

# Clustering

Unsupervised learning; group data points which are similar to each other

$\mu_1, \mu_2, \dots, \mu_K$  cluster centers

We minimize the total squared distance from data points to cluster centers:

$$J(c, \mu) = \sum_{i=1}^N \|x^{(i)} - \mu_{c^{(i)}}\|^2$$

K-means Clustering Algorithm:

Randomly initialize  $\mu_1, \mu_2, \dots, \mu_K$

Repeat until convergence:

for each i:

$$c^{(i)} = \arg \min_j \|x^{(i)} - \mu_j\|^2$$

for each  $j \in \{1, \dots, K\}$ :

$$\mu_j = \frac{\sum_{i=1}^N 1\{c^{(i)}=j\} x^{(i)}}{\sum_{i=1}^N 1\{c^{(i)}=j\}}$$

## Random initialization

The algorithm may converge to local optimums.

We can run the algorithm with random initialization for 10 times, and choose the one with lowest  $J(c, \mu)$ .

$\mu_1 = x^{(j)}$  // randomly initialize first centroid as the jth data point

for  $k'' = 2$  to  $k$ :

$$d_j = \min_{k' < k''} \|x^{(j)} - \mu_{k'}\|, \forall j$$

$$p_j = \frac{d_j^2}{\sum_{i=1}^m d_j^2}, \forall j$$

j = randomly chosen with probability  $p_j$

$$\mu_{k''} = x^{(j)}$$

run k-means using  $\mu$  as initial centers

## **Documents as feature vectors**

Term frequency - Inverse Document Frequency