Region Segmentation

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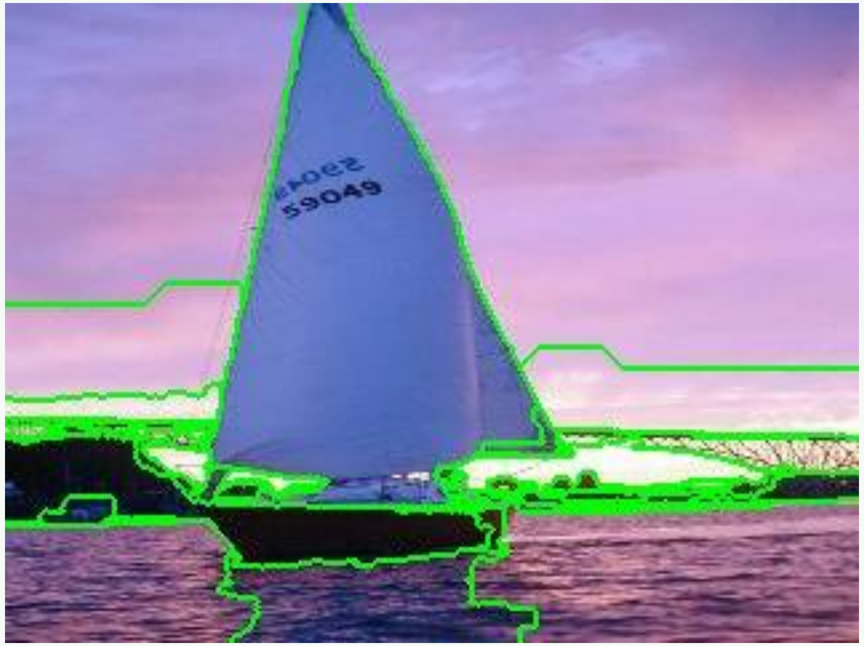
Artificial Inteligence
& Computer Vision
Laboratory

Image Segmentation

- Image segmentation is the operation of partitioning an image into a collection of connected sets of pixels (regions)



Region-based Segmentation

- **Goal:** find coherent (homogeneous) regions in the image
- Coherent regions contain pixel which share some ***similar property***
- ***Advantages:*** Better for noisy images
- ***Disadvantages: Oversegmented (too many regions),***
  Undersegmented (too few regions)
- ***Can't find objects that span multiple disconnected regions***

Types of Segmentation

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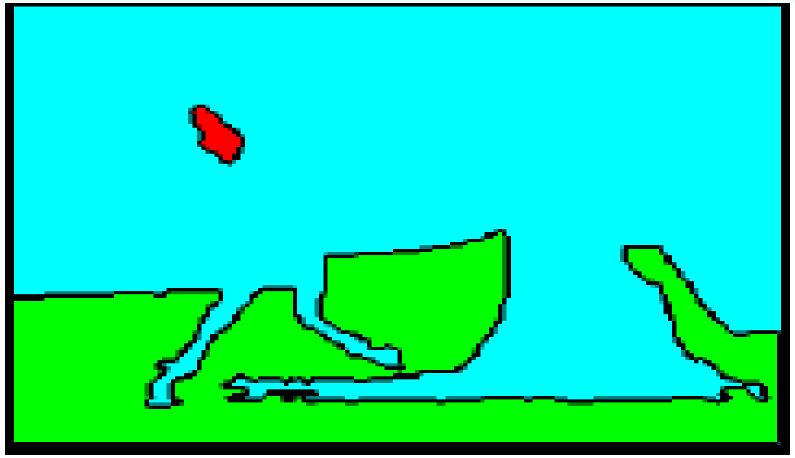
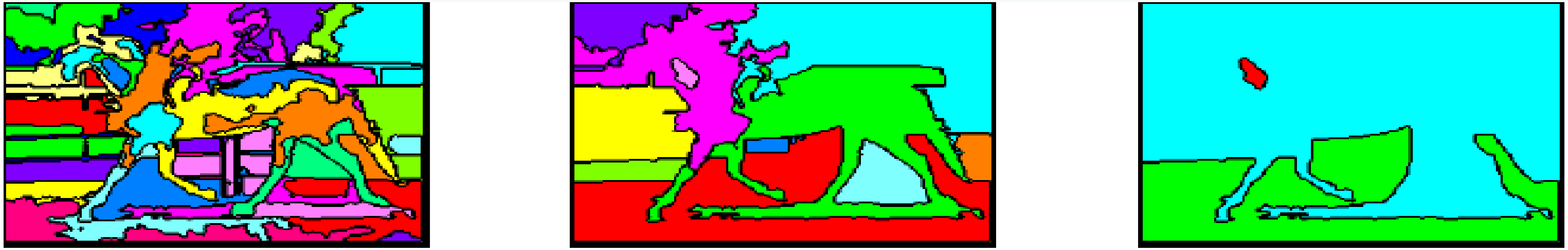
Input

Oversegmentation



Undersegmentation



Multiple Segmentations

Region-based Segmentation:Criteria

A segmentation is a partition of an image I into a set of regions S satisfying:

1. $\cup$ Si = S Partition covers the whole image.
2. Si $\cap$ Sj = ϕ, i $\neq$ j No regions intersect.
3. $\forall$ Si, P(Si) = true
4. P(Si $\cup$ Sj) = false, i $\neq$ j, Si adjacent Sj

Define and implement the **similarity** predicate.

Method of Region Segmentation

- **Region growing**
- **Split and merge**
- **Clustering**

Region Growing

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- It start with one pixel of a potential region
- Try to grow it by adding adjacent pixels till the pixels being compared are too dissimilar
- The first pixel selected can be
  - The first unlabelled pixel in the image
  - A set of seed pixels can be chosen from the image.
- Usually a statistical test is used to decide which pixels can be added to a region

Split and Merge

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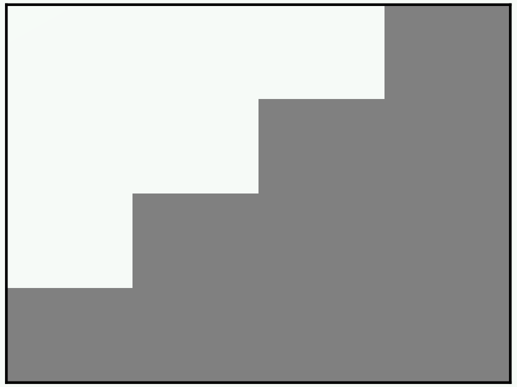
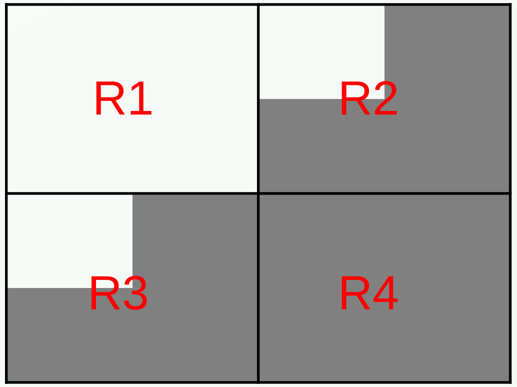
- Split into four disjoint coordinates any region R_i for which $Q(R_i)$=false
- When no further splitting is possible, merge **adjacent** region for which $Q(R_i \cup R_j)$= true
- Stop when no further merging is possible

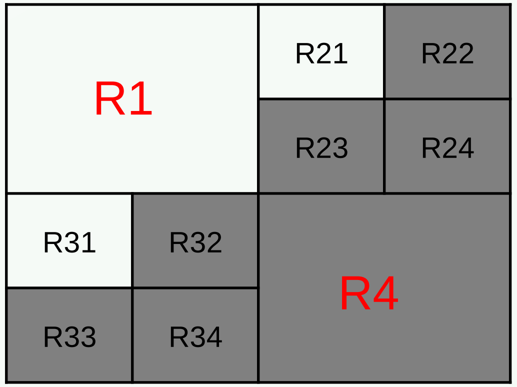
Exercise



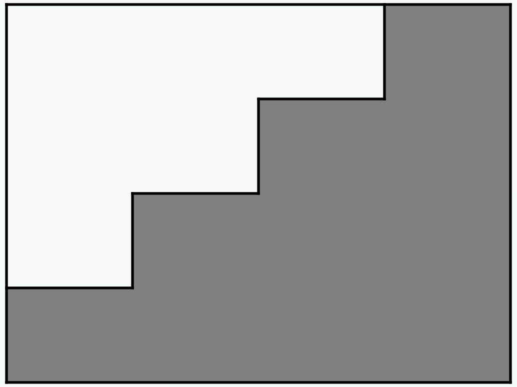
Input image



Split



Split

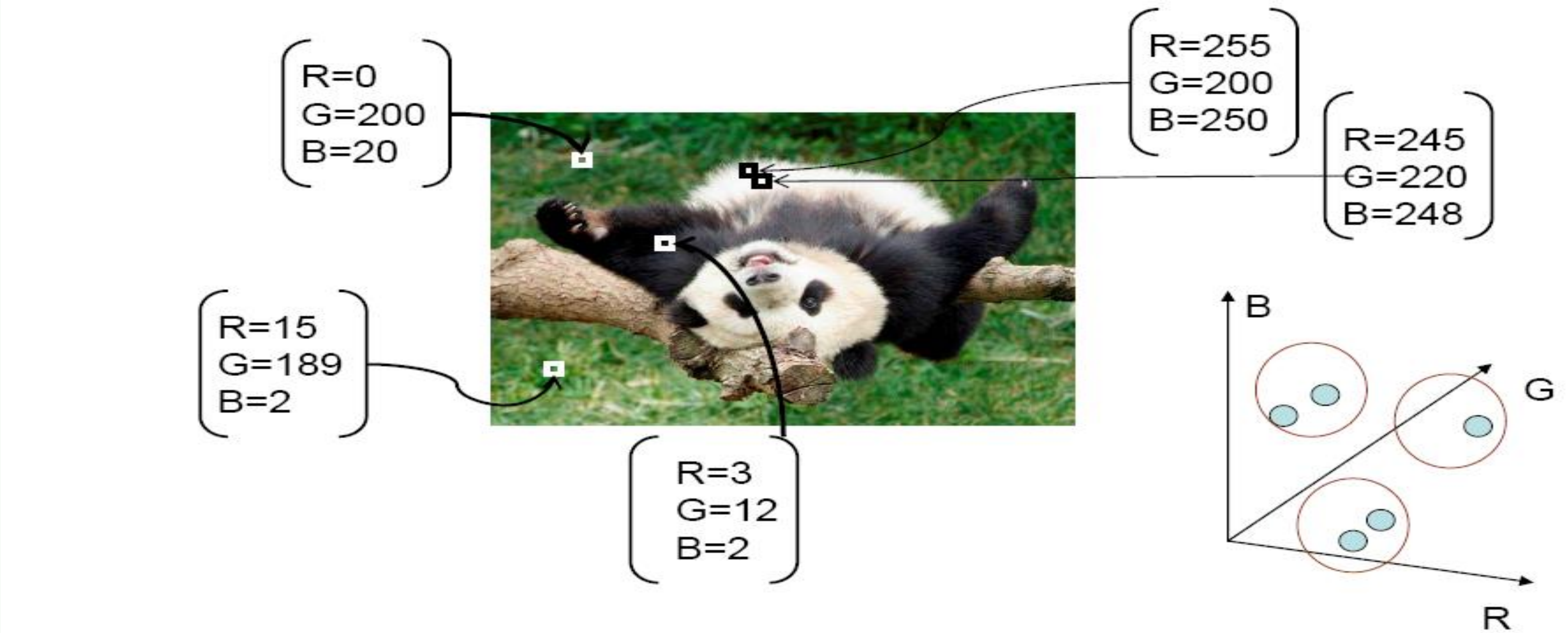


Merge

Clustering

- Task of grouping a set of objects
- Objects in the same group (called a **cluster**) are more similar (in some sense or another) to each other
- Object of one cluster is different from an object of the another cluster
- Connectivity model, centroid model, distribution model, density model, graph based model, hard clustering, soft-clustering, …

Clustering: feature space



Centroid Model

- Computational time is short
- User have to decide the number of clusters before starting classifying data
- The concept of **centroid**
- One of the famous method: **K-means** Method

Clustering

- There are K clusters C1,…, CK with means m1,…, mK.

- The least-squares error is defined as

$$D = \sum_{k=1}^{K} \sum_{x_i \in C_k} \| x_i - m_k \|^2 .$$

- Out of all possible partitions into K clusters, choose the one that minimizes D.

K-means Clustering

Form K-means clusters from a set of n-dimensional vectors

1. Set ic (iteration count) to 1

2. Choose randomly a set of K means $m_1(1)$, …, $m_K(1)$.

3. For each vector x_i compute $D(x_i, m_k(ic))$, $k=1,\ldots K$ and assign x_i to the cluster C_j with nearest mean.

4. Increment ic by 1, update the means to get $m_1(ic),\ldots,m_K(ic)$.

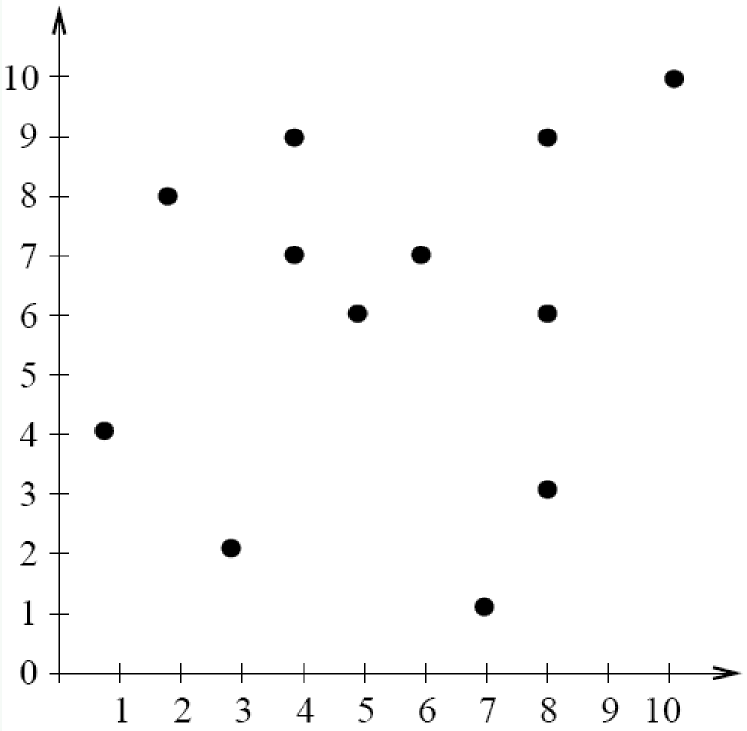
5. Repeat steps 3 and 4 until $C_k(ic) = C_k(ic+1)$ for all k.

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Select an initial clusters (k = 3)



$R_1^1 = \boxed{1 \quad 6}$

$R_2^1 = \boxed{9 \quad 7}$

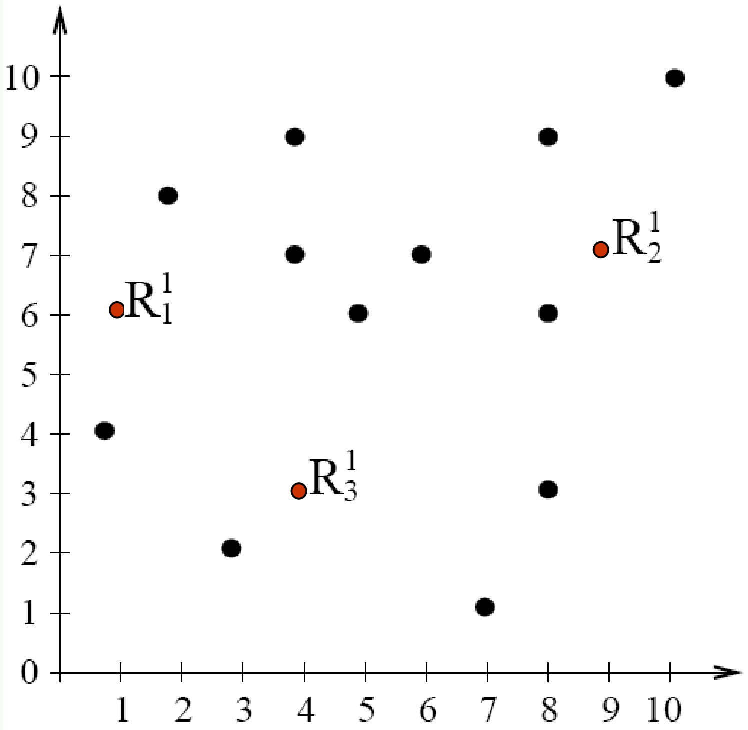
$R_3^1 = \boxed{4 \quad 3}$

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Plot these clusters (k = 3)



$R_1^1 = \boxed{1 \quad 6}$

$R_2^1 = \boxed{9 \quad 7}$

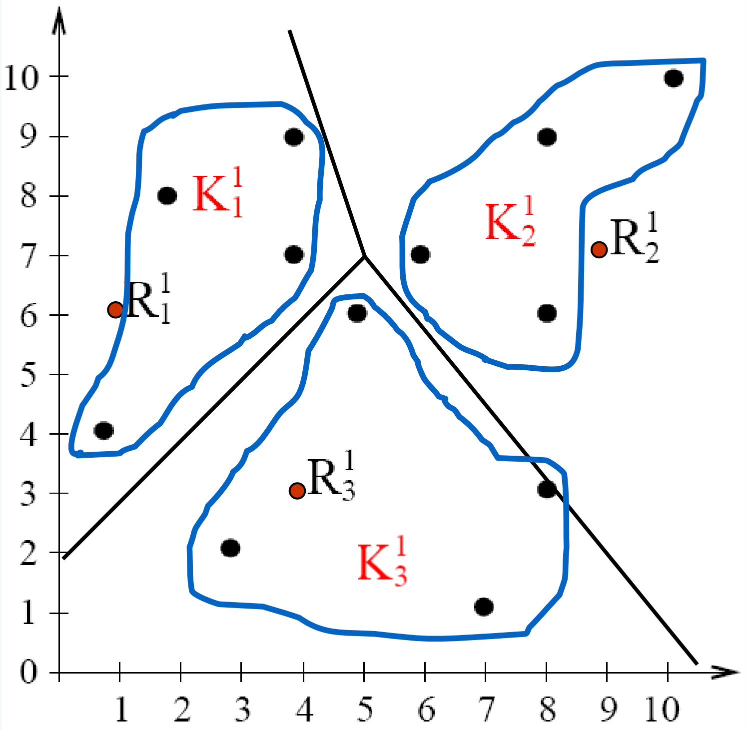
$R_3^1 = \boxed{4 \quad 3}$

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Group vectors around the cluster entries and build clusters



$R_1^1 = \boxed{1 \quad 6}$

$R_2^1 = \boxed{9 \quad 7}$

$R_3^1 = \boxed{4 \quad 3}$

$K_1^1 =$	4 7	4 9	1 4	2 8
$K_2^1 =$	6 7	8 6	8 9	10 10
$K_3^1 =$	8 3	7 1	3 2	5 6

Partitional Clustering

Apply the K-means algorithm on the following input:

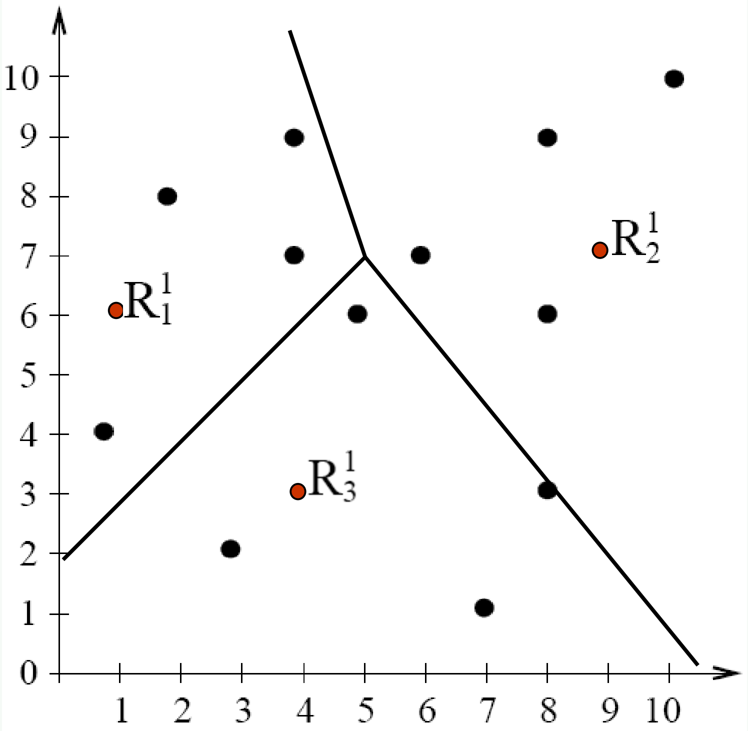
(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Calculate centroids for each cluster and Use these centroids as the new cluster

$$R_1^1 = \boxed{1 \quad 6}$$

$$R_2^1 = \boxed{9 \quad 7}$$

$$R_3^1 = \boxed{4 \quad 3}$$



Centroids

$$K_1^1 = \boxed{4 \quad 7}\ \boxed{4 \quad 9}\ \boxed{1 \quad 4}\ \boxed{2 \quad 8} = \boxed{2.75 \quad 7}$$

$$K_2^1 = \boxed{6 \quad 7}\ \boxed{8 \quad 6}\ \boxed{8 \quad 9}\ \boxed{10 \quad 10} = \boxed{8 \quad 8}$$

$$K_3^1 = \boxed{8 \quad 3}\ \boxed{7 \quad 1}\ \boxed{3 \quad 2}\ \boxed{5 \quad 6} = \boxed{5.75 \quad 3}$$

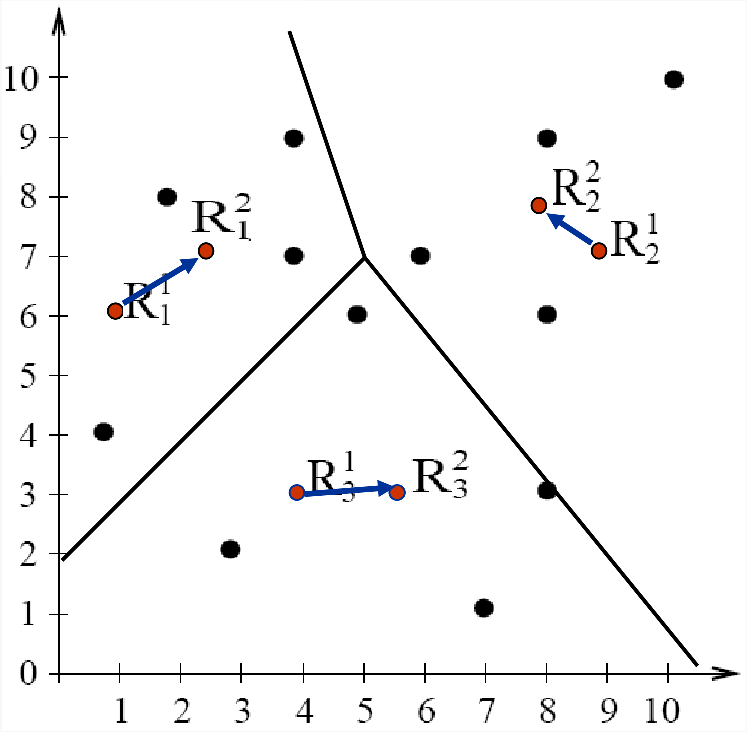
$$\text{Distortion} = 8.67$$

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Update the Plot and clustering



$R_1^2 = \boxed{2.75 \quad 7}$

$R_2^2 = \boxed{8 \quad 8}$

$R_3^2 = \boxed{5.75 \quad 3}$

Partitional Clustering

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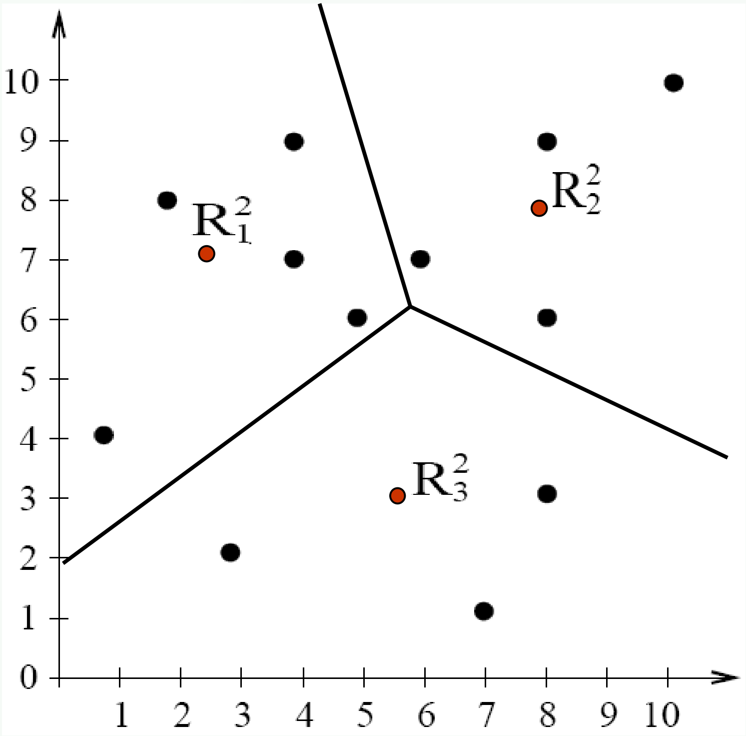
Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Update the Plot and clustering



$R_1^2 = \boxed{2.75 \quad 7}$

$R_2^2 = \boxed{8 \quad 8}$

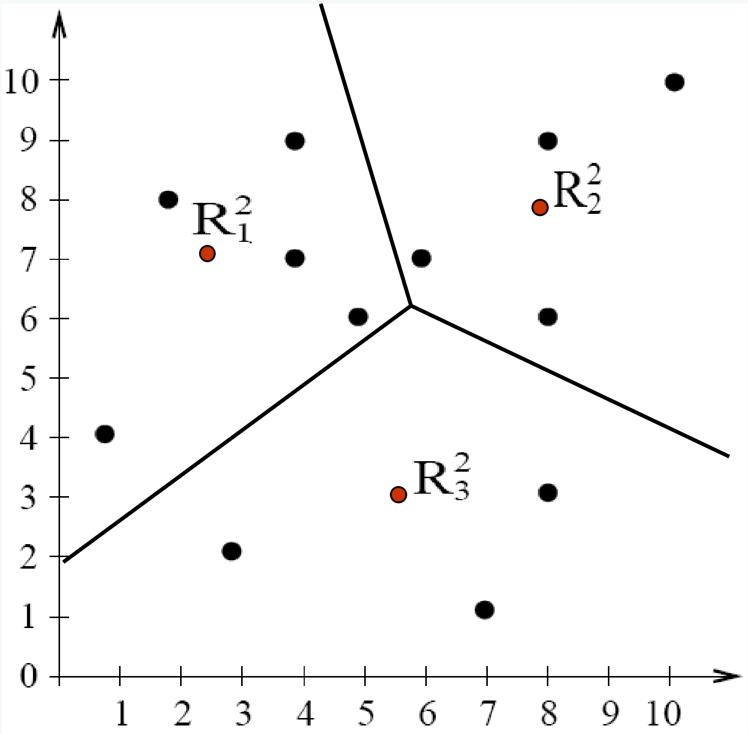
$R_3^2 = \boxed{5.75 \quad 3}$

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Update the Plot and clustering



$R_1^2 = \boxed{2.75 \;\; 7}$

$R_2^2 = \boxed{8 \;\; 8}$

$R_3^2 = \boxed{5.75 \;\; 3}$

$K_1^2 = \boxed{4 \;\; 7}\ \boxed{4 \;\; 9}\ \boxed{1 \;\; 4}\ \boxed{2 \;\; 8}\ \boxed{5 \;\; 6}$

$K_2^2 = \boxed{6 \;\; 7}\ \boxed{8 \;\; 6}\ \boxed{8 \;\; 9}\ \boxed{10\; 10}$

$K_3^2 = \boxed{8 \;\; 3}\ \boxed{7 \;\; 1}\ \boxed{3 \;\; 2}$

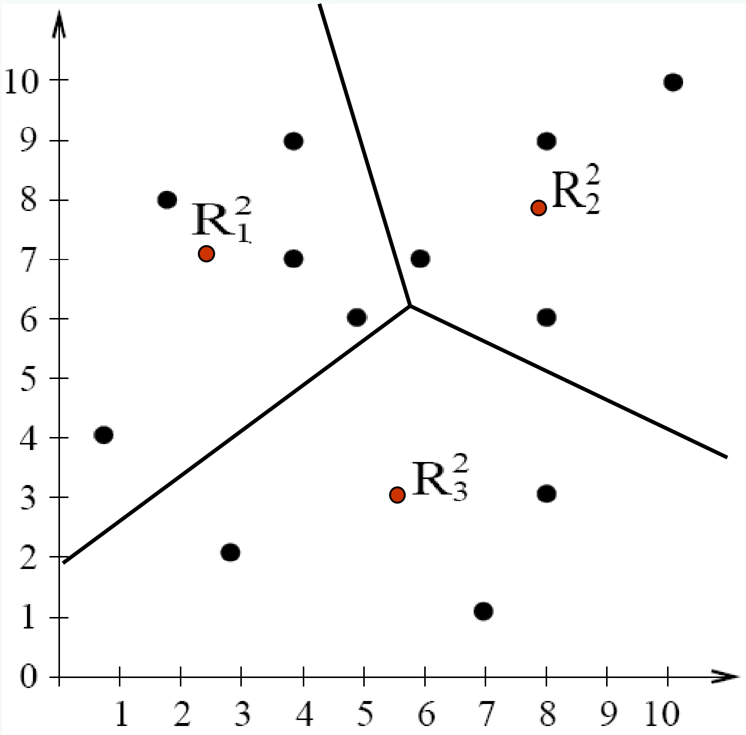
Distortion = 5.34

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Calculate the new centroids and use as cluster



$$R_1^3 = \boxed{3.2 \quad 6.8}$$
$$R_2^3 = \boxed{8 \quad 8}$$
$$R_3^3 = \boxed{6 \quad 2}$$

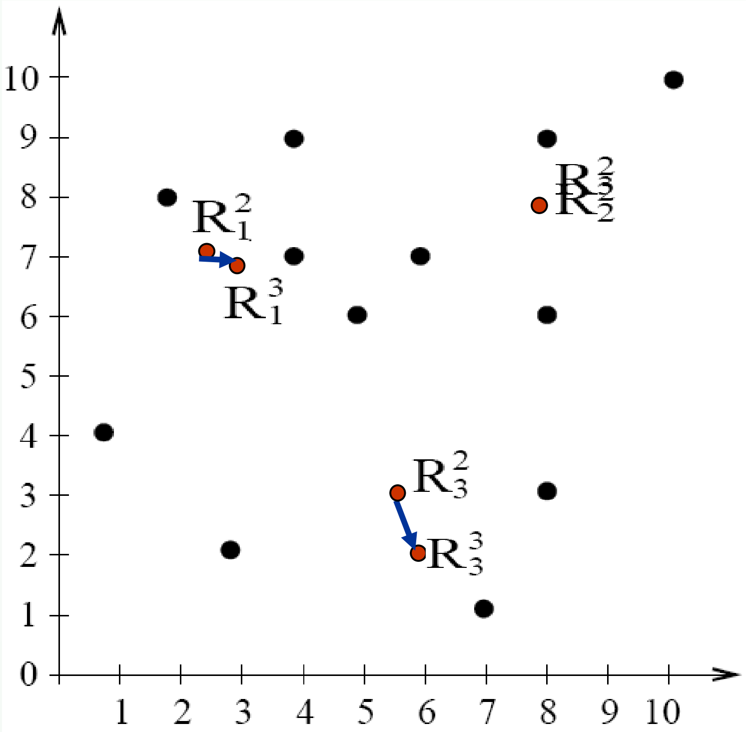
$$K_1^2 = \boxed{4 \quad 7}\ \boxed{4 \quad 9}\ \boxed{1 \quad 4}\ \boxed{2 \quad 8}\ \boxed{5 \quad 6}$$
$$K_2^2 = \boxed{6 \quad 7}\ \boxed{8 \quad 6}\ \boxed{8 \quad 9}\ \boxed{10\ 10}$$
$$K_3^2 = \boxed{8 \quad 3}\ \boxed{7 \quad 1}\ \boxed{3 \quad 2}$$

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Update the Plot



$R_1^3 = \boxed{3.2\ \ 6.8}$

$R_2^3 = \boxed{8\ \ 8}$

$R_3^3 = \boxed{6\ \ 2}$

$K_1^2 = \boxed{4\ \ 7}\ \boxed{4\ \ 9}\ \boxed{1\ \ 4}\ \boxed{2\ \ 8}\ \boxed{5\ \ 6}$

$K_2^2 = \boxed{6\ \ 7}\ \boxed{8\ \ 6}\ \boxed{8\ \ 9}\ \boxed{10\ \ 10}$

$K_3^2 = \boxed{8\ \ 3}\ \boxed{7\ \ 1}\ \boxed{3\ \ 2}$

Partitional Clustering

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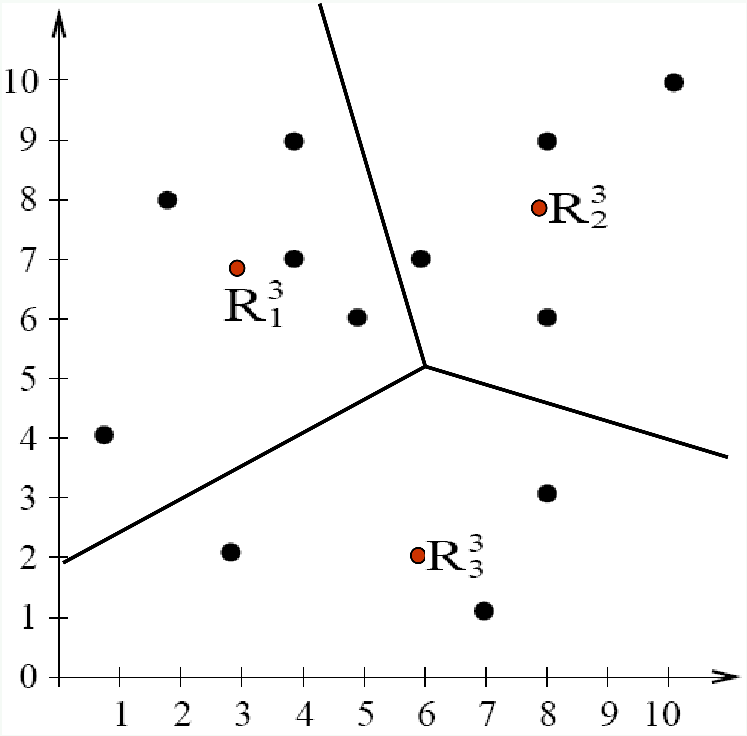
Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Update the Plot



$R_1^3 = \boxed{3.2\ 6.8}$

$R_2^3 = \boxed{8\quad 8}$

$R_3^3 = \boxed{6\quad 2}$

$K_1^2 = \boxed{4\quad 7}\ \boxed{4\quad 9}\ \boxed{1\quad 4}\ \boxed{2\quad 8}\ \boxed{5\quad 6}$

$K_2^2 = \boxed{6\quad 7}\ \boxed{8\quad 6}\ \boxed{8\quad 9}\ \boxed{10\ 10}$

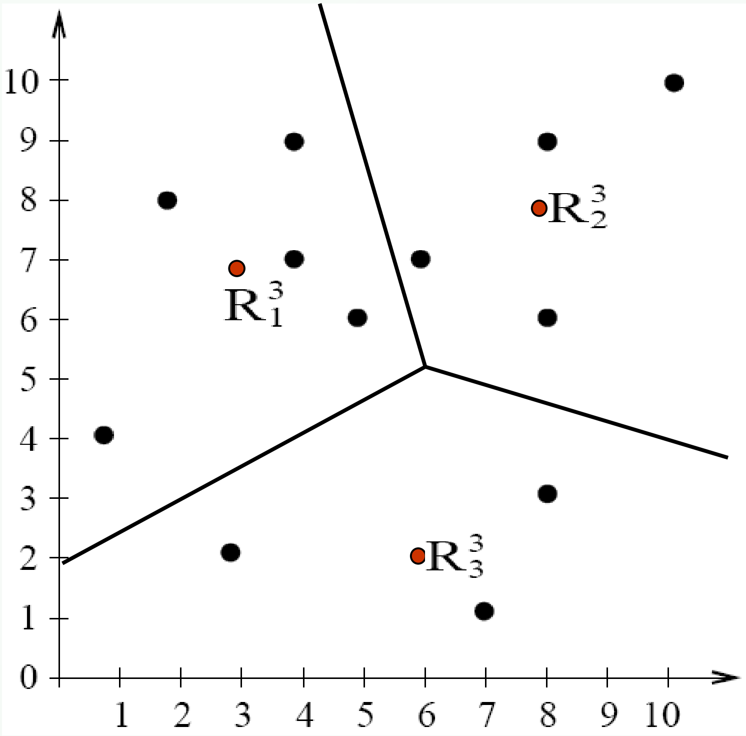
$K_3^2 = \boxed{8\quad 3}\ \boxed{7\quad 1}\ \boxed{3\quad 2}$

Partitional Clustering

Apply the K-means algorithm on the following input:

(4,7), (6,7), (8,6), (8,9), (4,9), (10,10), (1,4), (8,3), (7,1), (3,2), (2,8), (5,6)

Clusters remain the same (and so do the centroins), so we finish



$$R_1^3 = \boxed{3.2\ \ 6.8}$$
$$R_2^3 = \boxed{8\ \ 8}$$
$$R_3^3 = \boxed{6\ \ 2}$$

$$K_1^2 = \boxed{4\ \ 7}\ \boxed{4\ \ 9}\ \boxed{1\ \ 4}\ \boxed{2\ \ 8}\ \boxed{5\ \ 6}$$
$$K_2^2 = \boxed{6\ \ 7}\ \boxed{8\ \ 6}\ \boxed{8\ \ 9}\ \boxed{10\ \ 10}$$
$$K_3^2 = \boxed{8\ \ 3}\ \boxed{7\ \ 1}\ \boxed{3\ \ 2}$$

$$\text{Distortion} = 4.97$$

Exercise

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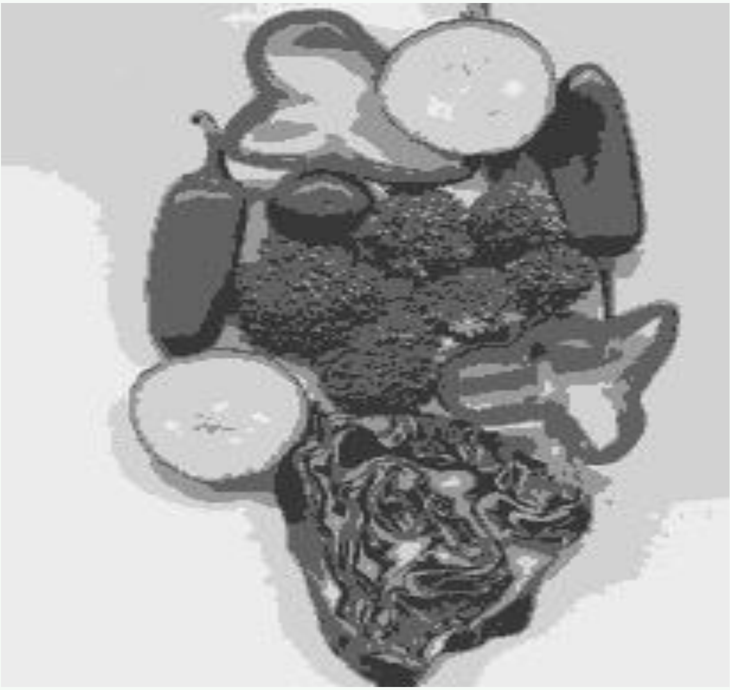
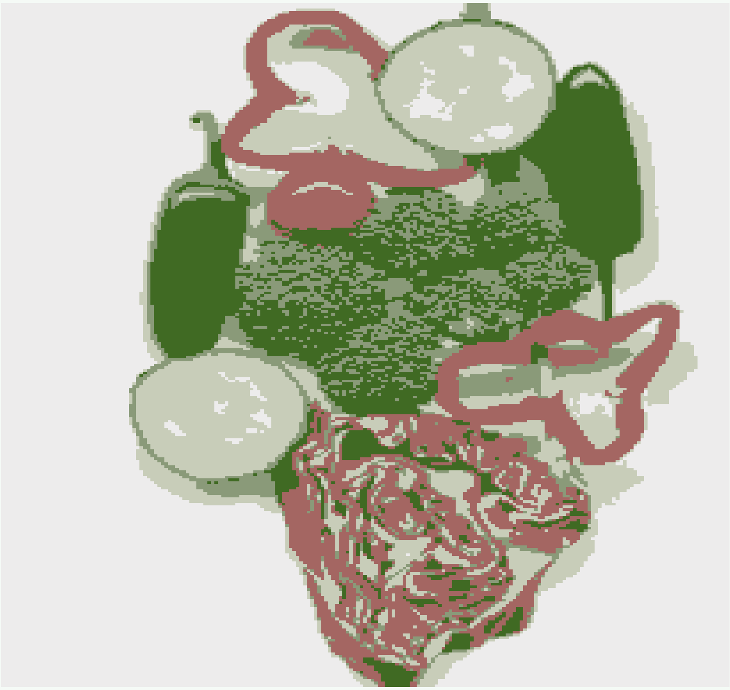
Image

Clusters on intensity

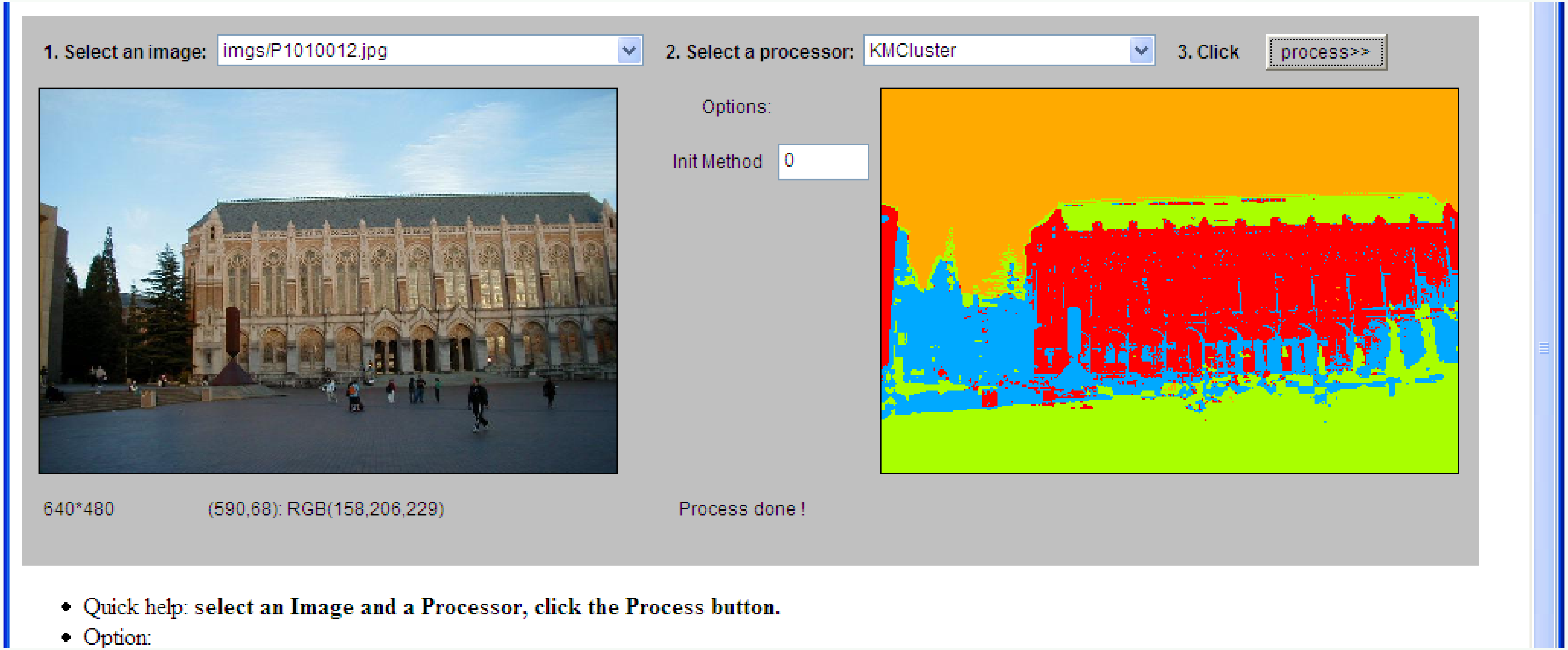


Clusters on color

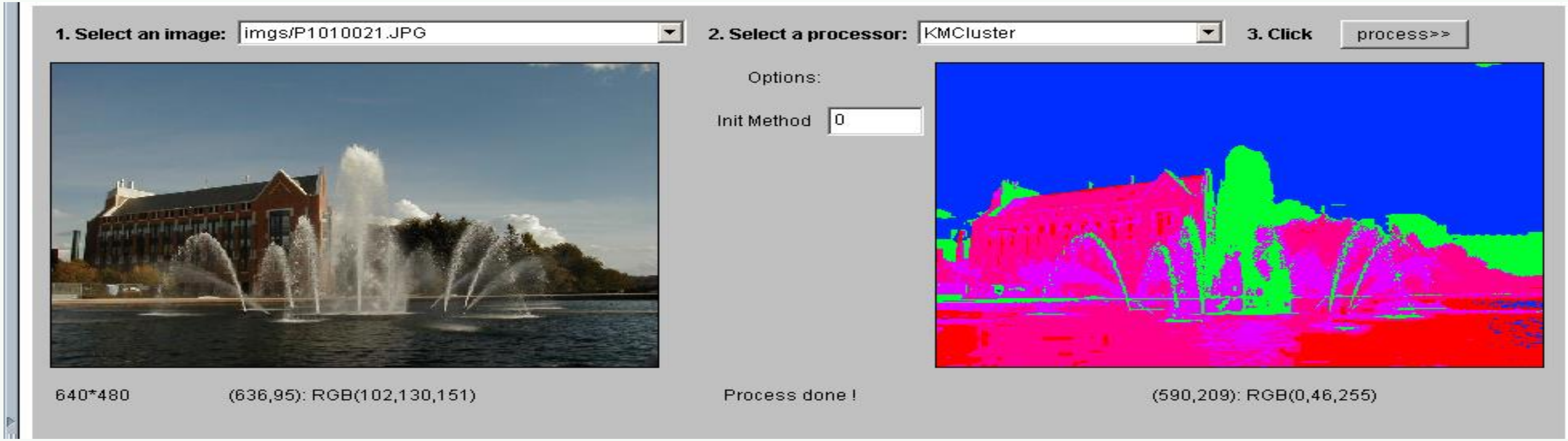


Slides by D.A. Forsyth

K-Means Example 1



K-Means Example 2



K-Means Example 3

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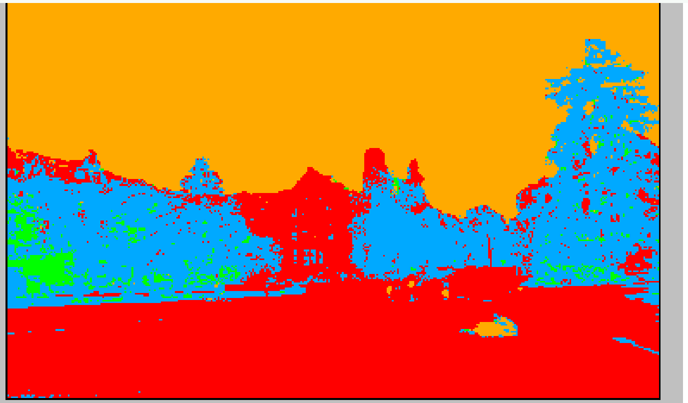
Init Method 0



640*480 (607,118): RGB(20,22,1) Process done ! (228,26): RGB(255,170,0)

- Quick help: **select an Image and a Processor, click the Process button.**
- Option:
  - Init Method: 0-Random, 1-Linear, 2-CUBE, 3-Statistics, 4-Possibility
- Processors:
  - *KMCluster*. Interative K-Means Cluster

[comments to yi@cs.washington.edu]
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