

Clusterbased Segmentation

Introduction

Clustering Analysis

Image Segmentation with Clustering

K-mean

Idea

K-means++

mean a

What is Mean

XX71....

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



Contents

Clusterbased Segmentation

Introductio

Clustering Analysis

Image Segmentation with Clusterin

K-means

K-means++

Idea

What is Mean Shift

Why Algorithm

1 Introduction

- Clustering Analysis
- \blacksquare Image Segmentation with Clustering

2 K-means

- Idea
- Algorithm
- \blacksquare K-means++

3 Mean Shift

- Idea
- What is Mean Shift
- Why
- Algorithm



Clustering Analysis

Clusterbased Segmentation

Introduction

Clustering Analysis

Segmentation with Clusterin

K-means

Algorithr

K-means+-

Idea What is Mean

Shift
Why
Algorithm

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



Clusterbased Segmentation

Introductio

Analysis

Image Segmentation with Clusterin

(-mea

Algorith

K-means++

wieai

What is Mean Shift

Why

Algorithm

Idea:

Cluster similar pixel features together.

How to segment images by clustering?





Clusterbased Segmentation

Introductio:

Clusterin Analysis

Image Segmentation with Clusterin

K-meai

Idea

Aigorithi

K-means+-

vieai

What is Mean

Why

Algorithm

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



Clusterbased Segmentation

Introduction

Clusterin Analysis

Image Segmentation with Clusterin

(-meai

Algorith:

K-means+-

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What is Mea

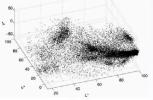
Why

Algorithm

 $Image \implies Feature space$

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







Clusterbased Segmentation

Introductio

Clusterin Analysis

Image Segmentation with Clusterin

K-meai

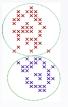
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K-means++

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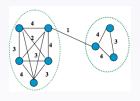
What is Mean Shift

Why Algorithm ■ Vector Clustering



Each point has a vector.

• Graph Clustering



Each vertex is connected to others by edges.



Clusterbased Segmentation

Introduction

Clusterin Analysis

Image Segmentation with Clusterin

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Algorith:

K-means+-

Y-1--

What is Mea

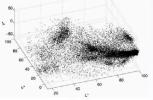
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Clusterbased Segmentation

Introductio

Clusterin Analysis

Image Segmentation

x-mean

Algorith

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it-means-

Idea

What is Mean Shift

Why

Algorithm

Techniques:

- K-means
- Mean Shift



Clusterbased Segmentation

Introduction

Analysis
Image
Segmentation
with Clusterin

with Clusteri K-means

Idea Algorithm

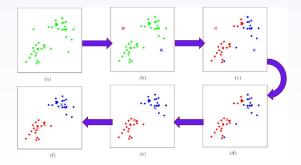
K-means++

Idea What is Mean Shift

Why Algorithm

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

Introduction

Clustering Analysis Image Segmentation

K moans

Idea Algorithm

K-means++

Mean Shif ^{Idea}

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.



Clusterbased Segmentation

Introduction

Clustering Analysis Image

with Cluste

Idea

K-means++

Idea What is Mean Shift

Shift Why Algorithm

Pros:

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

Cons:

- Sensitive to initialization
- Need to pick K

K-means++

Clusterbased Segmentation

Introduction

Analysis
Image
Segmentation

Segmentation with Clusterin

Idea Algorithm

K-means++

Idea
What is Mean
Shift
Why

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.



Clusterbased Segmentation

Introduction

Clustering Analysis Image

with Cluste

Idea

K-means+

Idea What is Mear

Shift Why Algorithm

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Mean Shift¹

Clusterbased Segmentation

Introductio:

Clustering Analysis

Segmentation with Clusterin

Idea Algorithm

K-means++

Mean Shift

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?

Clusterbased Segmentation

Introduction

Clustering Analysis

Segmentation with Clustering

K-meai

 $_{\mathrm{Idea}}$

Algorithm

K-means+-

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What is Mear Shift

Why





What and How?

Clusterbased Segmentation

Introduction

Analysis
Image
Segmentation
with Chesterine

K-meai

Idea Algorithn

K-means++

Idea

What is Mean Shift

Why

Why Algorithm



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



Mean Shift Vector

Clusterbased Segmentation

Introduction

Clustering Analysis

Segmentation with Clustering

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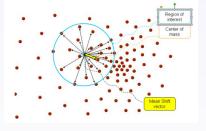
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Idea

What is Mea Shift

Why



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



Clusterbased Segmentation

Introductio

Clustering Analysis

Segmentation with Clusterin

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Idea

Algorithi

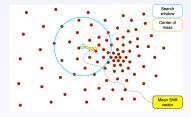
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What is Mea

Why

Algorithr





Clusterbased Segmentation

Introductio

Clusterin Analysis

Segmentation with Clusteri

K-meai

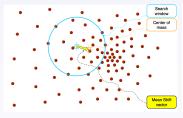
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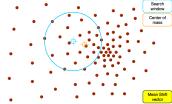
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Idea What is Me

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Clusterbased Segmentation

Introductio

Clusterin Analysis

Segmentation with Clusterin

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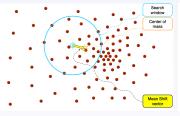
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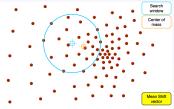
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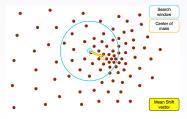
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What is Mea

Shift









Clusterbased Segmentation

Introductio

Clusterin Analysis

Segmentation with Clusteri

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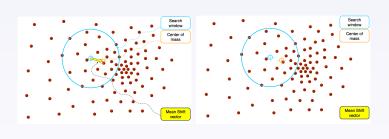
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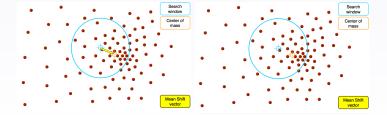
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What is Mean

Shift







Clusterbased Segmenta tion

Introductio

Clustering Analysis

Segmentation with Clusterin

₹-mear

Idea

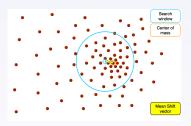
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What is Mear Shift

Why





Clusterbased Segmentation

Introductio

Clustering Analysis

Segmentation with Clusterin

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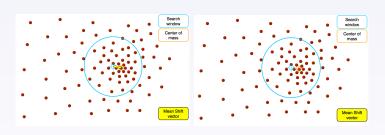
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What is Mea Shift

Why





Clusterbased Segmentation

Introductio

Clustering Analysis

Segmentation with Clusteri

K-mea

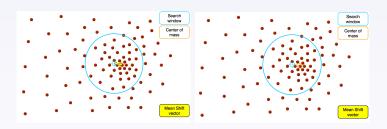
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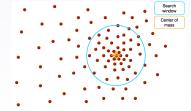
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What is Mea

Why







Clusterbased Segmenta tion

Introduction

Clustering Analysis

Segmentation with Clusterin

K-mea:

Algorith

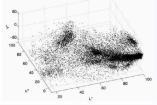
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What is Mea Shift

Why







Density Estimation

Clusterbased Segmentation

Introduction

Clusterin Analysis

Segmentation with Clustering

K-mea:

Idea

Algorith

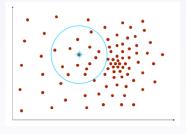
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Idea

Shift

Why



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

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



Kernel density estimation (Parzen windows)

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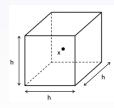
Kernel density estimation:

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:

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





Clusterbased Segmentation

Introduction

Clustering Analysis Image

with Ch

K-mear

Idea

K-means++

Mean S

What is Mean Shift

Why

Algorithm

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

Density gradient:

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



Clusterbased Segmentation

Introduction

Clusterin Analysis

Image Segmentation

with Clusterin

Idea Algoritha

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Idea

What is Mea: Shift

 \mathbf{Why}

Algorithn

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

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



Clusterbased Segmentation

Introduction

Clusterin; Analysis

Segmentation with Clustering

K-meai

Idea

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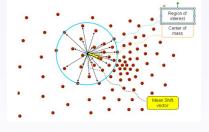
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 $_{\rm Idea}$

Shift

 $_{\rm Why}$

Algorithn



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



Clusterbased Segmentation

Introduction

Clusterin Analysis

Segmentation with Cluster

K-mean

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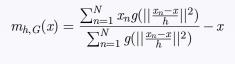
Algorithm

K-means++

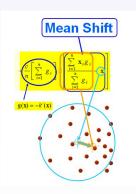
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Why



$$m_{h,G}(x) = 0$$





Clusterbased Segmentation

Introductio

Clusterin Analysis

Segmentation with Clusteri

K-mea

Idea Algorithi

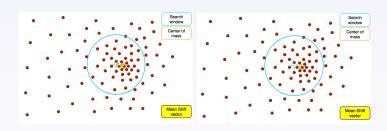
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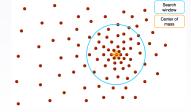
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Idea

Shift

Why







Clusterbased Segmentation

Introductio

Clustering Analysis

Image Segmentation with Clustering

K-mean

Idea

Algorith

K-means++

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What is Mea: Shift

Why

Algorithr

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

Clusterbased Segmentation

Introduction

Clustering Analysis

Segmentation with Clusterin

Idea

K-means++

Idea What is Mear Shift

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 $z_i = (x_i, y_{i,k})$.



Clusterbased Segmentation

Introduction

Clustering Analysis

Segmentation with Clustering

K-mear

Idea

Algorithm

K-means++

Mean Shii

Idea

What 18 Mean Shift

Why

Algorithm

Thanks!