

Clusterbased Segmentation

Introduction

Clustering Analysis

Image Segmentation with Clustering

K-mean

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K-means++

mean a

What is Mean

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Algorithm

Cluster-based Segmentation

基于聚类的图像分割

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CVBIOUC

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May 19, 2015



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Clustering Analysis

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Clustering is unsupervised classification: no predefined classes.

Cluster: a collection of data objects

- Similar to one another within the same cluster
- Dissimilar to the objects in other clusters



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Idea:

Cluster similar pixel features together.

How to segment images by clustering?





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 ${\rm Image} \quad \Longrightarrow \quad {\rm Feature \ space}$



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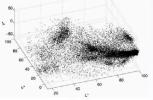
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 $Image \implies Feature space$

Feature space: (R,G,B), (R,G,B,X,Y), (L,U,V)...







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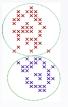
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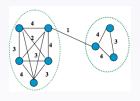
What is Mean Shift

Why Algorithm ■ Vector Clustering



Each point has a vector.

• Graph Clustering



Each vertex is connected to others by edges.



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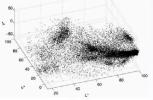
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Techniques:

- K-means
- Mean Shift



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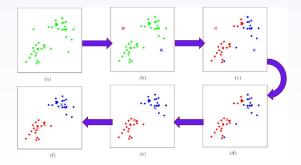
K-means++

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Idea:

- **1** Randomly initialize the K cluster centers.
- 2 For each point, find the closest cluster centers. Put the point into the cluster.
- 3 Change the cluster centers.



Clusterbased Segmentation

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What is Mear Shift Why

Algorithm:

- **1** Choose randomly K-means m_1, \ldots, m_k .
- 2 For each vector x_i compute $D(x_i, m_k(ic)), k = 1, ..., K$ and assign x_i to the cluster C_j with nearest mean.
- 3 Update the means to get $m_1(ic), \ldots, m_K(ic)$.

$$m_i^{(t+1)} = \frac{1}{|S_i^{(t)}|} \sum_{x_j \in S_i^{(t)}} x_j$$

4 Repeat steps 2 and 3 until $C_k(ic) = C_k(ic+1)$ for all k.



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Pros:

- Simple and fast
- Converges to a local minimum of the error function

Cons:

- Sensitive to initialization
- Need to pick K

K-means++

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Algorithm:

- **I** Take one center c_1 , chosen uniformly at random from X.
- 2 Take a new center c_i , choosing $x \in X$ with probability $\frac{D(x)^2}{\sum_{x \in X} D(x)^2}$
- \blacksquare Repeat Step 1, until we have taken k centers altogether.

D(x) denote the shortest distance from a data point to the closest center.



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Mean Shift¹

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What is Mean Shift

Why Algorithm An advanced and versatile technique for clustering-based segmentation.

Idea:

■ Find the clustering center.



¹D. Comaniciu and P. Meer, "Mean Shift: A Robust Approach toward Feature Space Analysis", PAMI, 2002.



What and How?

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Center is maximum points of probability density function and gradient direction.



Mean Shift Vector

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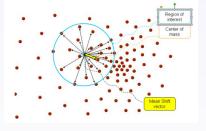
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$$M_h = \frac{1}{K} \sum_{x_i S_k} (x_i - x)$$



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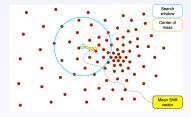
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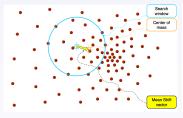
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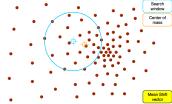
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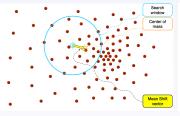
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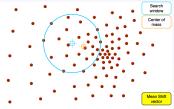
K-means++

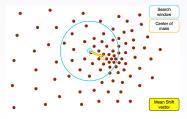
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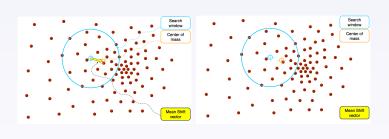
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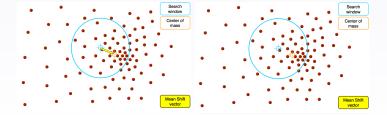
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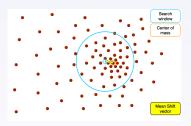
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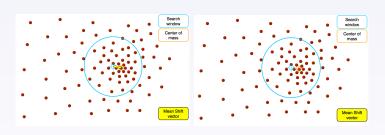
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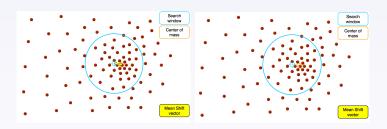
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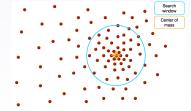
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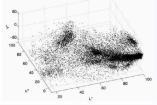
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Density Estimation

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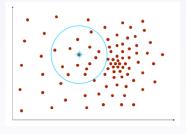
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Why



$$P = \frac{N_k}{N}$$

$$f(x) = \frac{P}{S} = \frac{N_k}{NS}$$



Kernel density estimation (Parzen windows)

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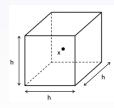
Kernel density estimation:

Let $(x_1, x_2, ..., x_n)$ be an independent and identically distributed sample drawn from some distribution with an unknown density f(x). Its kernel density estimator is

$$f(\hat{x})_{h,k} = \frac{1}{Nh^d} \sum_{n=1}^{N} k(\frac{x_n - x}{h})$$

Kernel function:

$$k(u) = \begin{cases} 1 & |u_i| \leq \frac{1}{2}, i = 1, \dots, D \\ 0 & otherwise \end{cases}$$





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$$\hat{f}_{h,K}(x) = \frac{1}{Nh^d} \sum_{n=1}^{N} k(||\frac{x - x_n}{h}||^2)$$

Density gradient:

$$\hat{\nabla} f_{h,K}(x) = \frac{2}{Nh^{d+2}} \sum_{n=1}^{N} (x_n - x) [-k'(||\frac{x - x_n}{h}||^2)]$$
$$g(x) = -k'(x)$$



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$$\hat{\nabla} f_{h,K}(x) = \frac{2}{Nh^{d+2}} \sum_{n=1}^{N} (x_n - x) [g(||\frac{x - x_n}{h}||^2)]$$

$$= \underbrace{\frac{2}{h^2}}_{C} \underbrace{\left[\frac{1}{Nh^d} \sum_{n=1}^{N} g(||\frac{x_n - x}{h}||^2)\right]}_{f_{h,\hat{G}}(x)} \underbrace{\left[\frac{\sum_{n=1}^{N} x_n g(||\frac{x_n - x}{h}||^2)}{\sum_{n=1}^{N} g(||\frac{x_n - x}{h}||^2)} - x\right]}_{m_{h,G}(x)}$$



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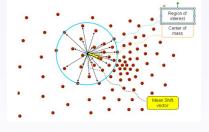
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$$M_h = \frac{1}{K} \sum_{x_i S_k} (x_i - x)$$



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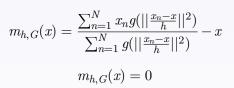
K-means+4

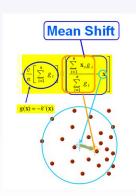
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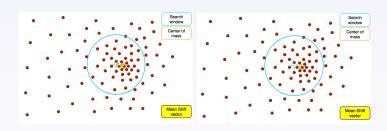
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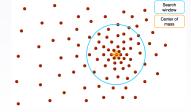
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Clustering center:

$$y_{i,k+1} = \frac{\sum_{n=1}^{N} x_n g(||\frac{x_n - x}{h}||^2)}{\sum_{n=1}^{N} g(||\frac{x_n - x}{h}||^2)}$$



Mean Shift

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Why Algorithm

- 1 Find features (color, gradients, texture, etc).
- 2 Initialize windows at individual pixel locations.
- 3 Compute $y_{i,k+1}$ until convergence, $y_{i,k} = y_{i,k+1}$.
- 4 Assign $z_i = (x_i, y_{i,k})$.



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Thanks!