

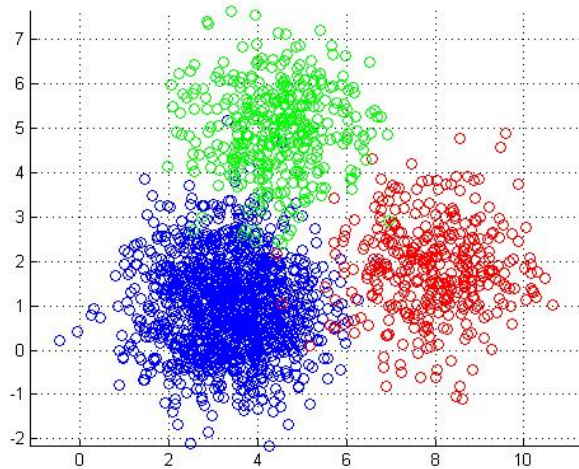
# Clustering

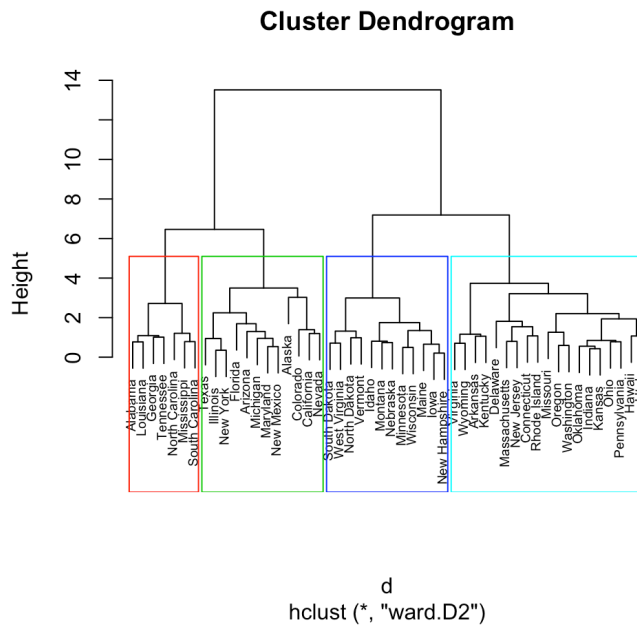
## Clustering

- Broad set of techniques for finding **subgroups**.
- Observations **within groups** are quite similar to each other and observations in **different groups** quite different from each other.

## Clustering methods

- Partitioning: **k-means** clustering
- Agglomerative/divisive: **hierarchical** clustering
- Model-based: mixture models





## K-means clustering

- Simple approach to partitioning a data set into **K** distinct, non-overlapping clusters.
- **K** is specified beforehand.

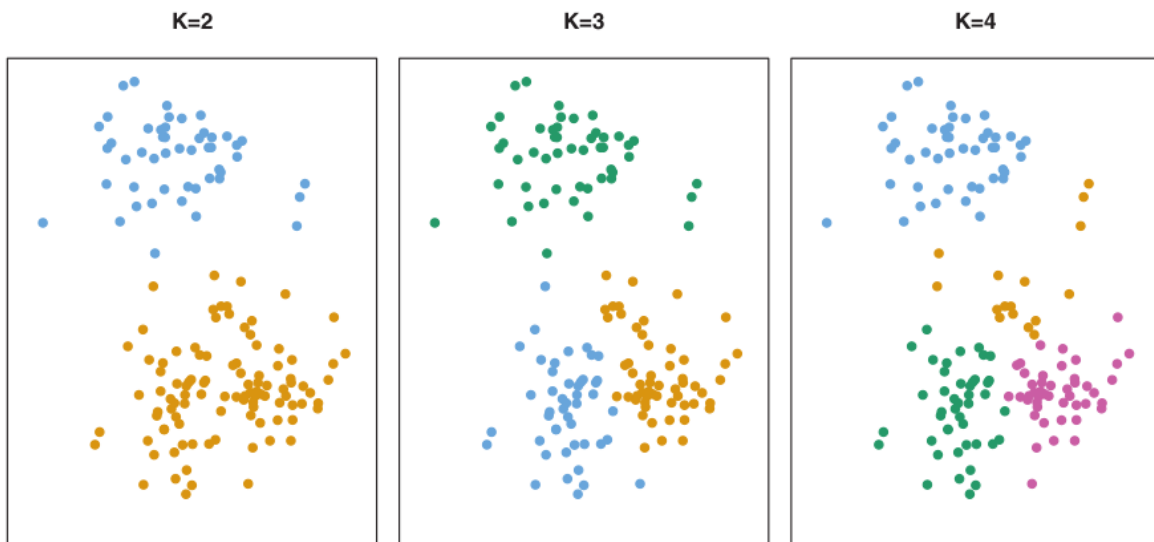


Figure 1: James et al. 2013

## K-means algorithm

- $K$  – number of clusters.

### The process:

1. **Randomly** assign each observation to groups **1 to K**;
2. For each of  $K$  clusters, derive its **centroid** (midpoint);
3. **Reassign** each observation into a cluster whose centroid is the **closest**;
4. **Iterate** until stability in cluster assignments is reached (local vs global optima).

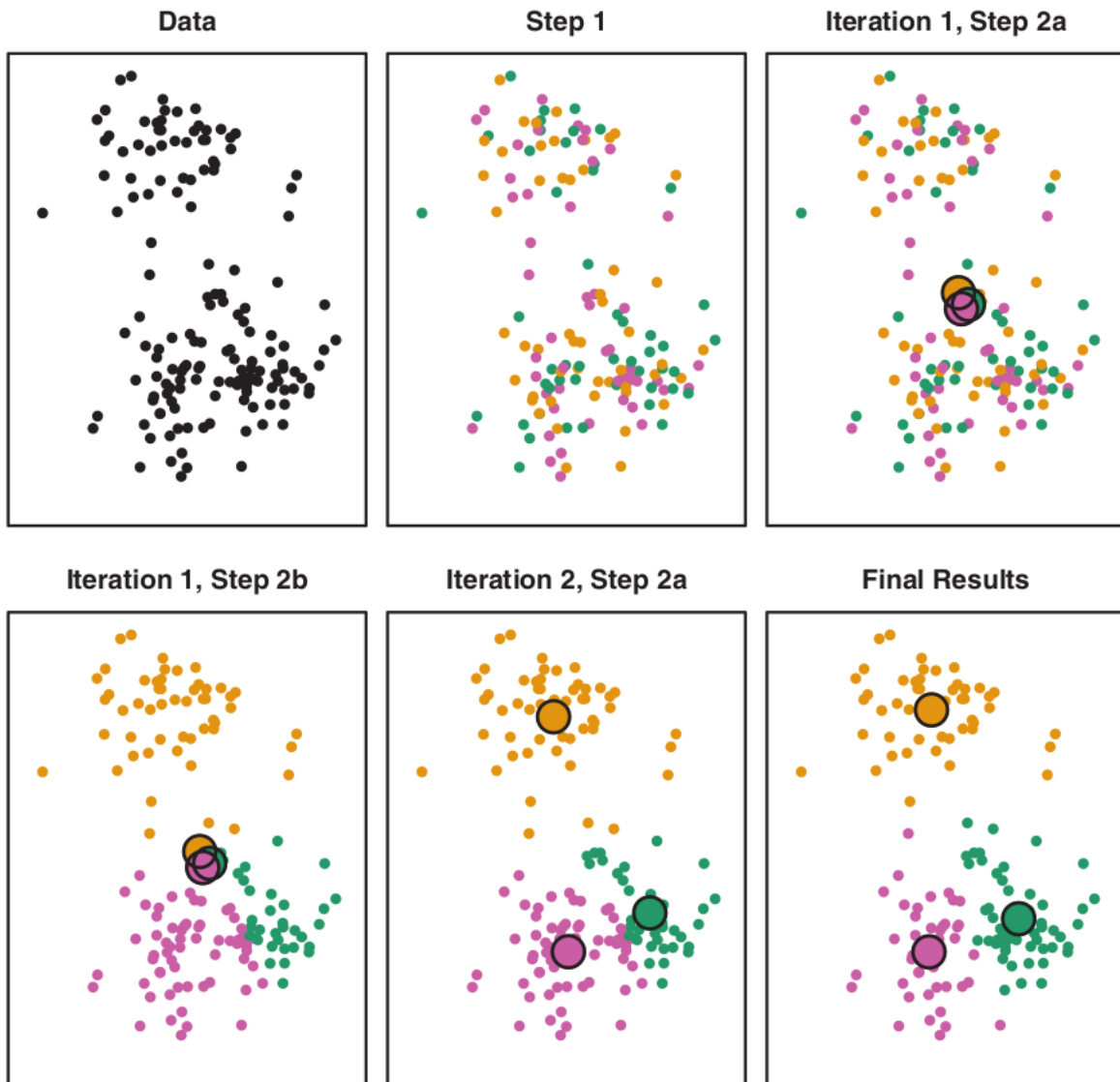
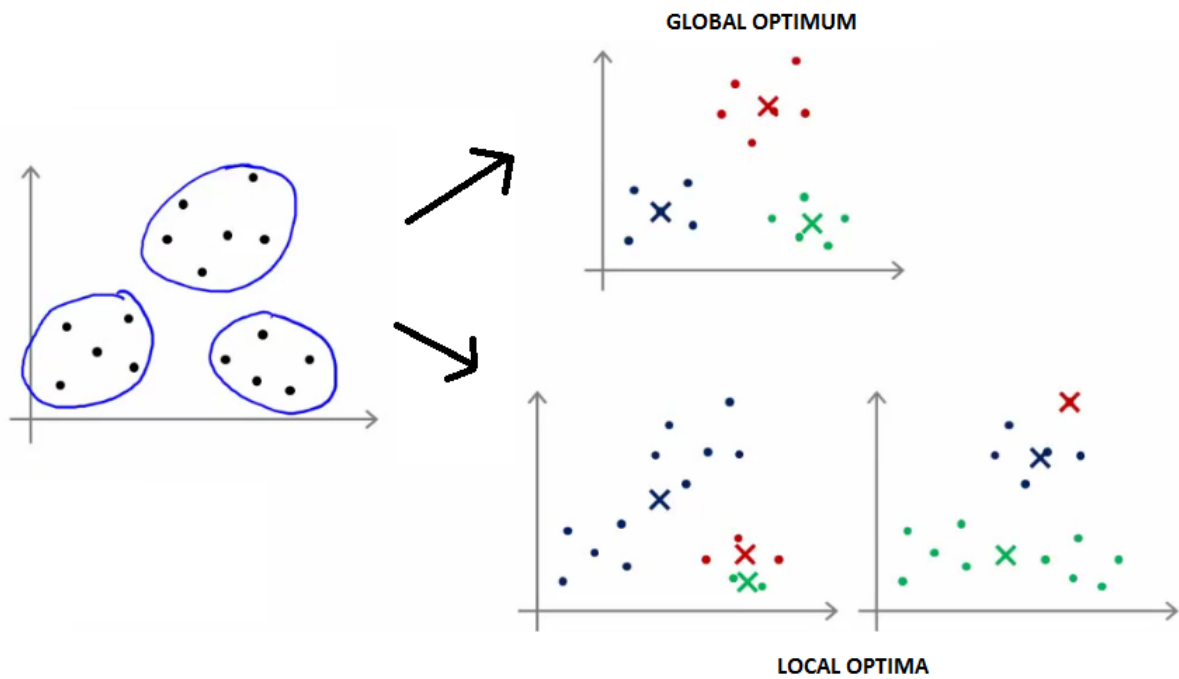


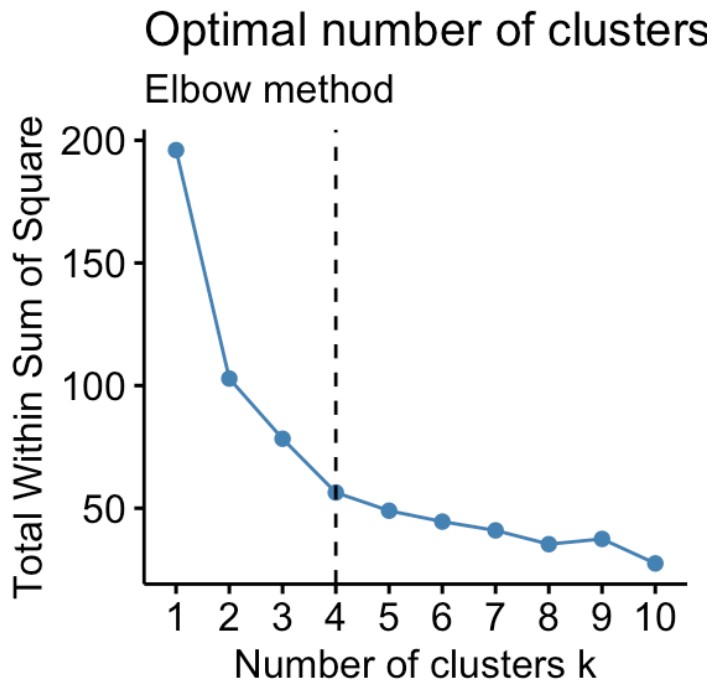
Figure 2: James et al. 2013

### Some properties of K-means partitioning

- Standard algorithm for k-means clustering is using **Euclidean distance** (distances are calculated using *Pythagorean theorem*).
- Different **local optima** (stability) can be reached.



- **Number of clusters  $K$**  must be specified in advance
- How to determine **optimal** number of clusters?
  - Elbow method,
  - Silhouette method



### Hierarchical clustering

- The number of clusters is **not specified beforehand**.
- Output is a **dendrogram** – a hierarchical structure visualizing the cluster growth.
- Starts with a **distance matrix**.



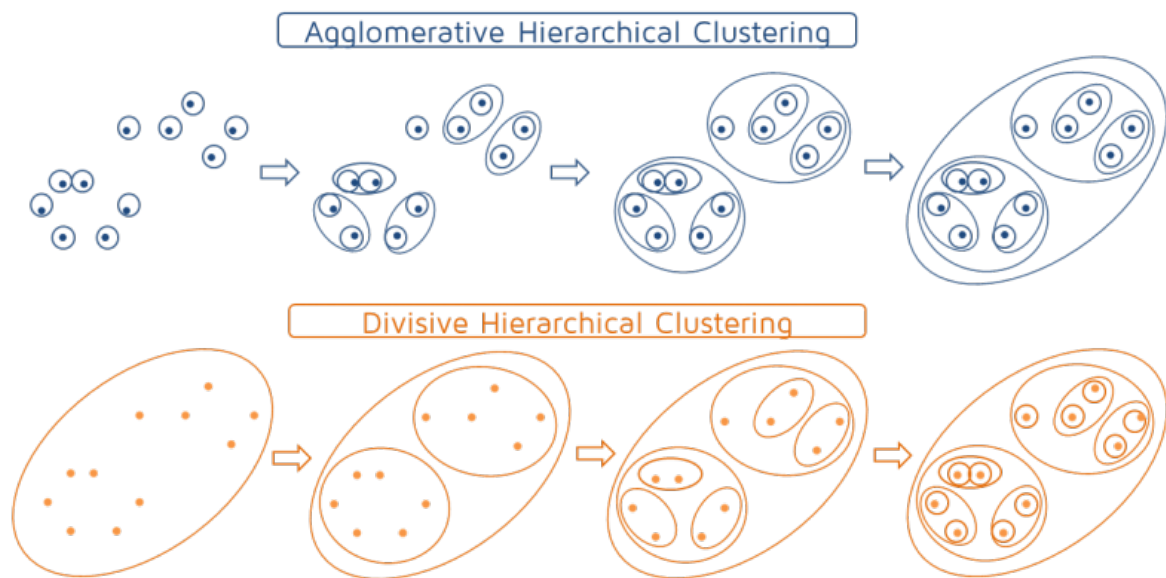
## Agglomerative

- Builds the hierarchy of clusters from **bottom-up** until a **single cluster is reached**.
1. Put each object in its own cluster;
  2. Join the clusters that are the closest;
  3. Iterate until a single cluster encompassing all objects is reached.

## Divisive

- **Divides** a single large cluster into **individual objects** (top-down).
1. Put all objects into a single cluster;
  2. Divide the cluster into subclusters at a similar distance;
  3. Iterate until all objects are in their own clusters.

## Hierarchical clustering algorithms

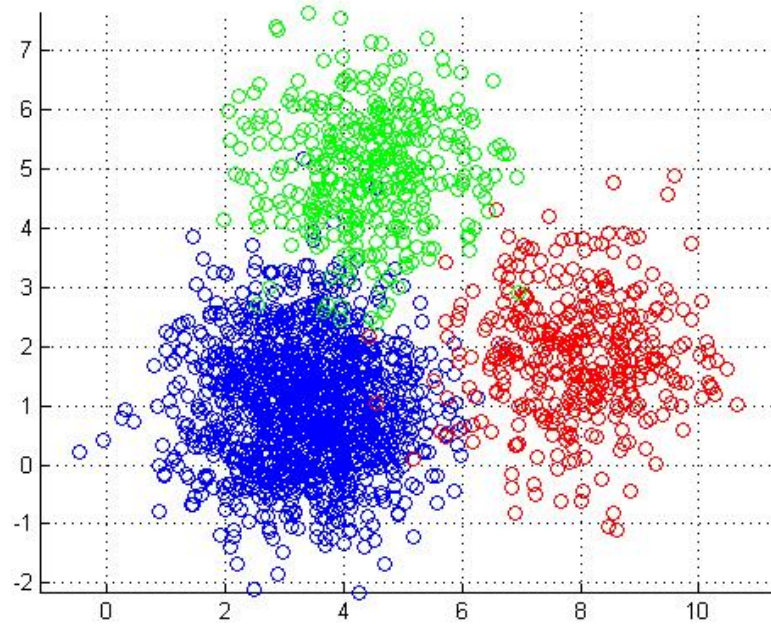


## Clustering methods comparison

### K-means partitioning

- Pre-specified number of clusters.
- Clusters may vary (different local optima).

- Best when groups in data are (hyper)spheres.

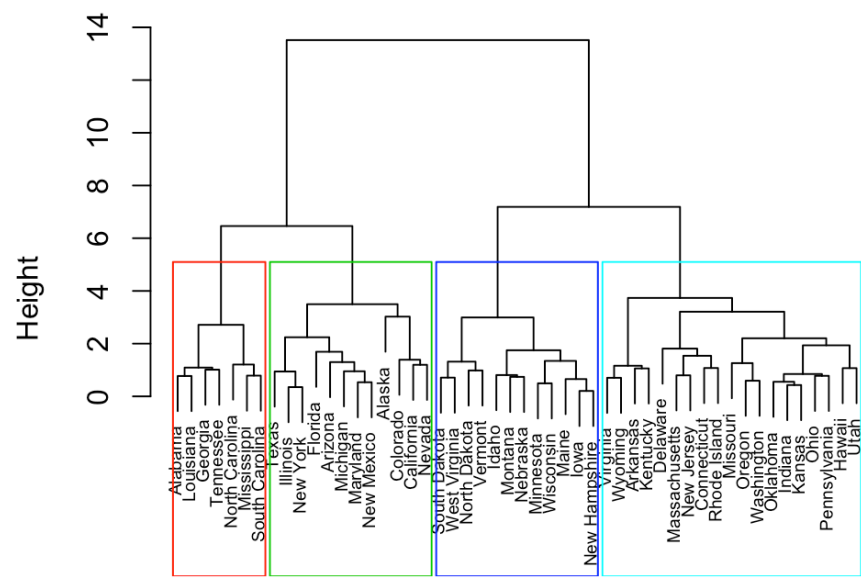


### **Hierarchical clustering**

- Variable cluster numbers.
- Clusters are stable.
- Any shape of data distribution.



Cluster Dendrogram



d  
hclust (\*, "ward.D2")