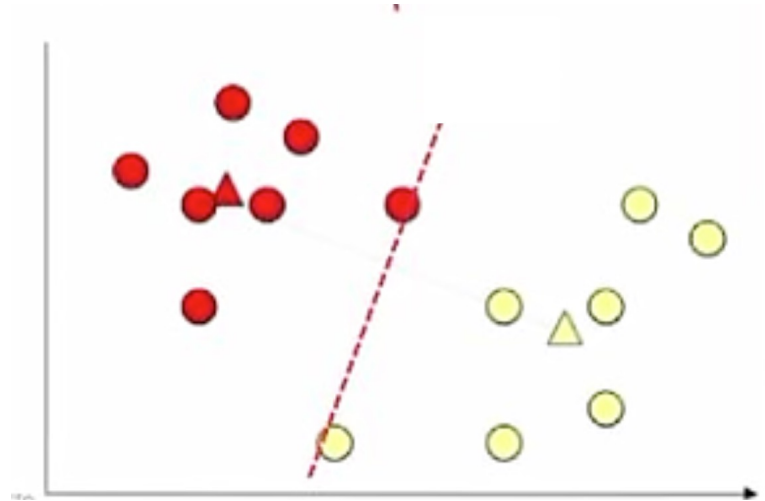
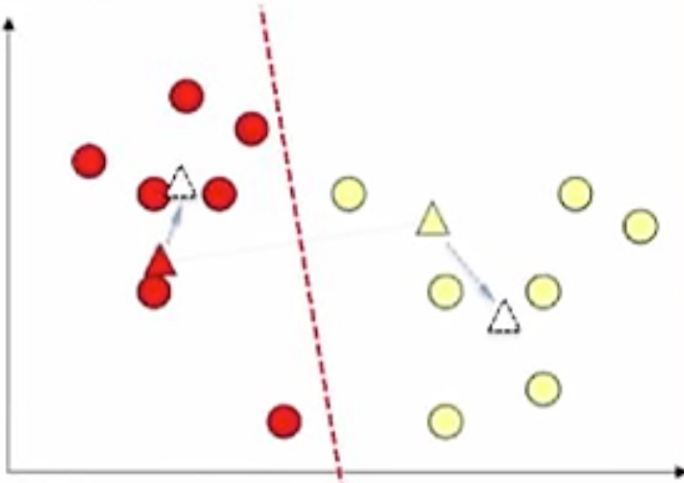
$$c_j(a) = \frac{1}{n_j} \sum_{x_i \rightarrow c_j} x_i(a) \quad \text{for } a = 1, \dots$$

- for each cluster $j = 1, 2, \dots, k$:
 - new centroid c_j = mean of all points x_i assigned to cluster j in previous step

K-means clustering



K-means clustering



Convergence!

K-means clustering

KMeans

```
class sklearn.cluster.KMeans(n_clusters=8, *, init='k-means++',  
n_init='auto', max_iter=300, tol=0.0001, verbose=0, random_state=None,  
copy_x=True, algorithm='lloyd')
```

[source](#)



Number of clusters



initialization method of centroids

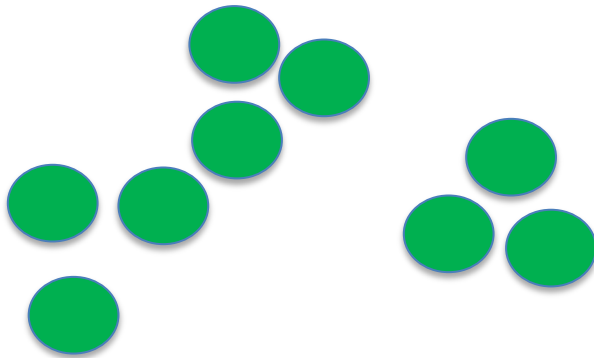
Hierarchical Clustering

Selecting K! Question of granularity

How coarse or fine-grained is the structure in your data?

The main problem of K-means is what a good k ?

No clustering algorithm can pick k .



How many clusters do you see?

Hierarchical Clustering

Instead of picking K , let's find a hierarchy of the structure:

At the top level – coarse grained

At low levels – fine grained

How to cluster:

Topmost cluster → have every points in the cluster

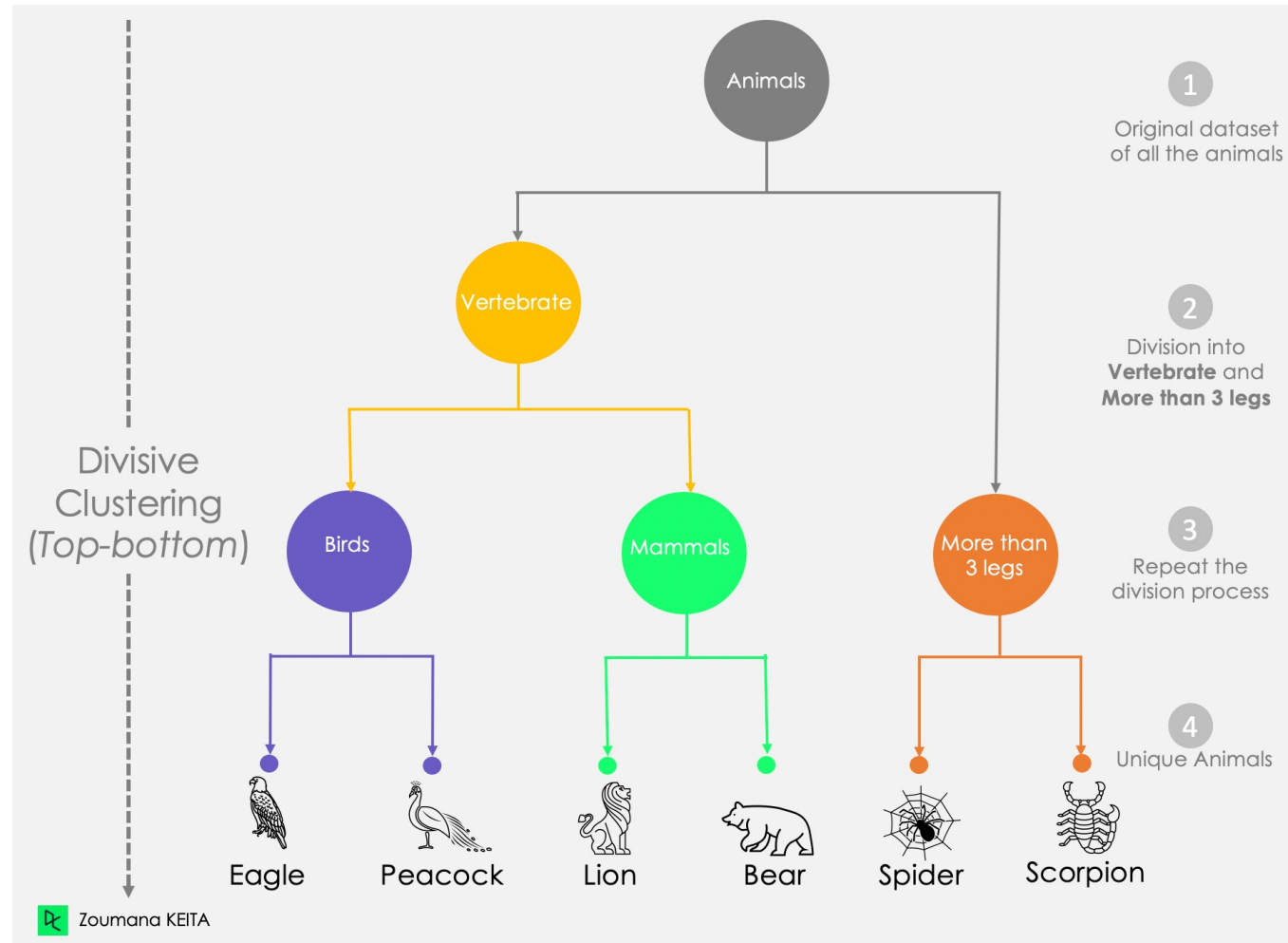
Bottom clusters → have n set of singletons

So, you will end up with a tree!

Hierarchical Clustering

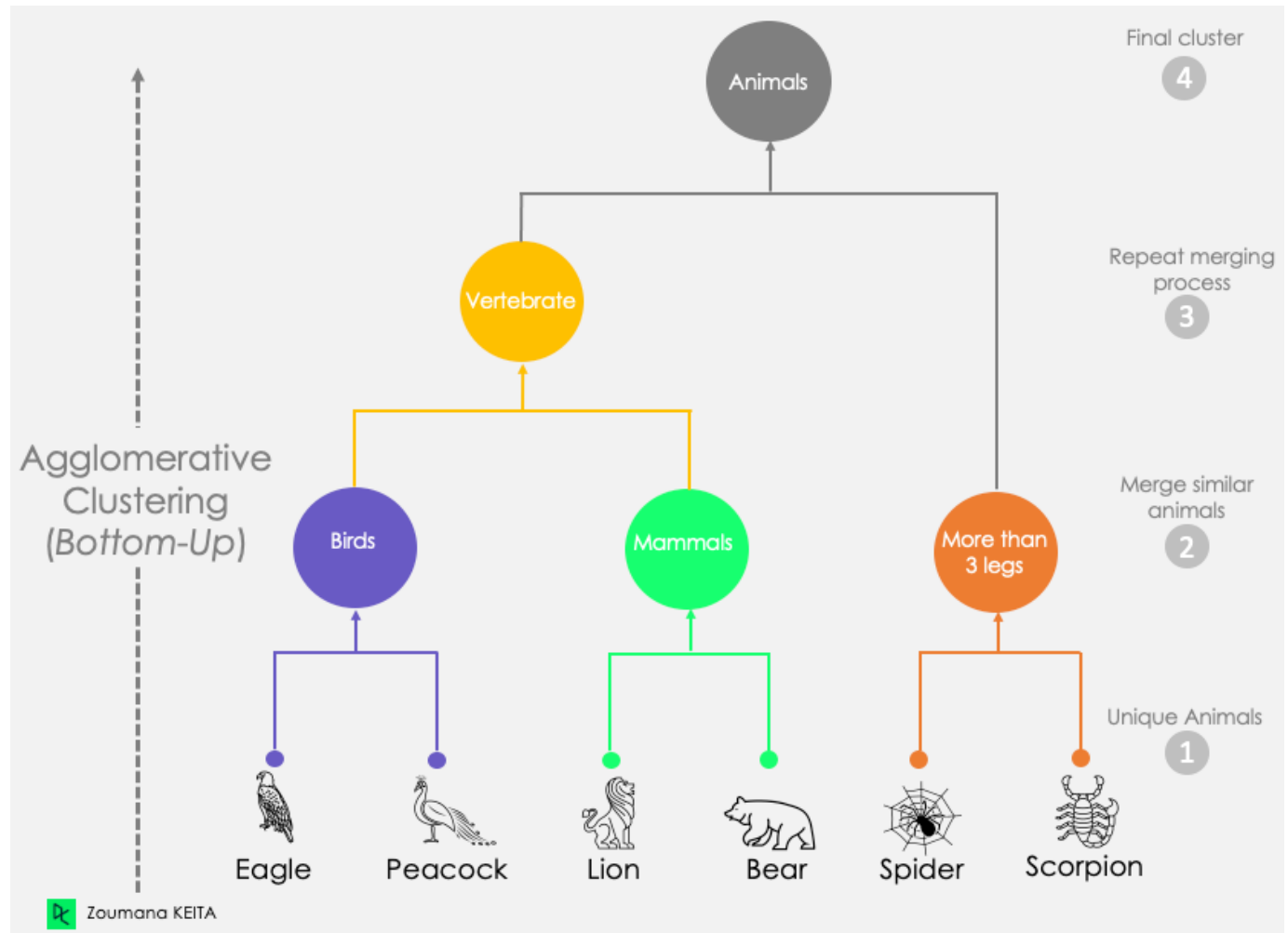
Two types of algorithm

- Divisive(Top-bottom)
- agglomerative (Bottom-up)



[Image source](#)

Hierarchical Clustering



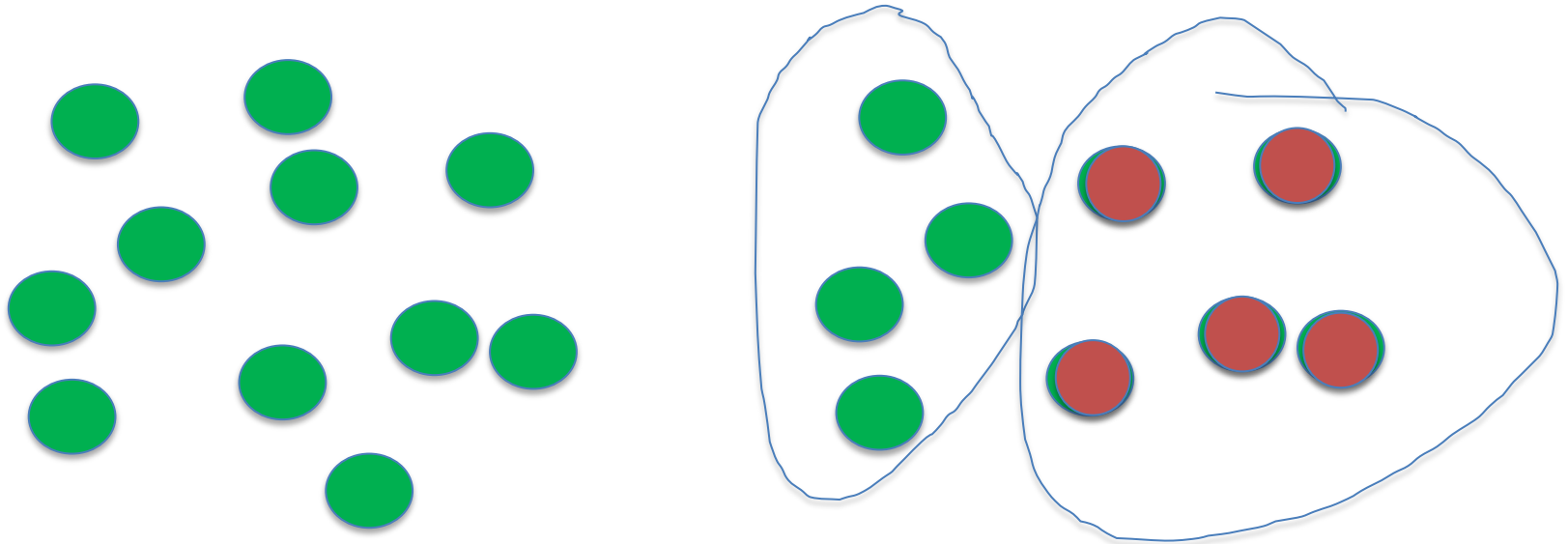
Hierarchical Clustering

Hierarchical algorithm (top-down approach):

Run K-means algorithm on the original data x_1, x_2, \dots, x_n

For each of the resulting clusters c_i , $i = 1, 2, \dots, k$

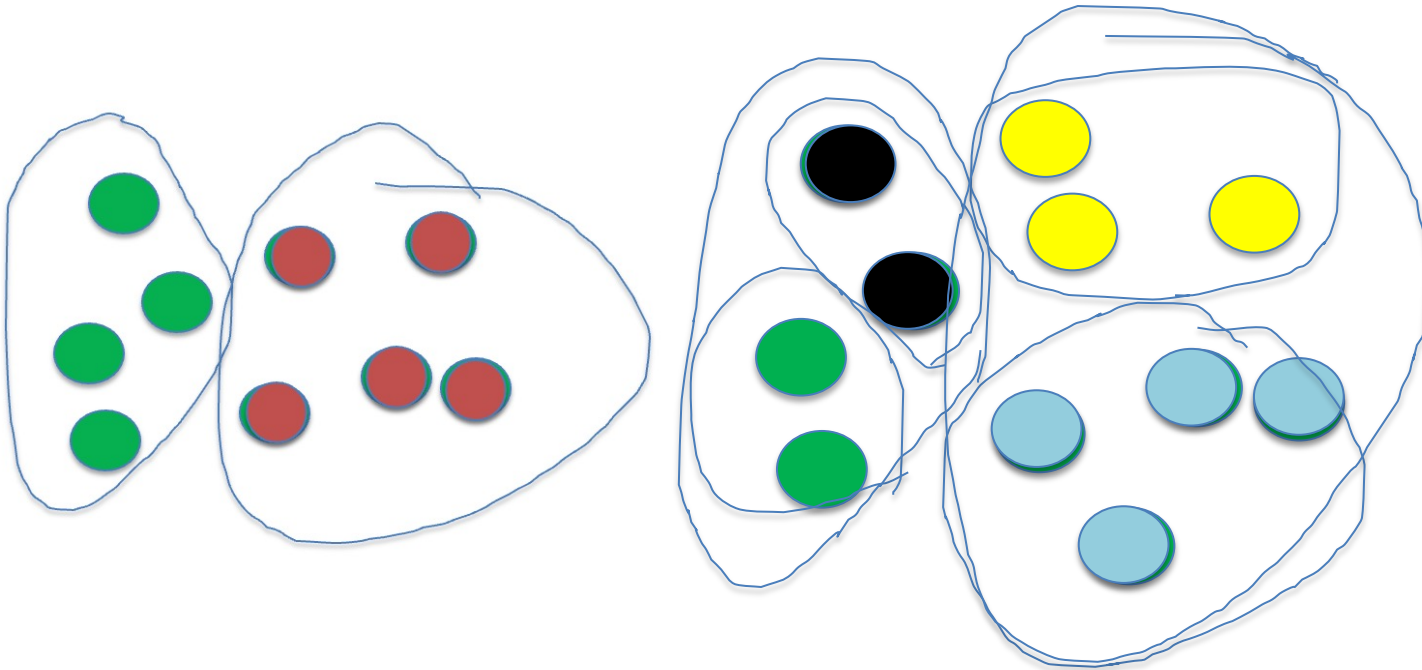
Recursively run K-means on points in cluster c_i



Hierarchical Clustering

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 - recursively run K-means on points in cluster c_i



Hierarchical Clustering

Applications of Hierarchical Clustering

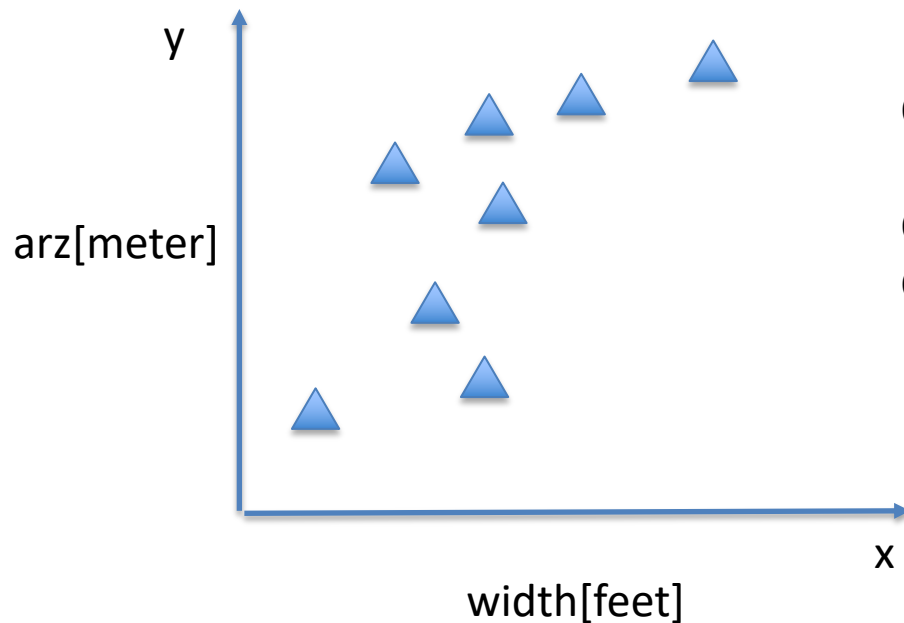
- Biology
 - The clustering of DNA sequences is one of the biggest challenges in bioinformatics.
- Image processing
 - Hierarchical clustering can be performed in image processing to group similar regions or pixels of an image in terms of color, intensity, or other features.
- Social network analysis
 - Hierarchical clustering can be used to identify groups or communities and to understand their relationships to each other and the structure of the network as a whole.

Hierarchical Clustering

- `scipy.cluster.hierarchy.linkage(y, method='single', metric='euclidean', optimal_ordering=False)`
- [source](#)

Principal Component Analysis (PCA)

- Suppose we have a dataset and we want to find the dimensionality of the data
- Each data point represent a pair (x, y) , where x and y are real numbers.



Question: really two dimension?

On the surface is but what is under the surface?
Can I find out?

Principal Component Analysis (PCA)

- A dataset including 5 features:
 - X1: number of car accidents
 - X2: number of burst water pumps
 - X3: number of school closure
 - X4: number of patients with broken legs or arms
 - X5: snowplow cost
- All of these are strongly influenced by one factor! What is that?

Principal Component Analysis (PCA)

Applications:

Texts - each word a separate feature

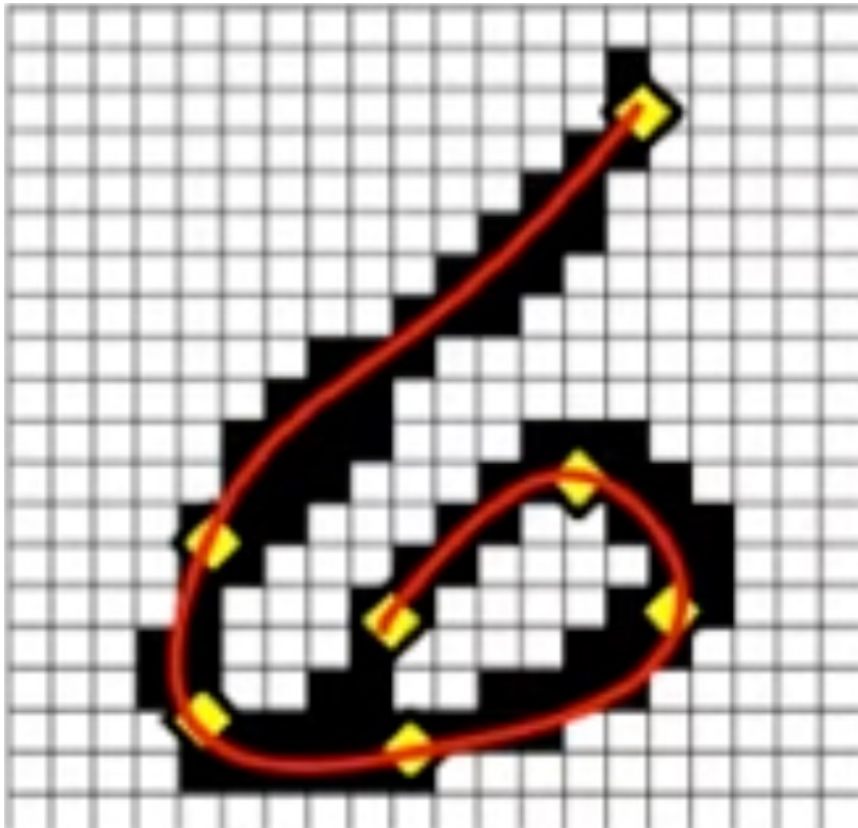
Image - each pixel a separate feature

Millions of features!!!

High dimensional

Principal Component Analysis (PCA)

Example 1



Example 2

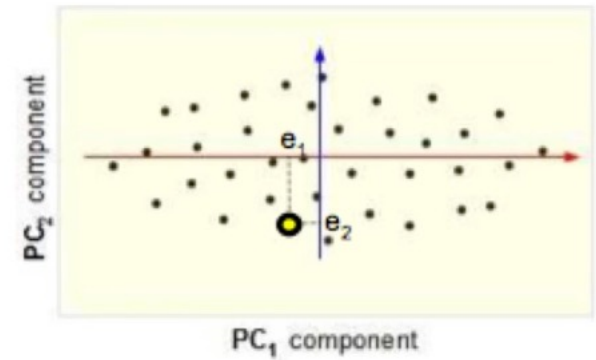
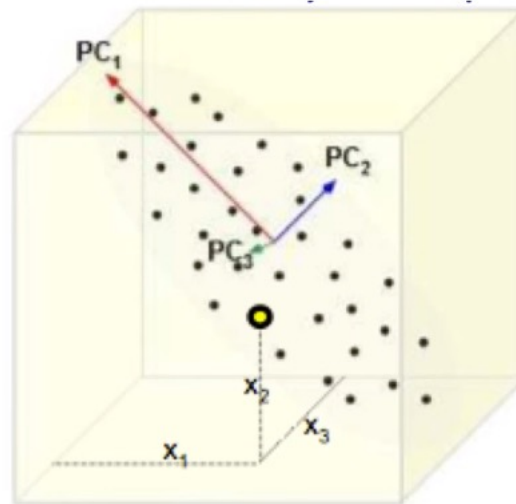
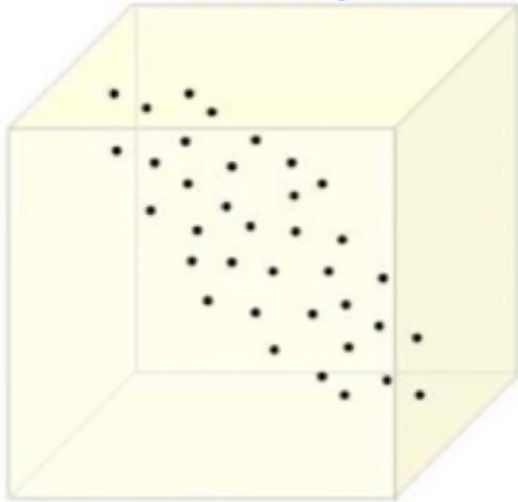
"Grouping, clustering, and categorizing data points into nested, ordered, and structured layers exemplifies the process of hierarchical algorithms."

"Grouping data into nested layers illustrates hierarchical algorithms."

Principal Component Analysis (PCA)

- We suppose we have our low dimensional data embedded in a high dimension space.
- Defines a set of principal components
 - 1st : direction of the greatest variability in the data
 - 2nd : perpendicular to 1st , greatest variability of what's left
 - Repeat this until d (original dimensionality)
- First $m \ll d$ components become m new dimensions
 - Change coordinates of every datapoint to these dimensions

Principal Component Analysis (PCA)



Principal Component Analysis (PCA)

PCA

```
class    sklearn.decomposition.PCA(n_components=None, *, copy=True,  
whiten=False, svd_solver='auto', tol=0.0, iterated_power='auto', n_oversa  
mples=10, power_iteration_normalizer='auto', random_state=None)
```

[source](#)