

# MIDS W207

# Applied Machine Learning

Week 10  
Live Session Slides

# K-Means Revision

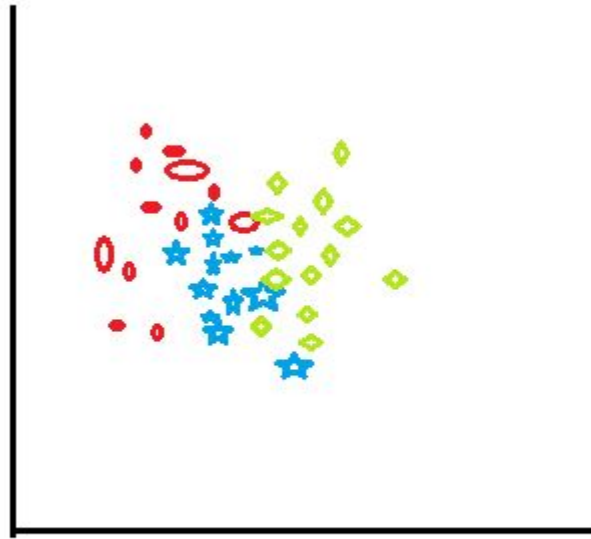


fig 1: before applying  
k-means clustering

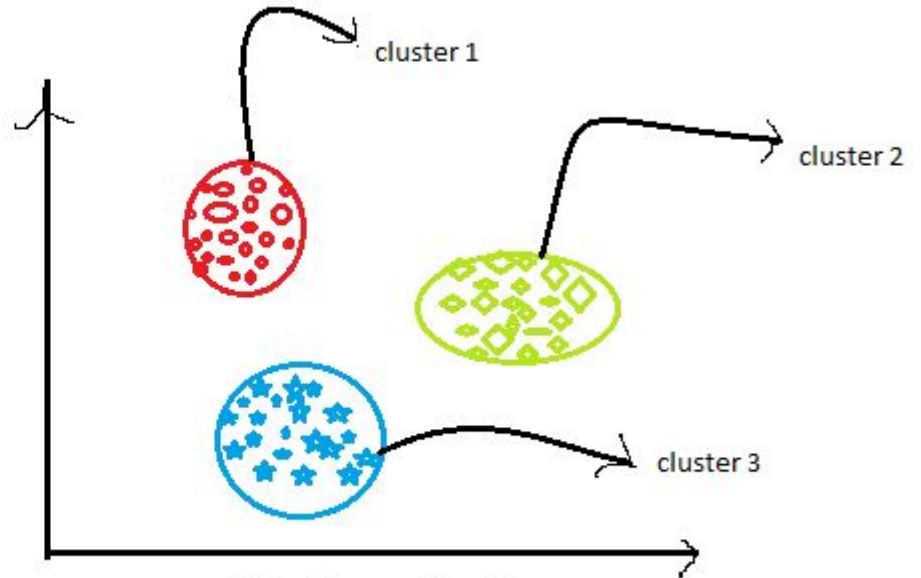
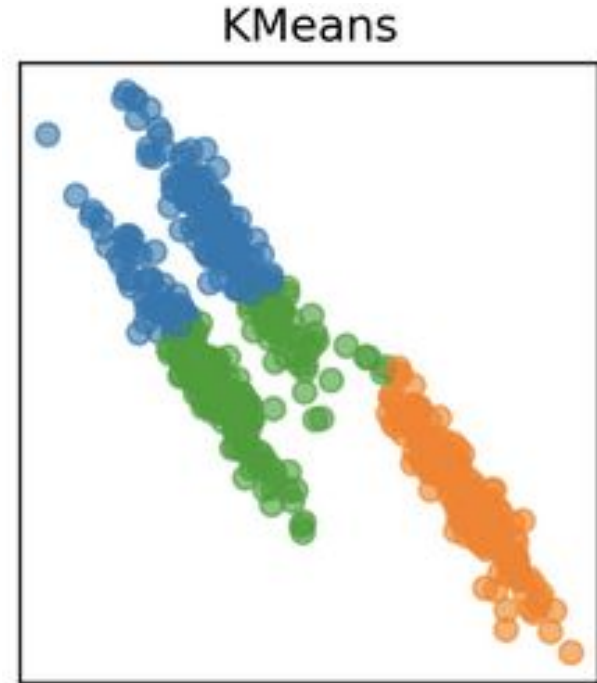
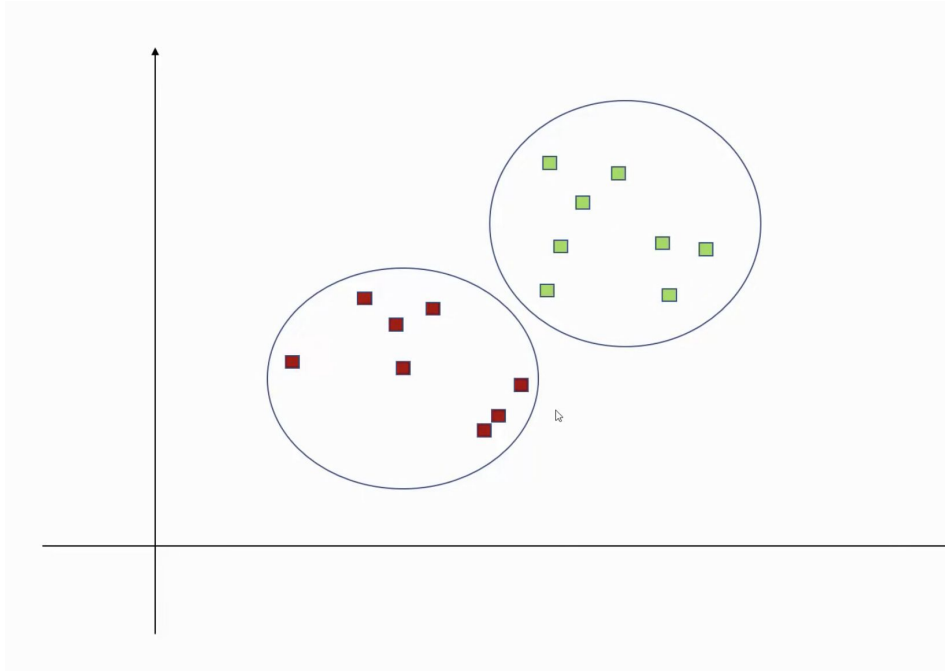
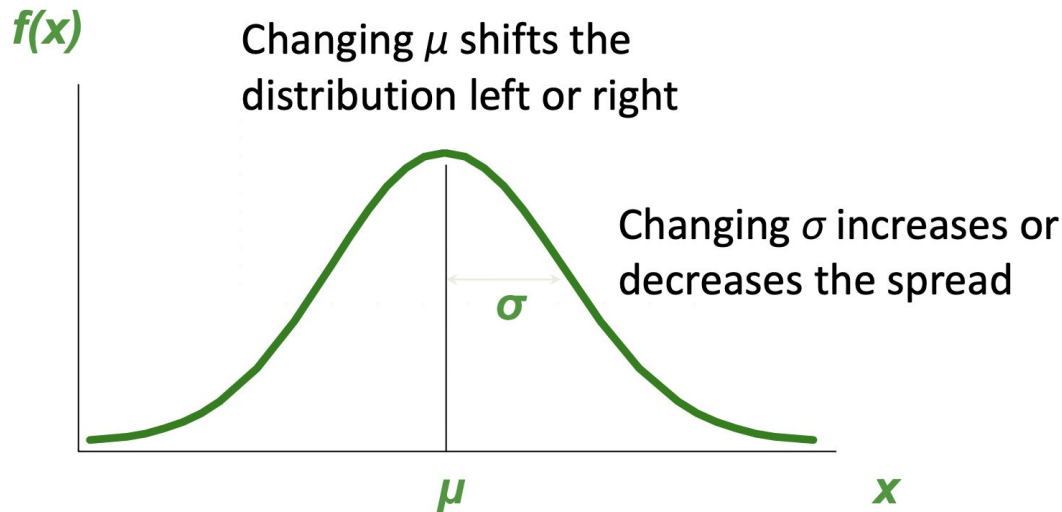


fig 2: After applying K-  
means clustering

# K-Means Limitations



# Gaussian Distribution



Probability density function  $f(x)$  is a function of  $x$  given  $\mu$  and  $\sigma$

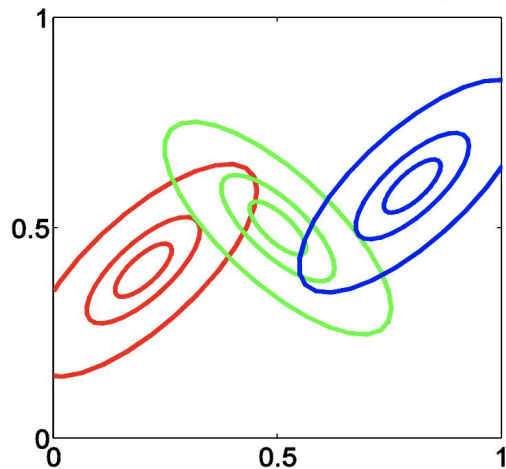
$$N(x | \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right)$$

# Gaussian Mixture Models

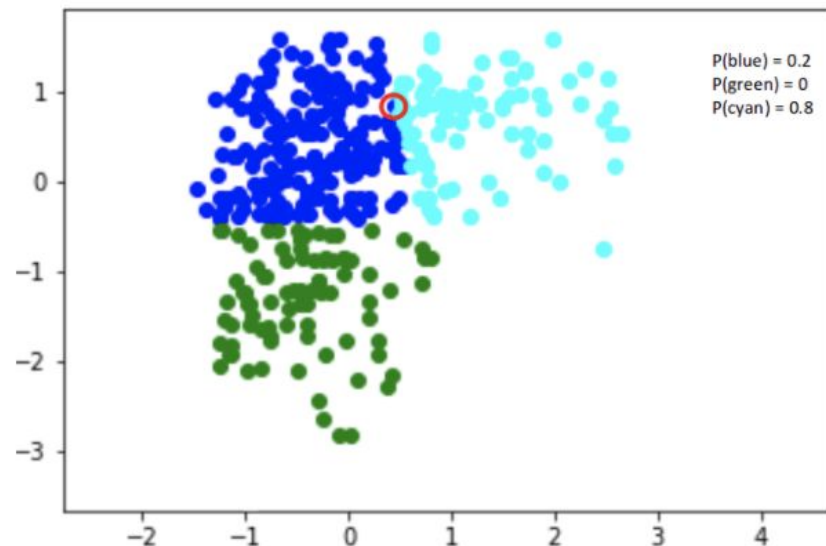
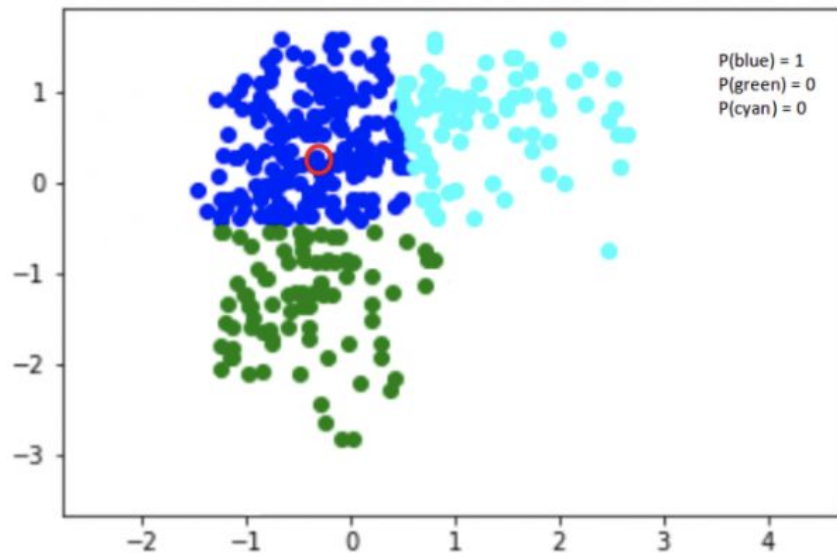
- Linear combination of Gaussians

$$p(x) = \sum_{k=1}^K \pi_k \mathcal{N}(x | \mu_k, \Sigma_k) \quad \text{where} \quad \sum_{k=1}^K \pi_k = 1, \quad 0 \leq \pi_k \leq 1$$

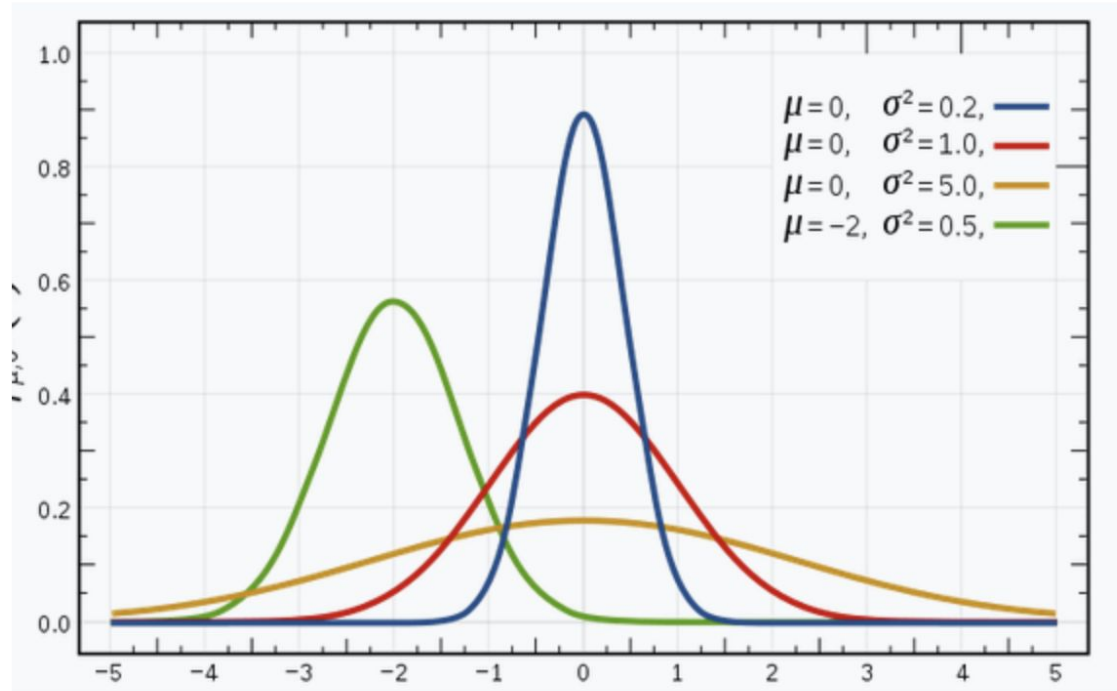
parameters to be estimated



# Gaussian Mixture Models

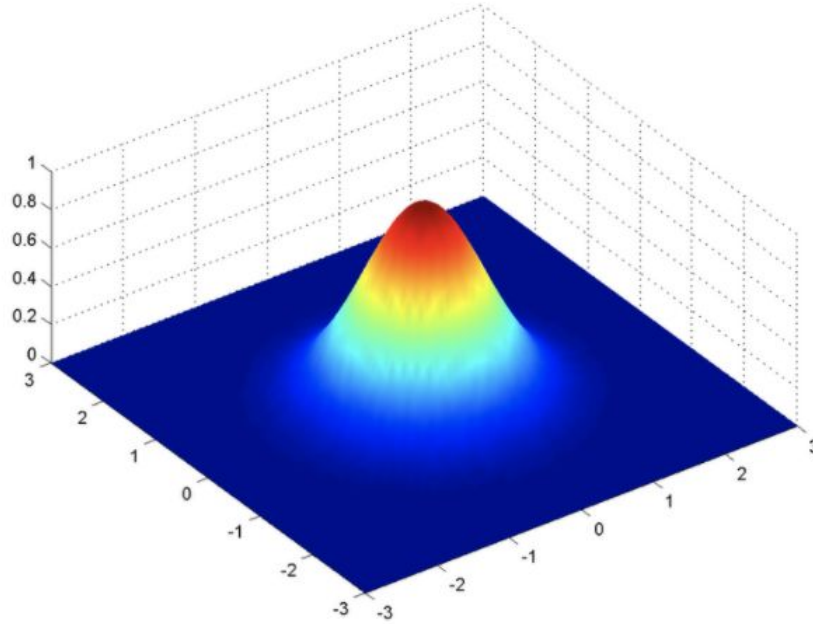


# Gaussian Distribution Contd.



$$f(x | \mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

# Gaussian Distribution Contd.



$$f(x | \mu, \Sigma) = \frac{1}{\sqrt{2\pi|\Sigma|}} \exp \left[ -\frac{1}{2} (\mathbf{x} - \boldsymbol{\mu})' \Sigma^{-1} (\mathbf{x} - \boldsymbol{\mu}) \right]$$



# Expectation Maximization

## E-Step

$$r_{ic} = \frac{\text{Probability } x_i \text{ belongs to } c}{\text{Sum of probability } x_i \text{ belongs to } c_1, c_2, \dots, c_k} = \frac{\pi_c \mathcal{N}(x_i; \mu_c, \Sigma_c)}{\sum_{c'} \pi_{c'} \mathcal{N}(x_i; \mu_{c'}, \Sigma_{c'})}$$

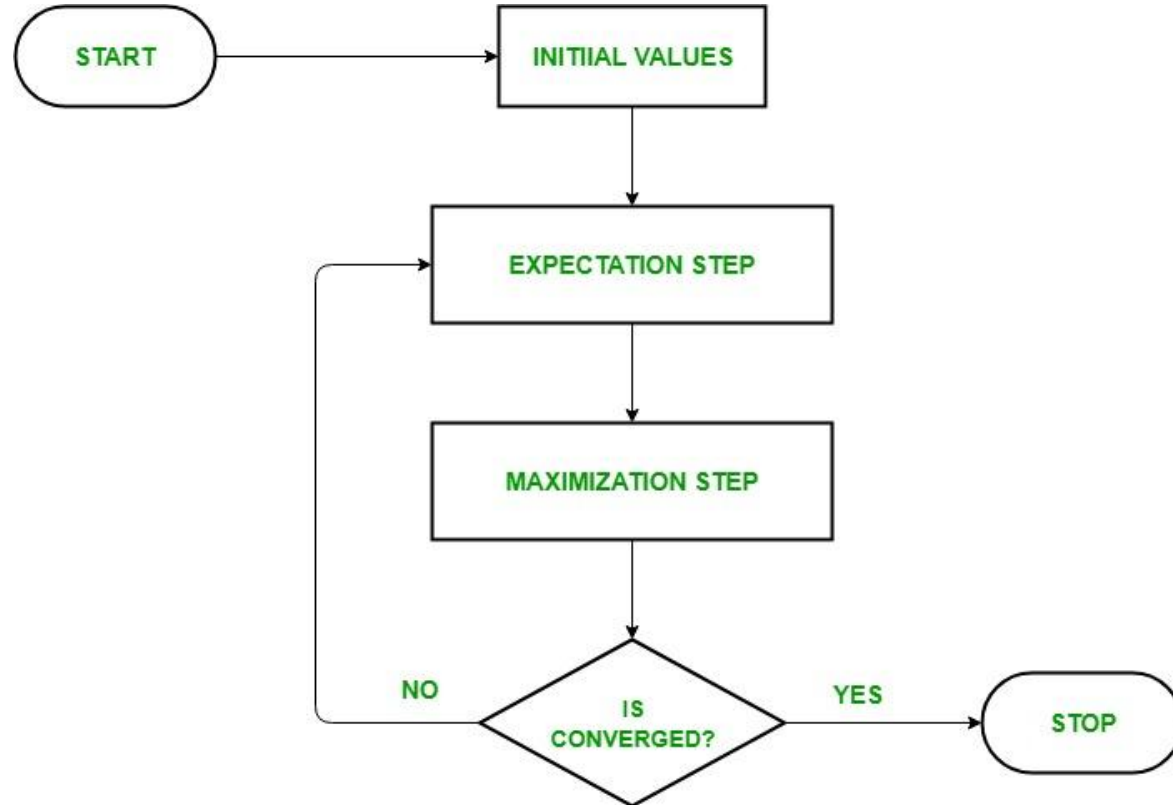
## M-Step

$$\Pi = \frac{\text{Number of points assigned to cluster}}{\text{Total number of points}}$$

$$\mu = \frac{1}{\text{Number of points assigned to cluster}} \sum_i r_{ic} x_i$$

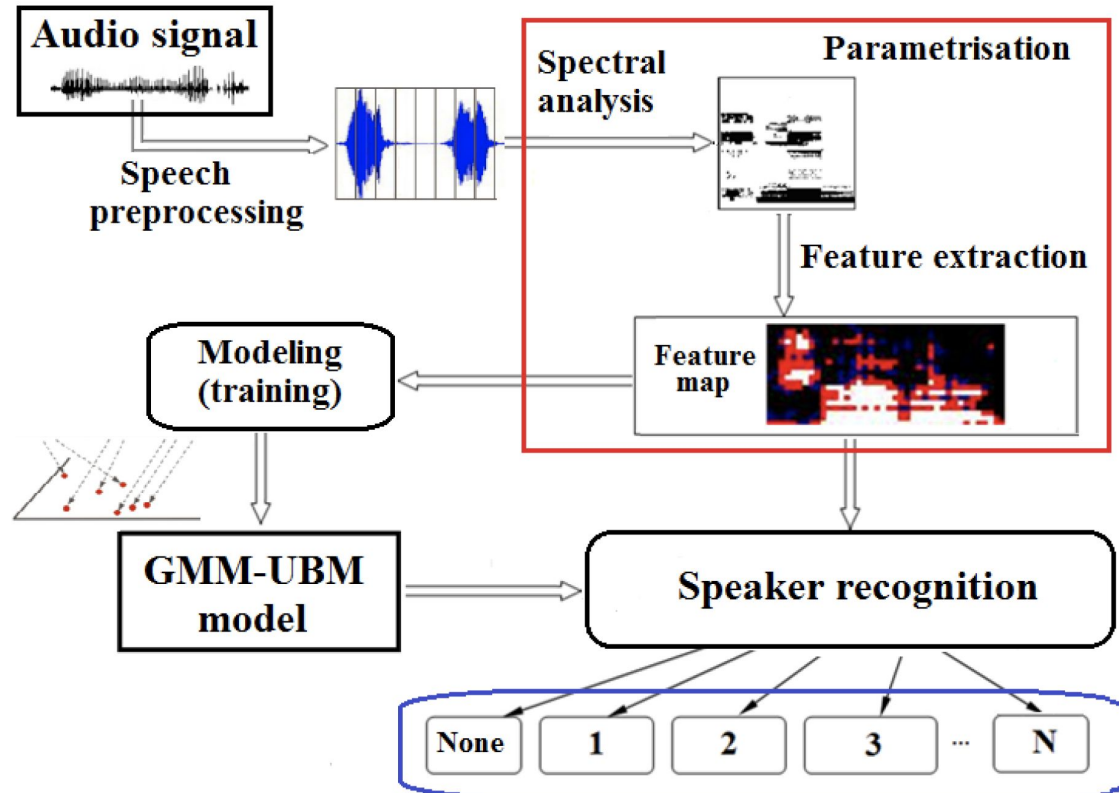
$$\Sigma_c = \frac{1}{\text{Number of points assigned to cluster}} \sum_i r_{ic} (x_i - \mu_c)^T (x_i - \mu_c)$$

# Expectation Maximization

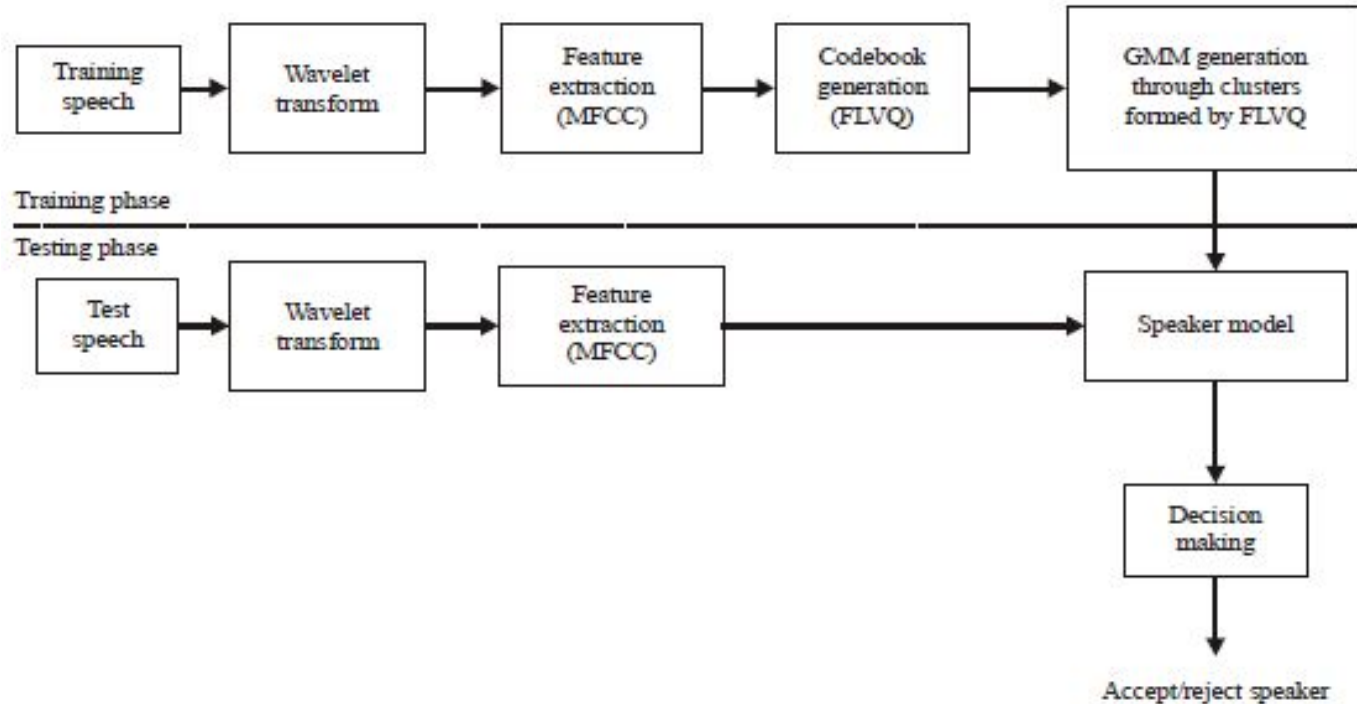


# Code Review

# Speaker Identification Problem



# Speaker Identification Problem



## Breakout Session Exercise