Lecture 21 Region-based Segmentation （chapter 10.4-10.6 ）

Yuyao Zhang PhD

zhangyy8@shanghaitech.edu.cn

SIST Building 2 302-F

上海科技大学
ShanghaiTech University

Outline

- Region-based Segmentation
  - Region growing
  - Region spilt and merge
  - Clustering and Super-pixel

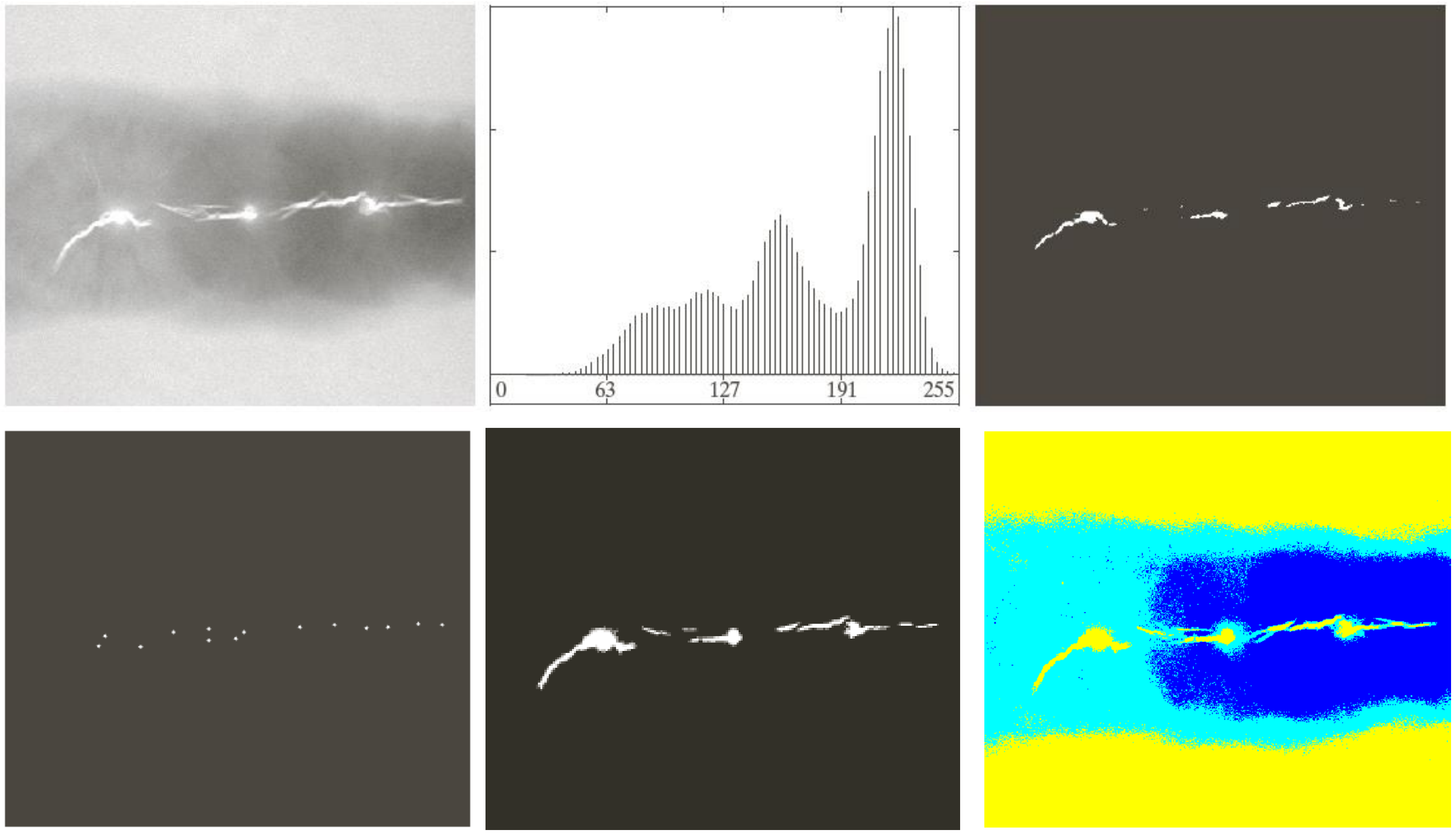
Basic region growing

- If we only want "common" pixels near one point.

  1) from input image $I(x, y)$ get a binary "seed image" $S(x, y)$ for locations of interest. (e.g. by thresholding).

  2) reduce seed connected components down to single point each.

  3) let $T(x, y) = 1$ if $I(x, y)$ satisfies some predicate/condition and 0 else. (e.g. (x, y) is 8-connected to seed point (x_i, y_i) and $|I(x, y) - I(x_i, y_i)| < T$).



Try this

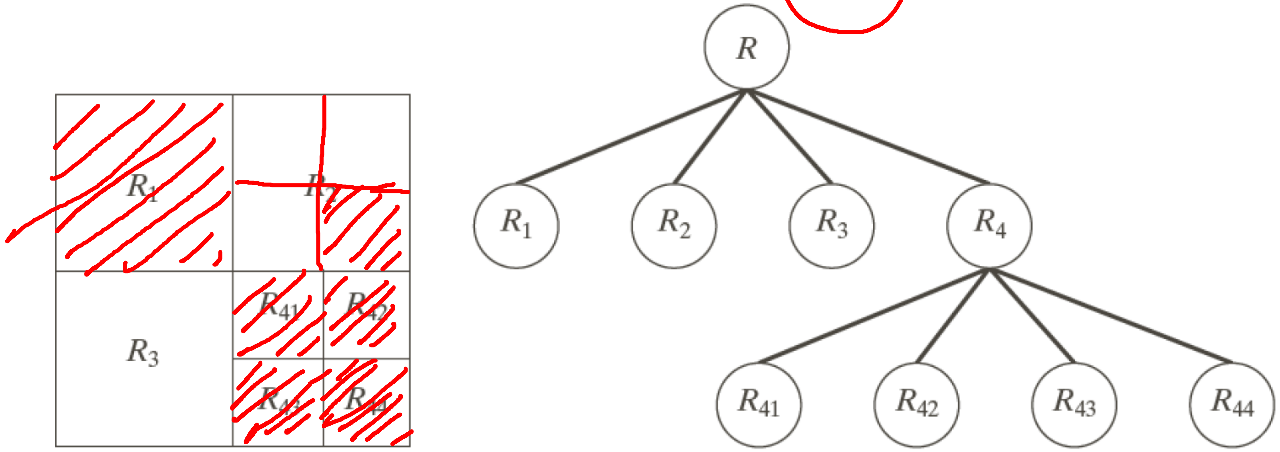
- Check the “regiongrow.m” function in discussion folder.

Region split and merge

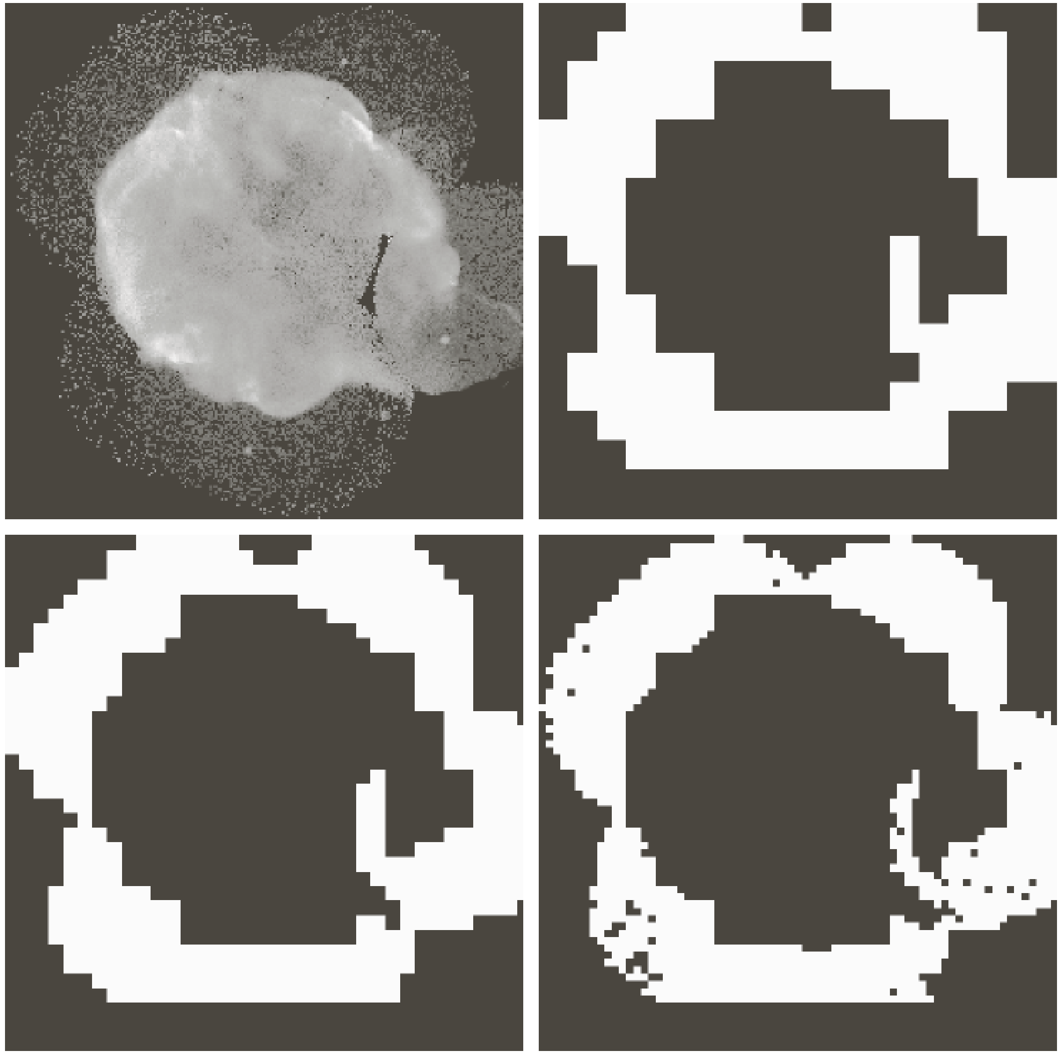
➢ Steps

1. Split into four disjoint quadrants any region R_i for which $Q(R_i) = False$ (need to specify a minimum quadregion size beyond which no further splitting is carried out;
2. Merge any adjacent regions R_j and R_k for which $Q(R_j \cup R_k) \ = True$;
3. Stop when no further merging is possible.

$|R_i(R,G,B) - (255,255,255)| < T$



Region Splitting and Merging



K-means Clustering

- Algorithm:

1) Specify an initial set of clusters centers $m_1, m_2, \cdots, m_k \in \mathcal{R}^n$.

2) For each $x_i \in \mathcal{R}^n$ in dataset, assign it to closest cluster

$$x_i \in cluster_j \text{ if } \|x_i - m_j\| < \|x_i - m_k\| \quad (k \neq j)$$

3) Update the mean m_j = average value of all x in cluster j.

$$m_j = \frac{1}{c_j} \cdot \sum_{x \in c_j} x \quad j = 1,2,\cdots,k$$

4) Keeps altering 2) and 3) until stop changing.

E.g. Image histogram

E.g. Color space k-means cluster.

K-means Clustering

- Algorithm:

1) Specify an initial set of clusters centers $m_1, m_2, \cdots, m_k \in \mathcal{R}^n$.

2) For each $x_i \in \mathcal{R}^n$ in dataset, assign it to closest cluster

$$x_i \in cluster_j \text{ if } \|x_i - m_j\| < \|x_i - m_k\| \quad (k \neq j)$$

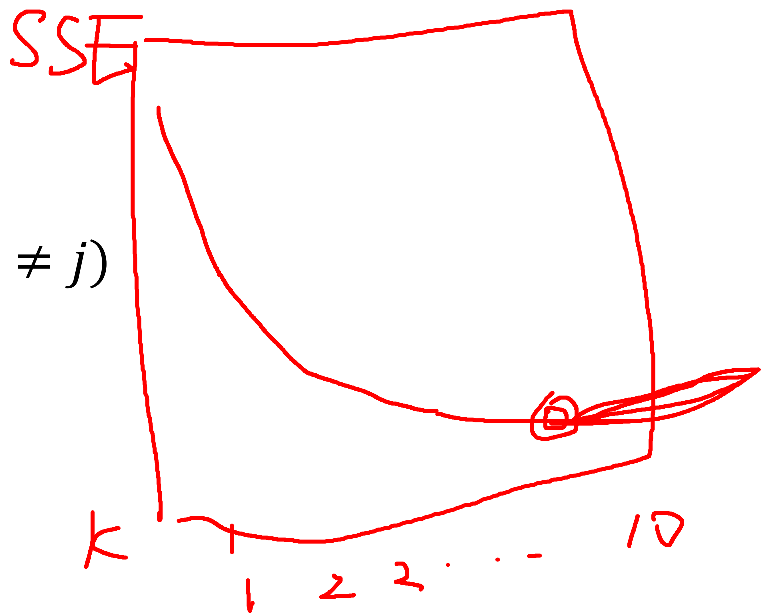
3) Update the mean m_j = average value of all x in cluster j.

$$m_j = \frac{1}{c_j} \cdot \sum_{x \in c_j} x \quad j = 1,2,\cdots,k$$

4) Keeps altering 2) and 3) until stop changing.

E.g. Image histogram

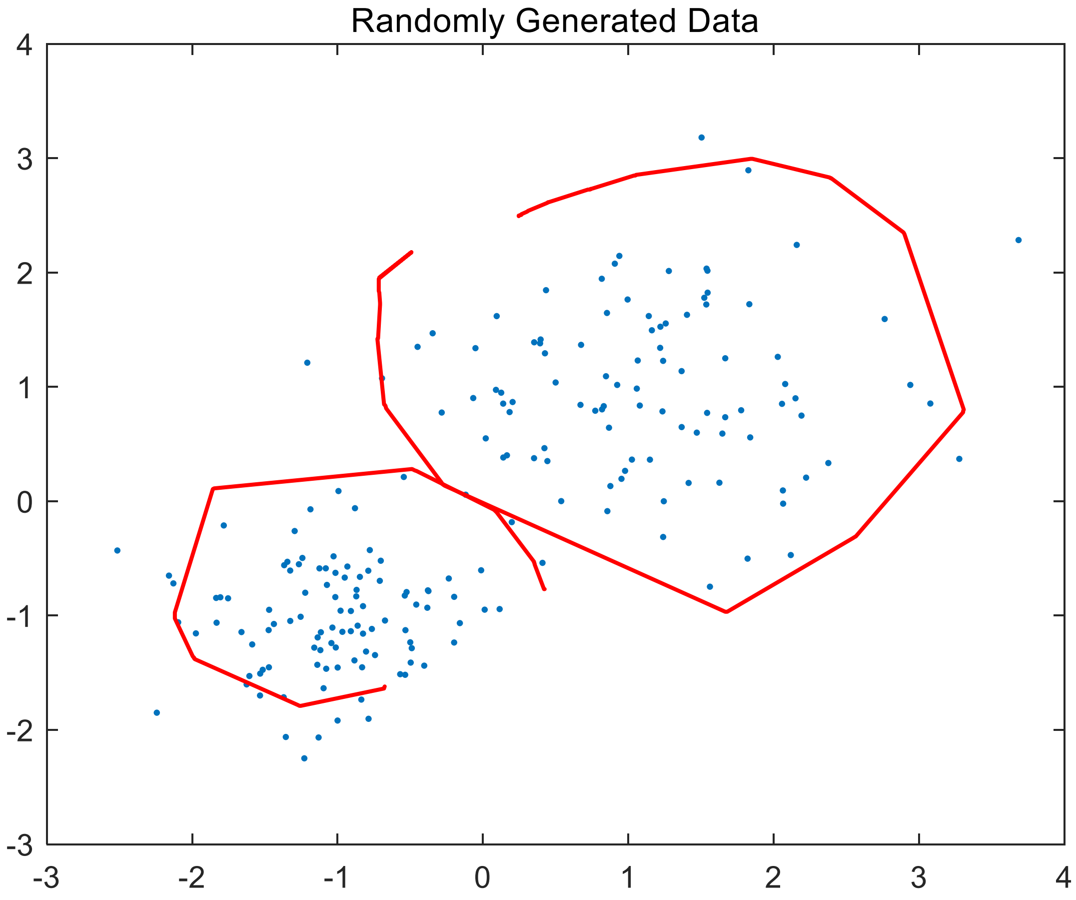
E.g. Color space k-means cluster.



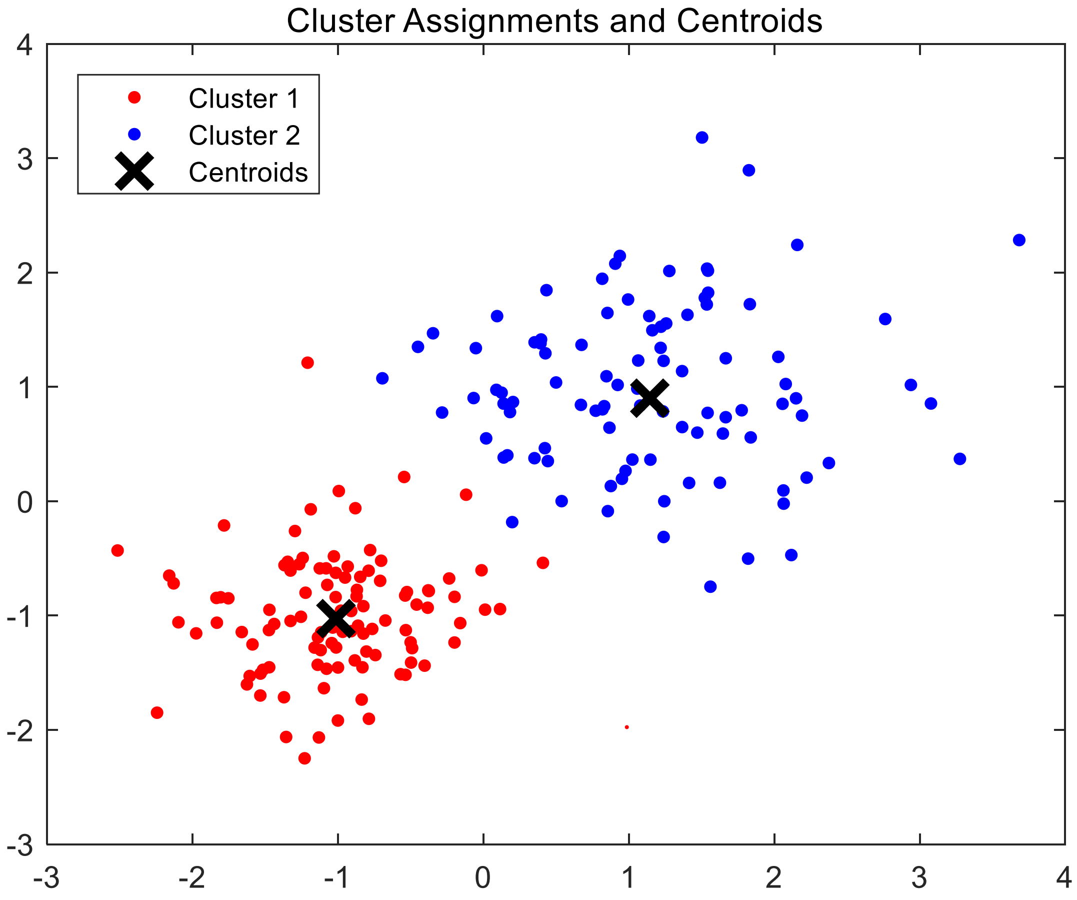
$$SSE = \sum_{k=1}^{K} \sum_{x \in C_k} |x - m_k|^2$$

min

K-means demo

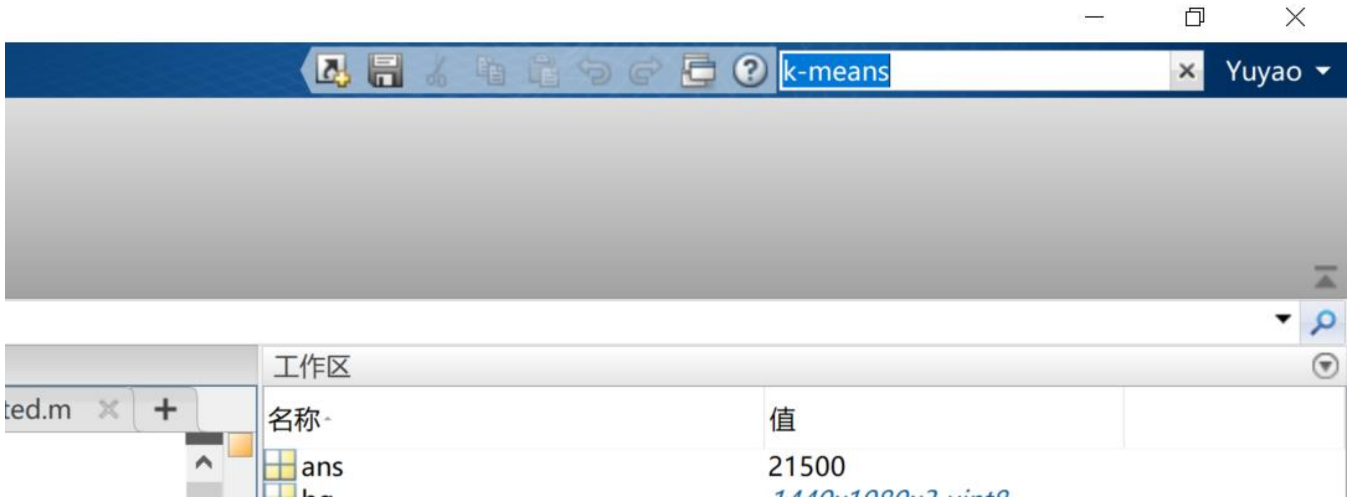


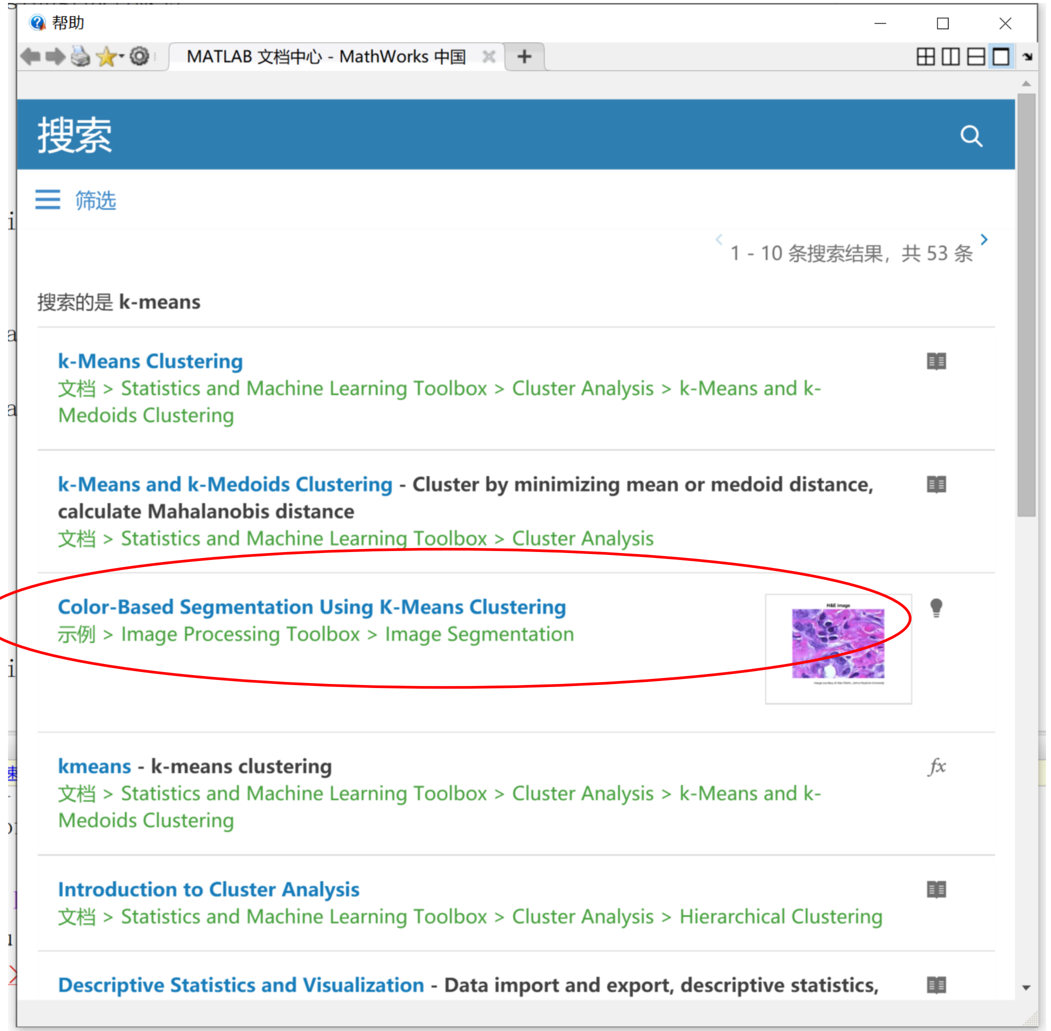
Randomly Generated Data
4
3
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
3
4



Cluster Assignments and Centroids
Cluster 1
Cluster 2
Centroids
4
3
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
3
4

Try this





上海科技大学 ShanghaiTech University

H&E image

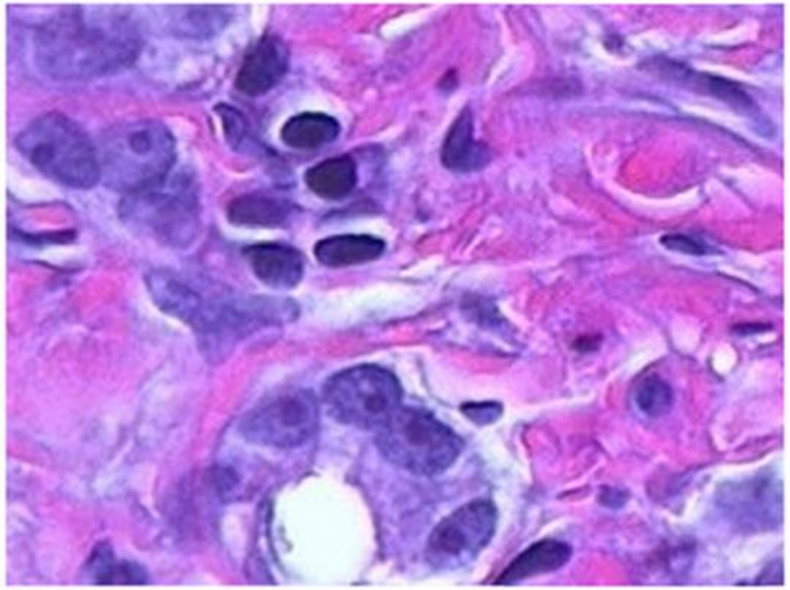
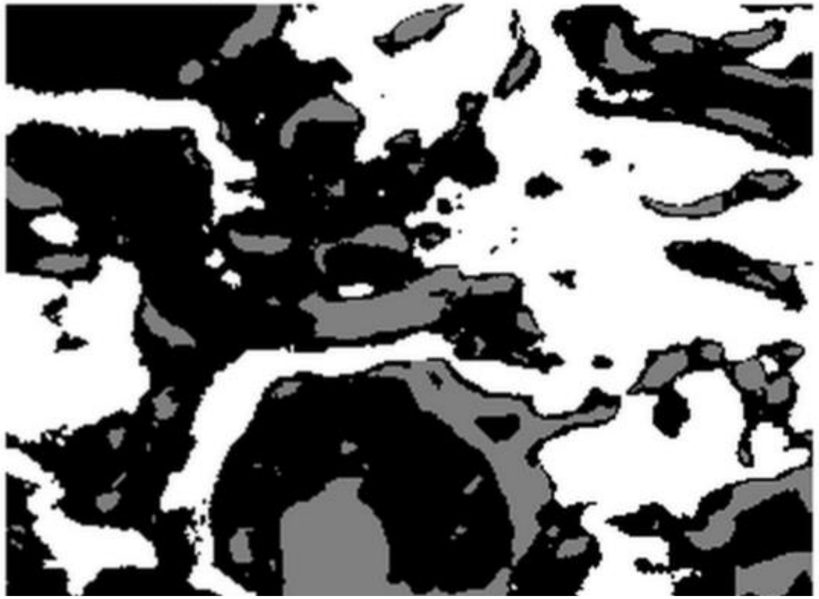
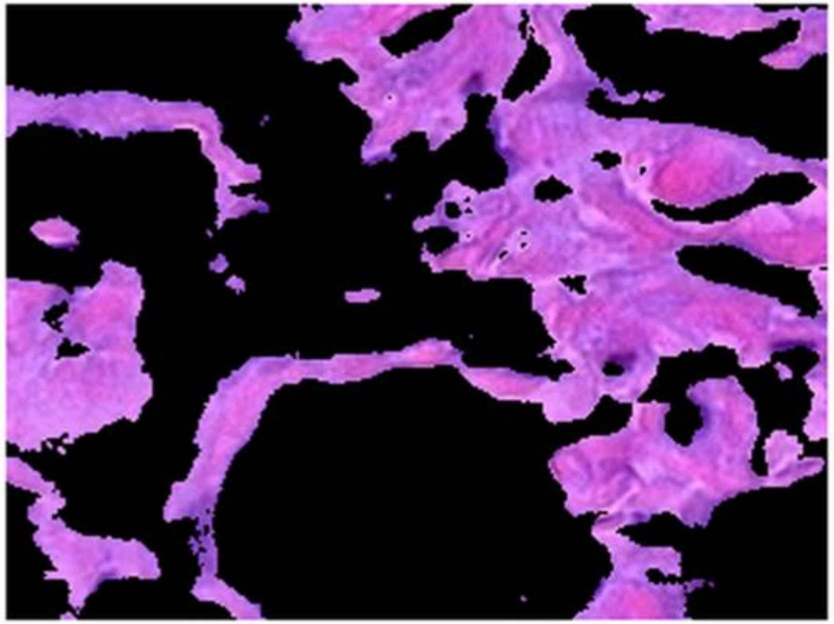


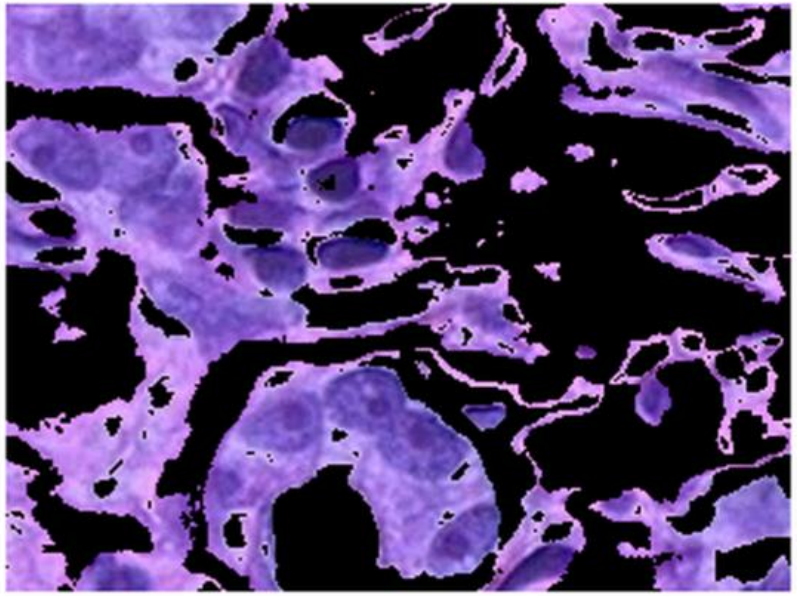
image labeled by cluster index



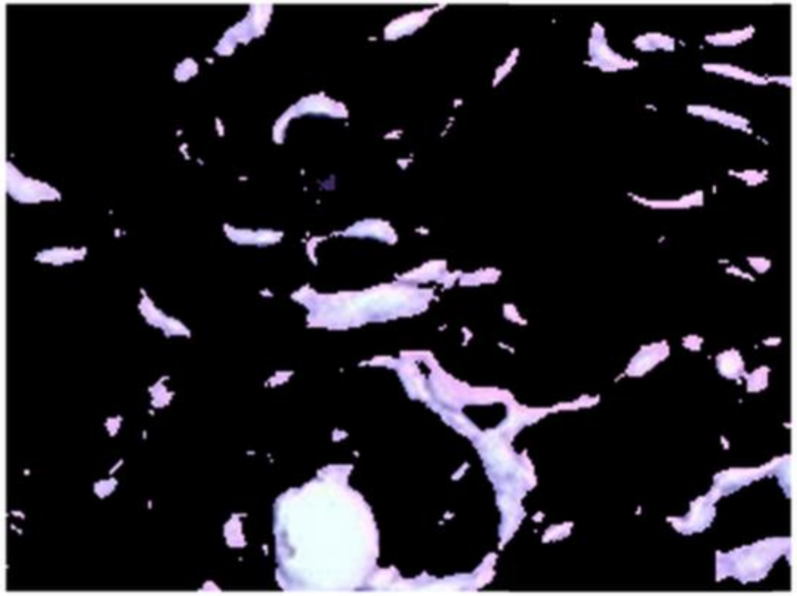
objects in cluster 3



objects in cluster 1



objects in cluster 2

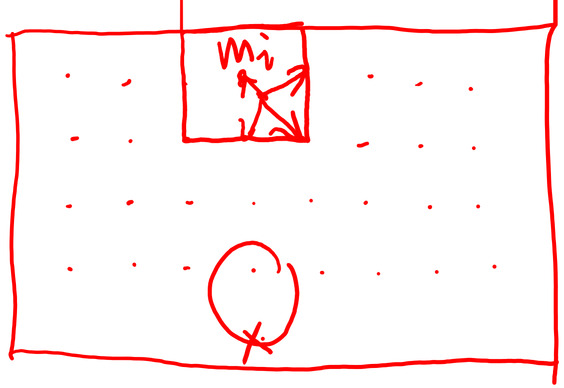


上海科技大学
ShanghaiTech University

Super-pixel

- Modification of K-means used in image processing;
- Regions of image that are contiguous and have similar intensity/color.
- Why doing this?
  - More compact (e.g. thousands of super-pixels could represent millions of pixels).
  - “Keeps things together” better for subsequent segmentation; computationally efficient.

Super-pixel



Idea: Clustering 5-D vectors $[r, g, b, x, y]$

1) initialize super-pixels center by sampling N locations on a region grid in image plane.

- ❖ Move slightly within 3x3 neighborhood to lie on lowest gradient position (Don't want to start on an edge).

2) For each cluster center m_{i}, compute distance bwt m_{i} and each pixel in a neighborhood of m_{i}.

$\begin{bmatrix} R_{m_i} \\ G_{m_i} \\ \vdots \\ X_{m_i} \end{bmatrix}$

$d_c = \left\| \begin{bmatrix} R \\ G \\ B \end{bmatrix}_i - \begin{bmatrix} R \\ G \\ B \end{bmatrix}_j \right\|_2$ color

- ❖ Only search in neighborhood, the region size depends on # of N.

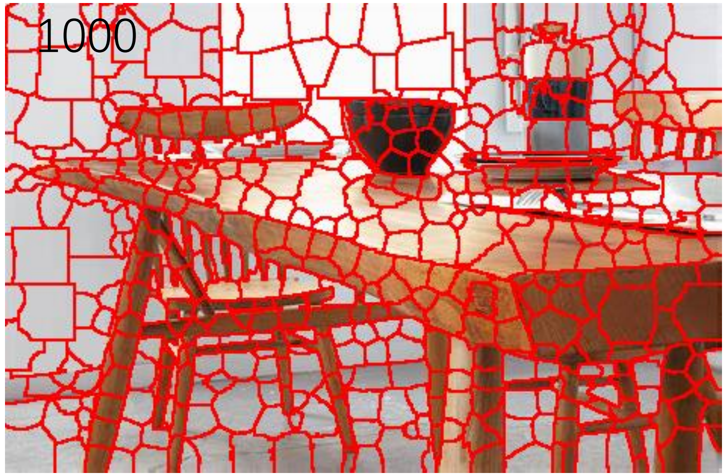
$d_s = \left\| \begin{bmatrix} x \\ y \end{bmatrix}_i - \begin{bmatrix} x \\ y \end{bmatrix}_j \right\|_2$ spatial

- ❖ Assign pixel to cluster i if its distance is better than its current value.

$$D = \sqrt{\left(\frac{d_c}{c}\right)^2 + \left(\frac{d_s}{s}\right)^2}$$

Try this

- Check the “mysuperpix.m” function in discussion folder.



Take home message

- **Pixel-based segmentation:**

  each pixel is segmented based on gray-level values, no contextual information, only histogram.

  -Example: hough transform

- **Region-based segmentation:**

  considers gray-levels from neighboring pixels by

  – including similar neighboring pixels (region growing),

  – split-and-merge,

  – or super-pixel segmentation.

- **Edge-based segmentation:**

  Detects and links edge pixels to form contours.

Take home message

- Region based methods are robust because:
  - – Regions cover more pixels than edges and thus you have more information available in order to characterize your region
  - – When detecting a region you could for instance use texture which is not easy when dealing with edges
  - – Region growing techniques are generally better in noisy images where edges are difficult to detect
- The edge based method can be preferable because:
  - – Algorithms are usually less complex
  - – Edges are important features in an image to separate regions
- The edge of a region can often be hard to find because of noise or occlusions
- Combination of results may often be a good idea