Image Segmentation-03

Region-Based Segmentation

- Region Growing

1. Region growing is a procedure that groups pixels or subregions into larger regions.

2. The simplest of these approaches is ***pixel aggregation***, which starts with a set of "seed" points and from these grows regions by appending to each seed points those **neighboring pixels** that have **similar properties** (such as gray level, texture, color, shape).

3. Region growing based techniques are better than the edge-based techniques in noisy images where edges are difficult to detect.

Region-Based Segmentation

Example: Region Growing based on 8-connectivity

$f(x, y)$: input image array

$S(x, y)$: seed array containing 1s (seeds) and 0s

$Q(x, y)$: predicate

Region Growing based on 8-connectivity

1. Find all connected components in $S(x, y)$ and erode each connected components to one pixel; label all such pixels found as 1. All other pixels in S are labeled 0.
2. Form an image f_Q such that, at a pair of coordinates (x,y), let $f_Q(x, y) = 1$ if the Q is satisfied otherwise $f_Q(x, y) = 0$.
3. Let g be an image formed by appending to each seed point in S all the 1-value points in f_Q that are 8-connected to that seed point.
4. Label each connencted component in g with a different region label. This is the segmented image obtained by region growing.

$$Q = \begin{cases} \text{TRUE} & \text{if the absolute difference of the intensities} \\ & \text{between the seed and the pixel at (x,y) is } \leq \text{T} \\ \text{FALSE} & \text{otherwise} \end{cases}$$

Suppose that we have the image given below.

(a) Use the region growing idea to segment the object. The seed for the object is the center of the image. Region is grown in horizontal and vertical directions, and when the difference between two pixel values is less than or equal to 5.

Table 1: Show the result of Part (a) on this figure.

10	10	10	10	10	10	10
10	10	10	69	70	10	10
59	10	60	64	59	56	60
10	59	10	<u>60</u>	70	10	62
10	60	59	65	67	10	65
10	10	10	10	10	10	10
10	10	10	10	10	10	10

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10	10	10	10	10	10	10
10	10	10	10	10	10	10

4-connectivity

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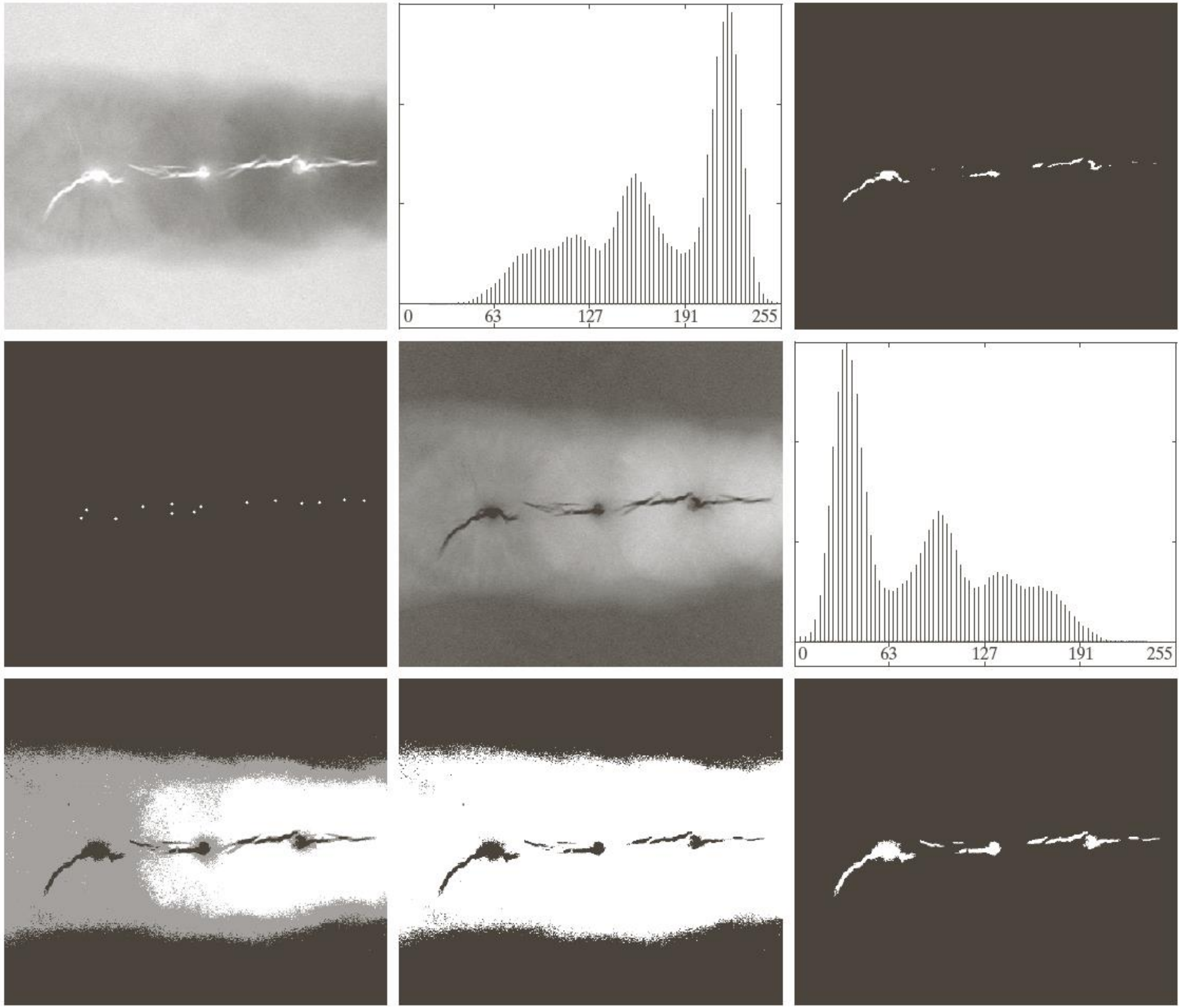
10	60	59	65	67	10	65
10	10	10	10	10	10	10
10	10	10	10	10	10	10

8-connectivity


0
63
127
191
255
0
63
127
191
255

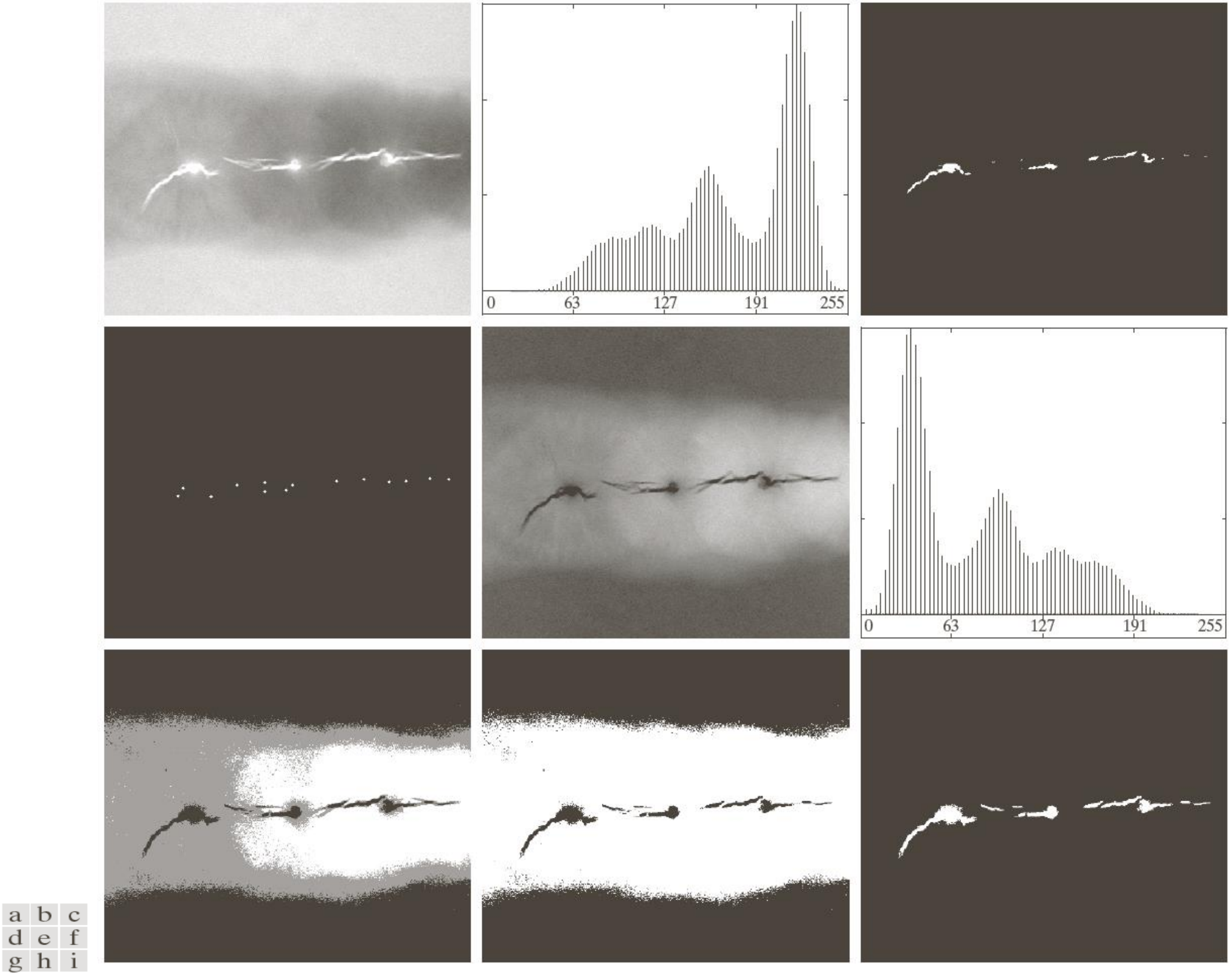
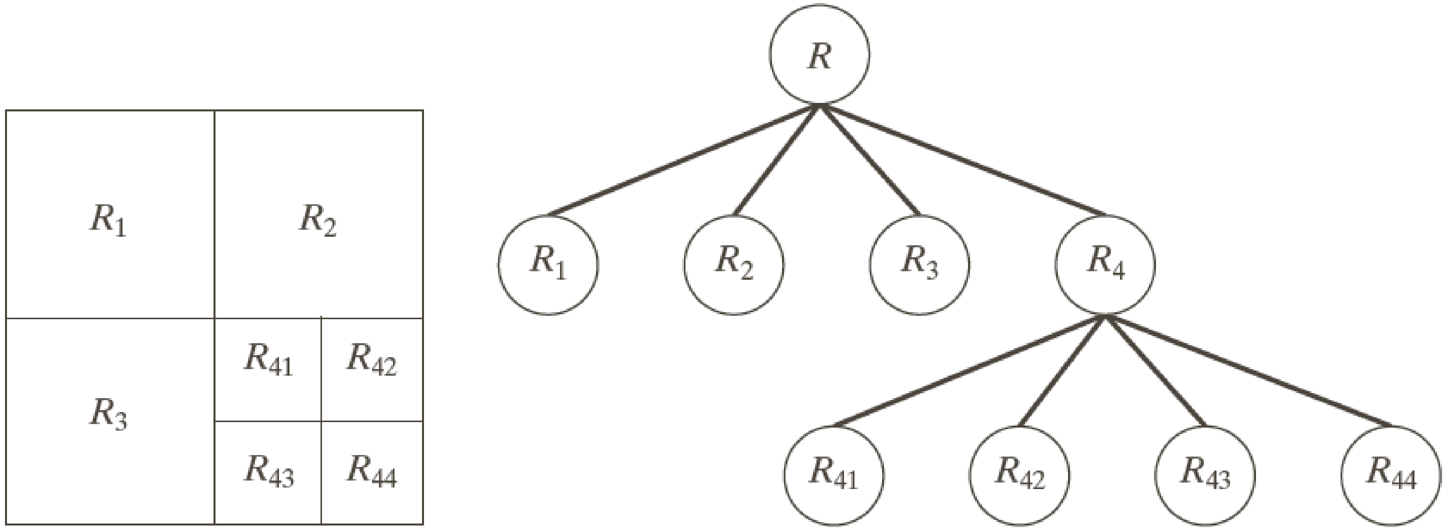


FIGURE 10.51 (a) X-ray image of a defective weld. (b) Histogram. (c) Initial seed image. (d) Final seed image (the points were enlarged for clarity). (e) Absolute value of the difference between (a) and (c). (f) Histogram of (e). (g) Difference image thresholded using dual thresholds. (h) Difference image thresholded with the smallest of the dual thresholds. (i) Segmentation result obtained by region growing. (Original image courtesy of X-TEK Systems, Ltd.)

Region Splitting and Merging

R : entire image R_i:entire image Q: predicate

1. For any region R_i, If $Q(R_i)$ = FALSE,
   we divide the image R_i into quadrants.
2. When no further splitting is possible,
   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.



a b

FIGURE 10.52 (a) Partitioned image. (b) Corresponding quadtree. R represents the entire image region.

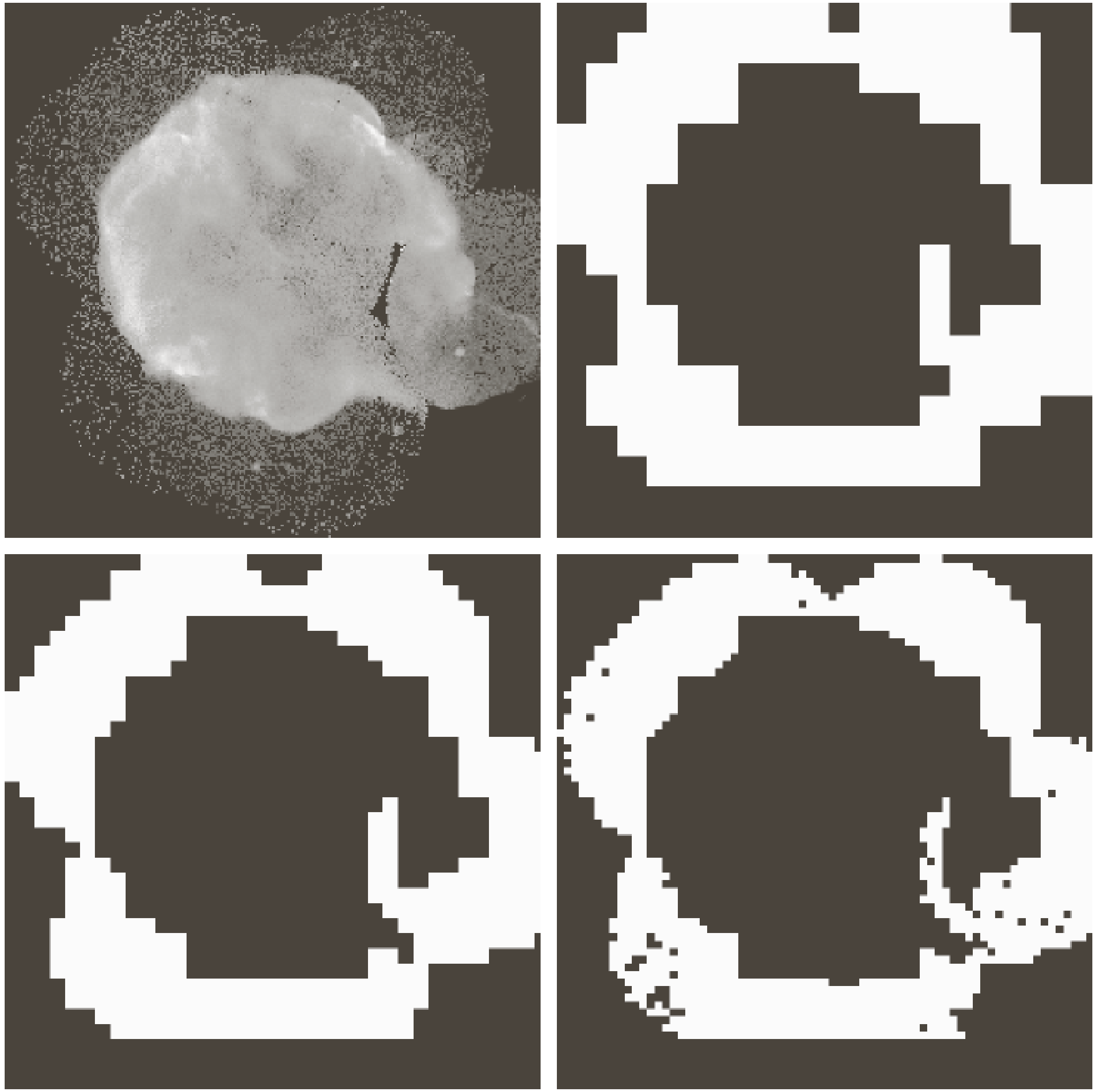
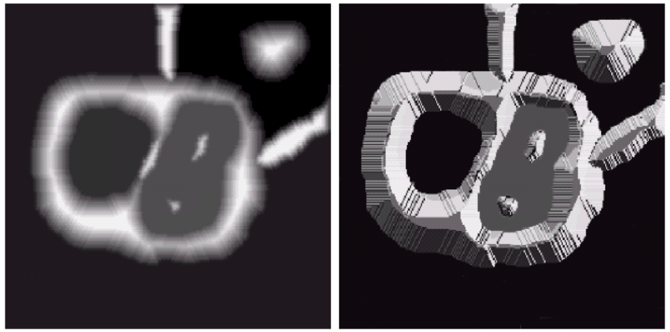


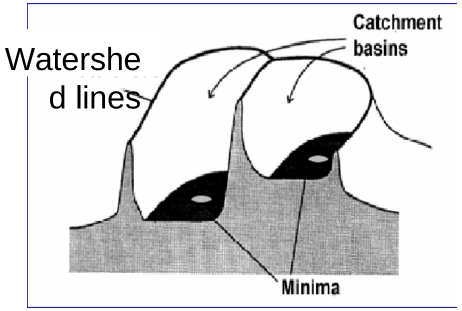
FIGURE 10.53 (a) Image of the Cygnus Loop supernova, taken in the X-ray band by NASA's Hubble Telescope. (b)–(d) Results of limiting the smallest allowed quadregion to sizes of 32×32, 16×16, and 8×8 pixels, respectively. (Original image courtesy of NASA.)

$$Q = \begin{cases} \text{TRUE} & \text{if } \sigma > a \text{ and } 0 < m < b \\ \text{FALSE} & \text{otherwise} \end{cases}$$

Segmentation Using Morphological Watersheds

- Three types of points in a topographic interpretation:
  - Points belonging to a regional minimum
  - Points at which a drop of water would fall to a single minimum. (→The *catchment basin* or *watershed* of that minimum.)
  - Points at which a drop of water would be equally likely to fall to more than one minimum. (→The *divide lines* or *watershed lines*.)





Segmentation Using Morphological Watersheds: Backgrounds

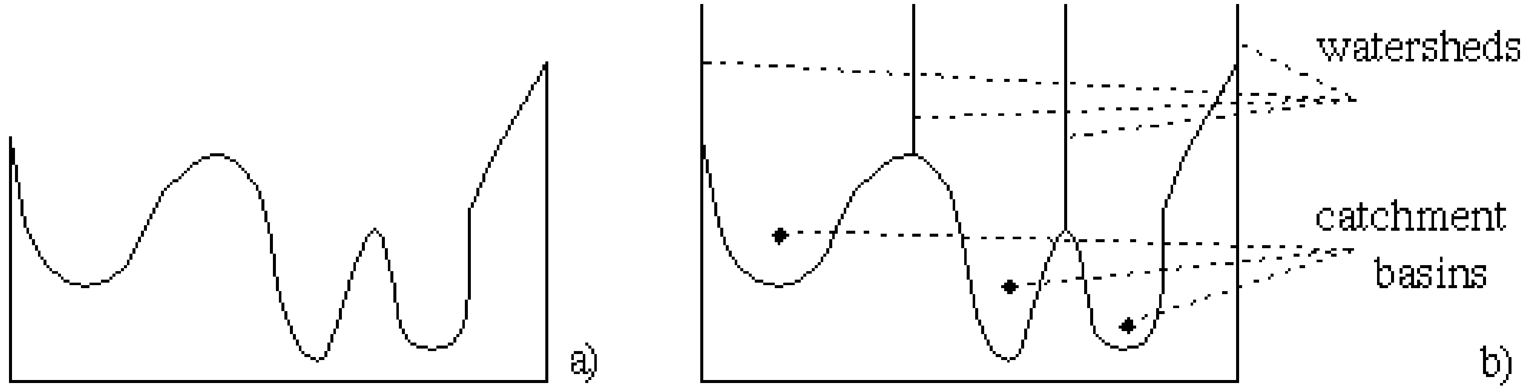
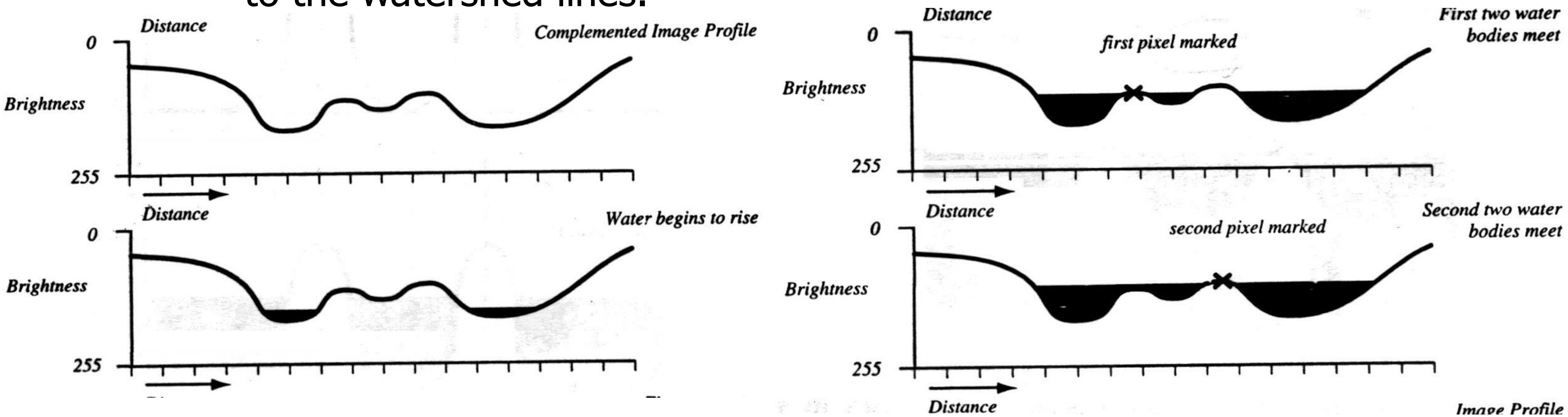


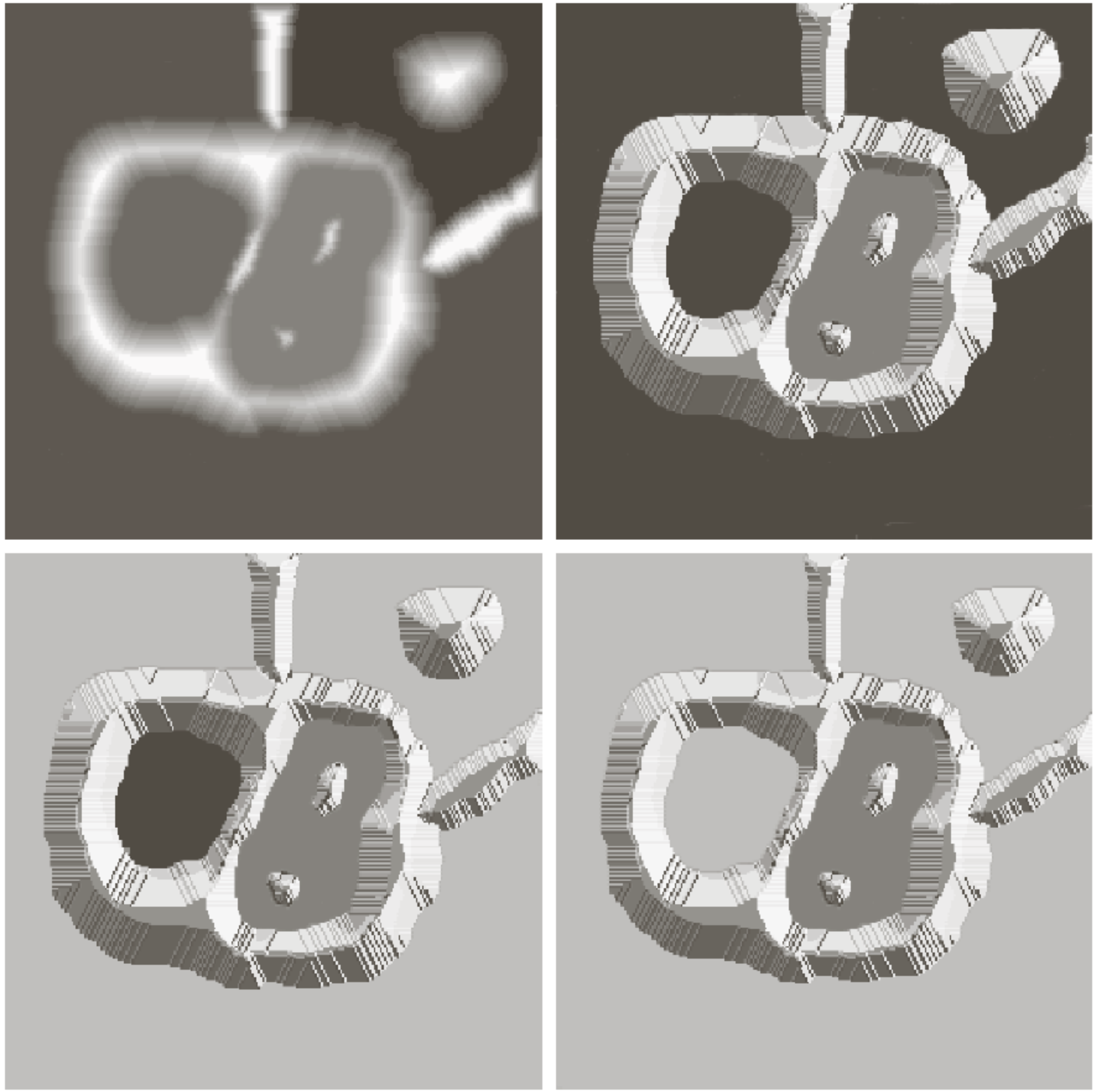
Figure 5.47 *One-dimensional example of watershed segmentation. (a) Gray level profile of image data. (b) Watershed segmentation – local minima of gray level (altitude) yield catchment basins, local maxima define the watershed lines.*

http://www.icaen.uiowa.edu/~dip/LECTURE/Segmentation3.html#watershed

Watershed Segmentation: Example

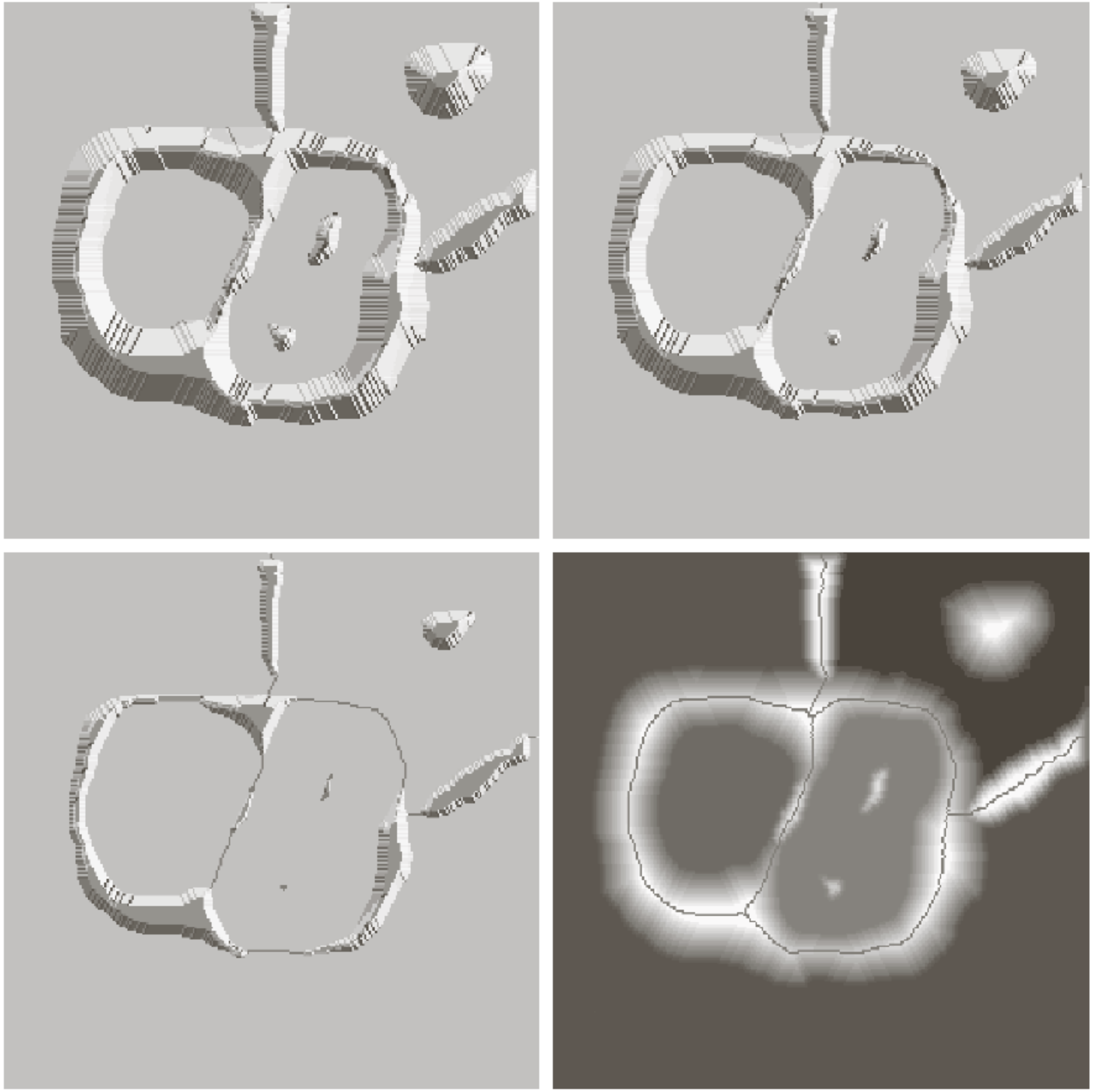
- The objective is to find watershed lines.
- The idea is simple:
  - Suppose that a hole is punched in each regional minimum and that the entire topography is flooded from below by letting water rise through the holes at a uniform rate.
  - When rising water in distinct catchment basins is about the merge, a dam is built to prevent merging. These dam boundaries correspond to the watershed lines.





a b
c d

FIGURE 10.54 (a) Original image. (b) Topographic view. (c)–(d) Two stages of flooding.



e f
g h

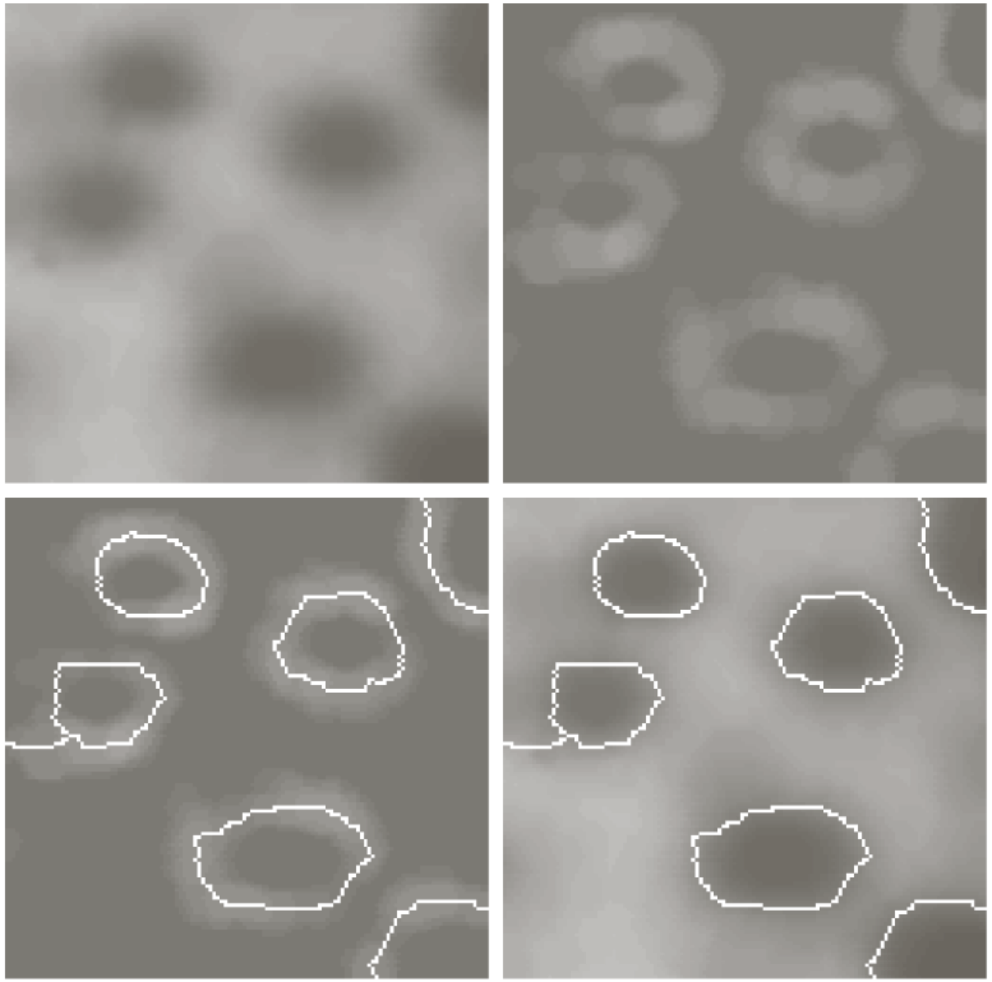
FIGURE 10.54 *(Continued)* (e) Result of further flooding. (f) Beginning of merging of water from two catchment basins (a short dam was built between them). (g) Longer dams. (h) Final watershed (segmentation) lines. (Courtesy of Dr. S. Beucher, CMM/Ecole des Mines de Paris.)

Watershed Segmentation Algorithm

- Start with all pixels with the lowest possible value.
  - These form the basis for initial watersheds
- For each intensity level k:
  - For each group of pixels of intensity k
    1. If adjacent to exactly one existing region, add these pixels to that region
    2. Else if adjacent to more than one existing regions, mark as boundary
    3. Else start a new region

Watershed Segmentation: Examples

Watershed algorithm is often used on the gradient image instead of the original image.



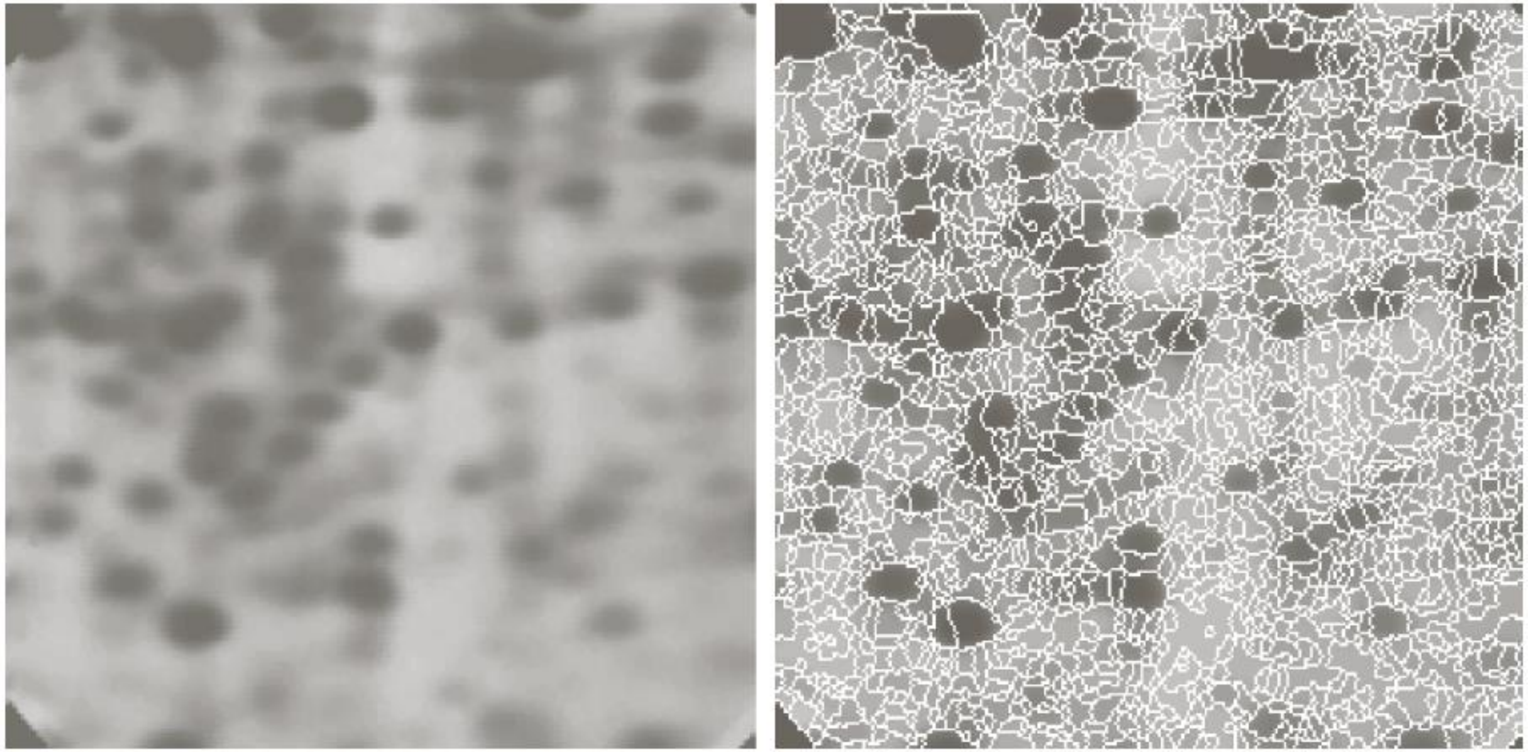
a b
c d

FIGURE 10.56
(a) Image of blobs. (b) Image gradient. (c) Watershed lines. (d) Watershed lines superimposed on original image. (Courtesy of Dr. S. Beucher, CMM/Ecole des Mines de Paris.)

Watershed Segmentation: Examples

a b

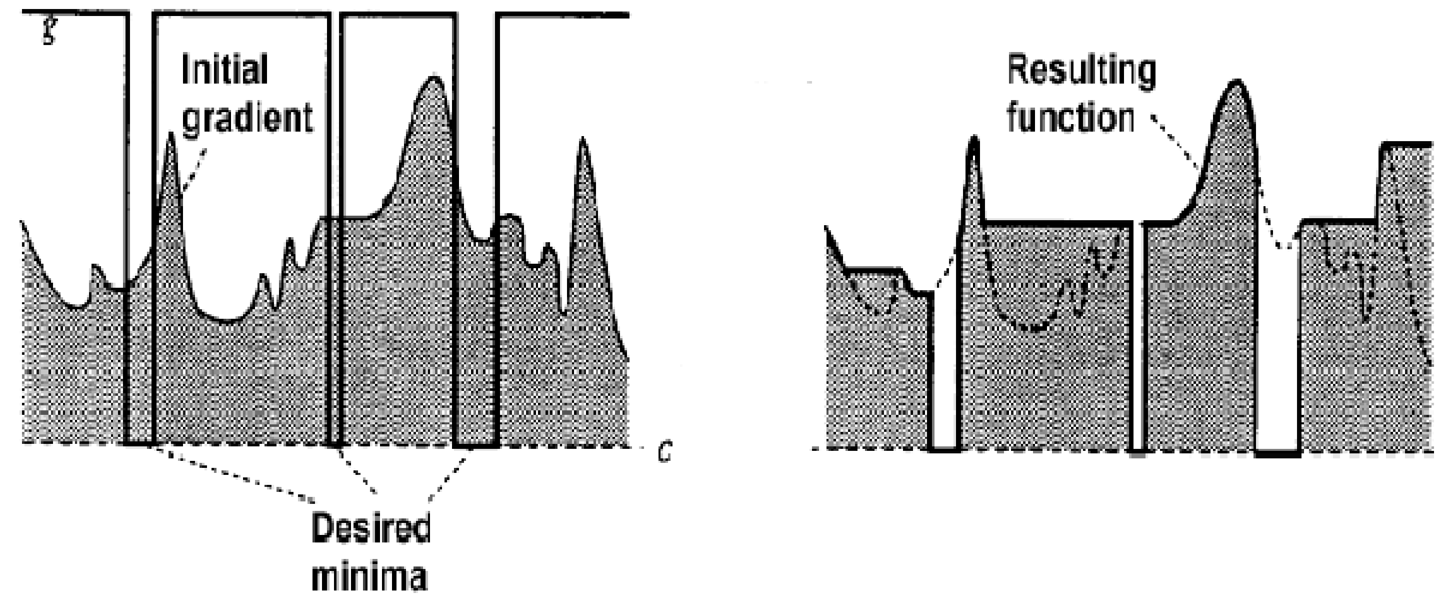
FIGURE 10.57 (a) Electrophoresis image. (b) Result of applying the watershed segmentation algorithm to the gradient image. Oversegmentation is evident. (Courtesy of Dr. S. Beucher, CMM/Ecole des Mines de Paris.)



Due to noise and other local irregularities of the gradient, over-segmentation might occur.

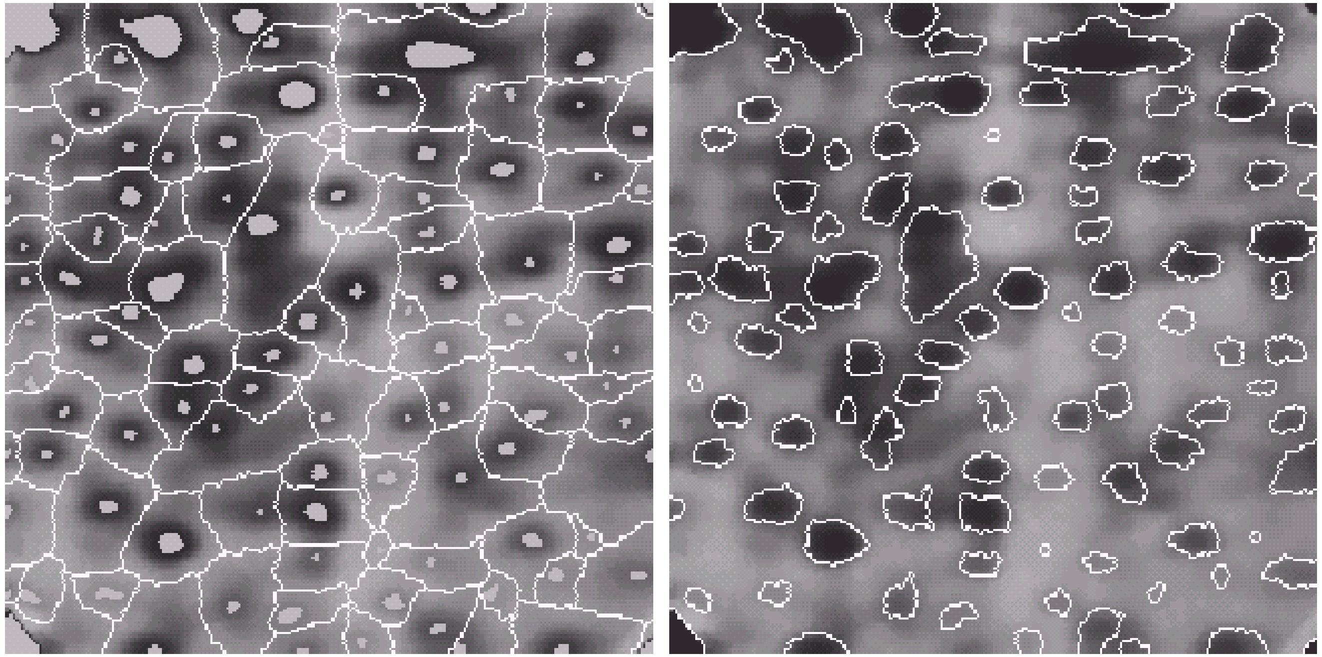
Watershed Segmentation: Examples

A solution is to limit the number of regional minima. Use markers to specify the only allowed regional minima.



Watershed Segmentation: Examples

A solution is to limit the number of regional minima. Use markers to specify the only allowed regional minima. (For example, gray-level values might be used as a marker.)



a b

FIGURE 10.48 (a) Image showing internal markers (light gray regions) and external markers (watershed lines). (b) Result of segmentation. Note the improvement over Fig. 10.47(b). (Courtesy of Dr. S. Beucher, CMM/Ecole des Mines de Paris.)

Use of Motion in Segmentation

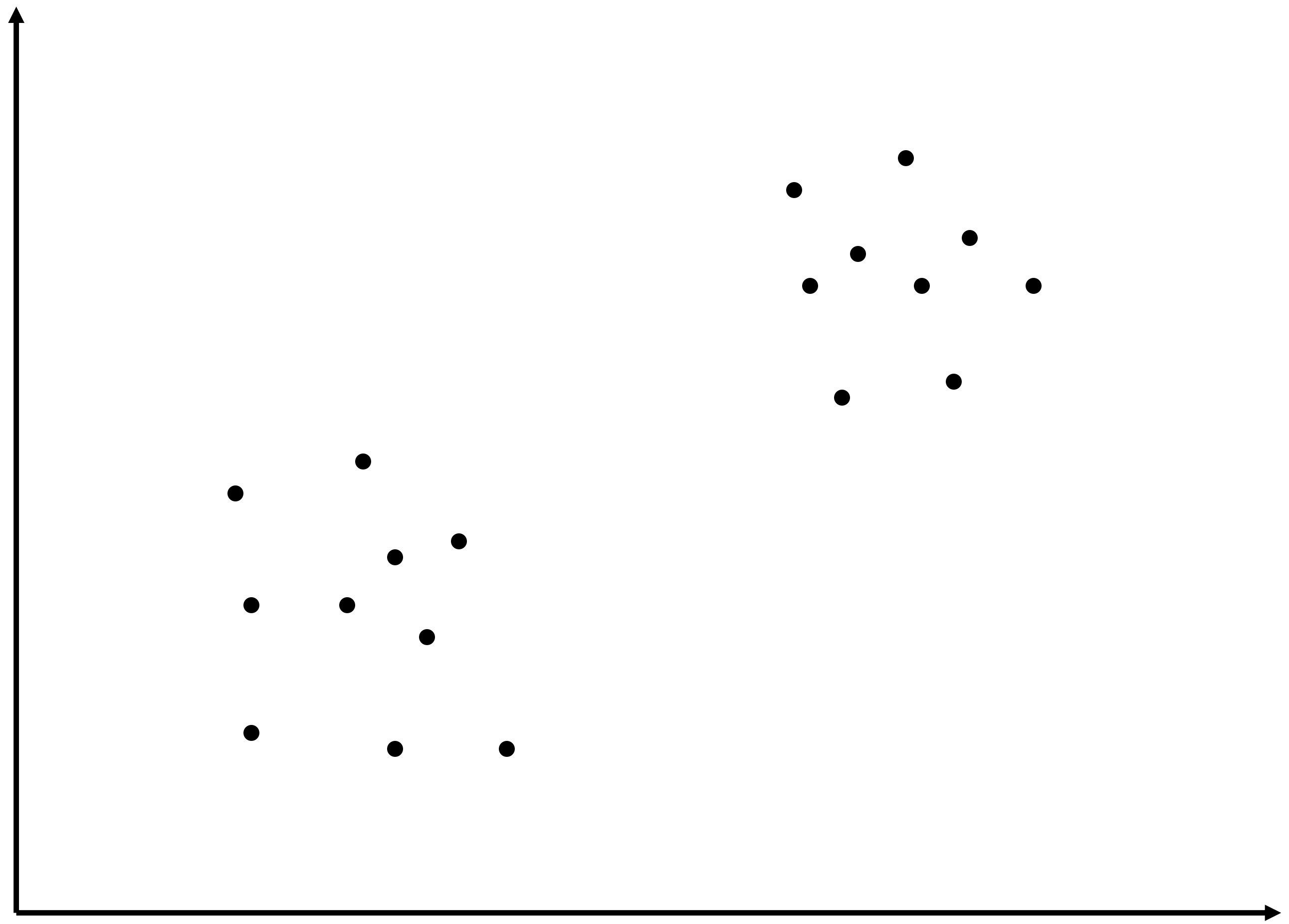
a b c

FIGURE 10.60 Building a static reference image. (a) and (b) Two frames in a sequence. (c) Eastbound automobile subtracted from (a) and the background restored from the corresponding area in (b). (Jain and Jain.)

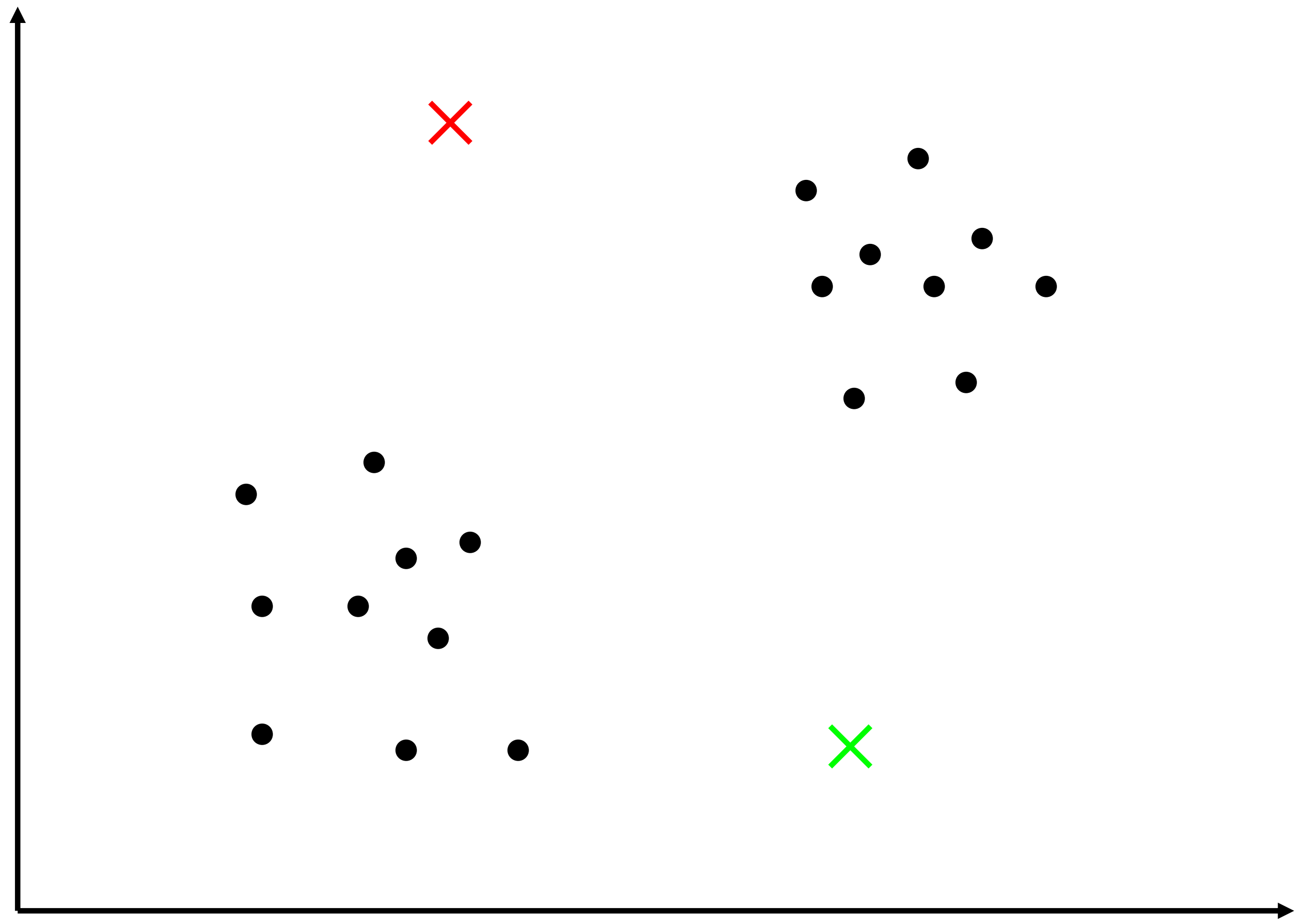
K-means Clustering

- Partition the data points into K clusters randomly. Find the centroids of each cluster.
- For each data point:
  - Calculate the distance from the data point to each cluster.
  - Assign the data point to the closest cluster.
- Recompute the centroid of each cluster.
- Repeat steps 2 and 3 until there is no further change in the assignment of data points (or in the centroids).

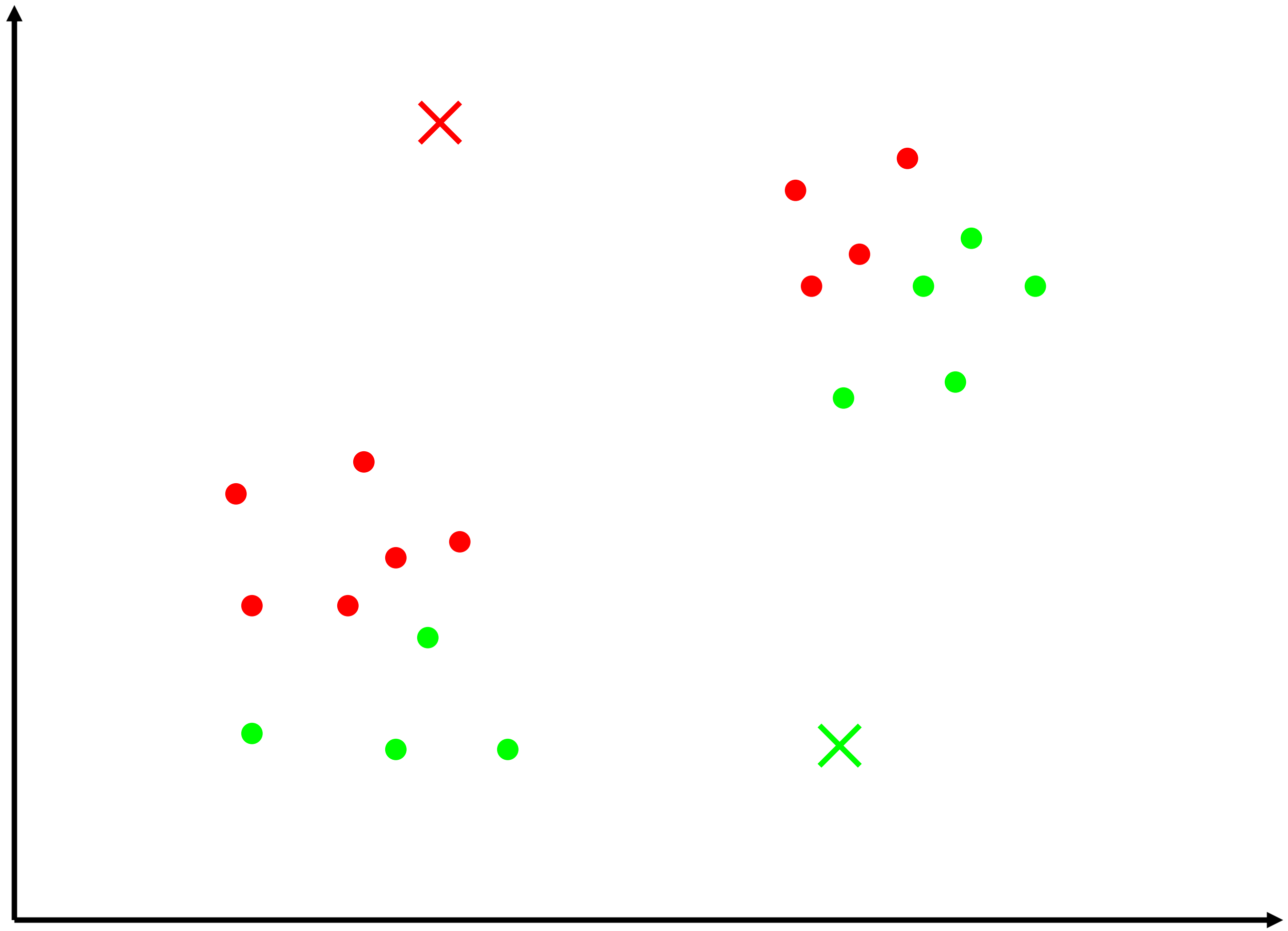
K-Means Clustering



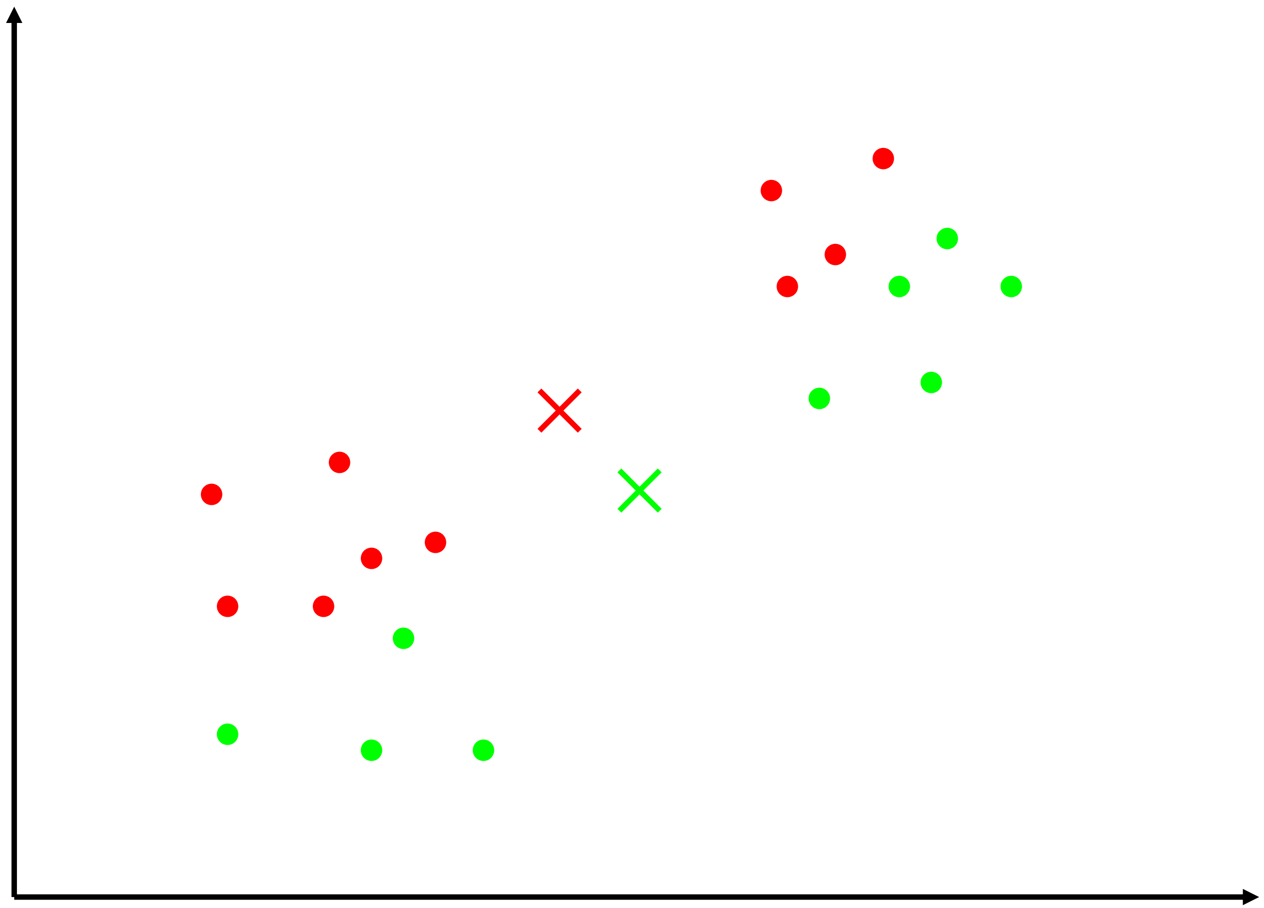
K-Means Clustering



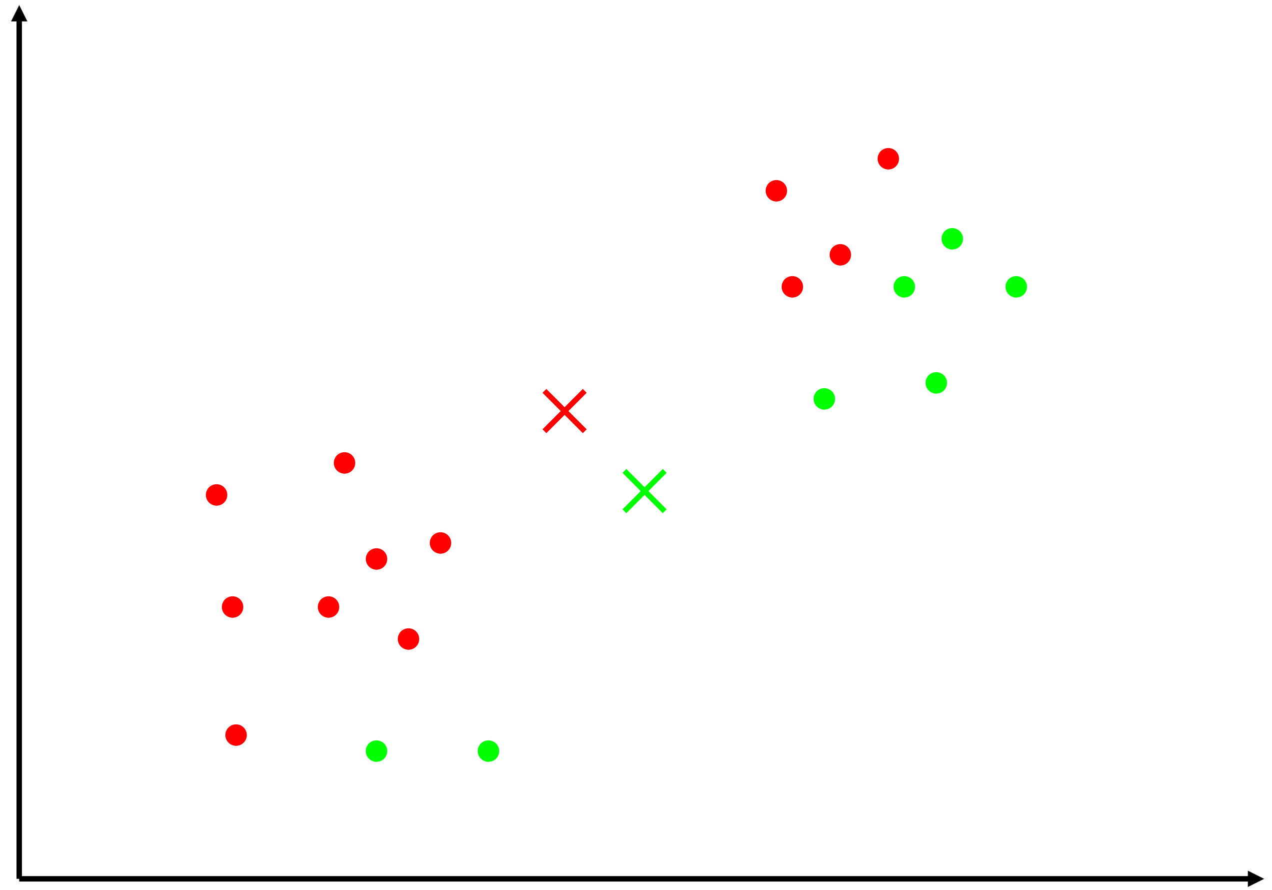
K-Means Clustering



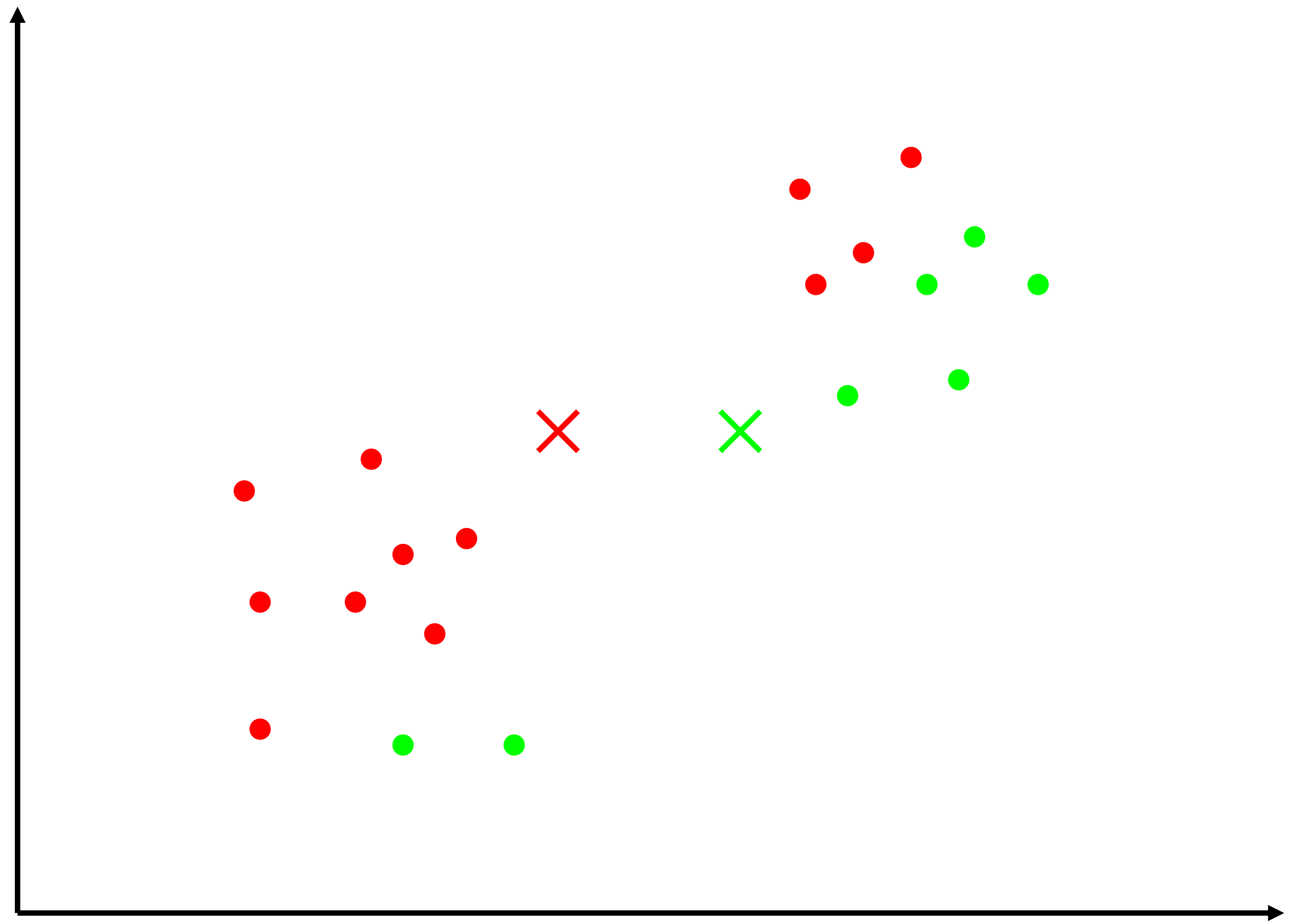
K-Means Clustering



K-Means Clustering



K-Means Clustering



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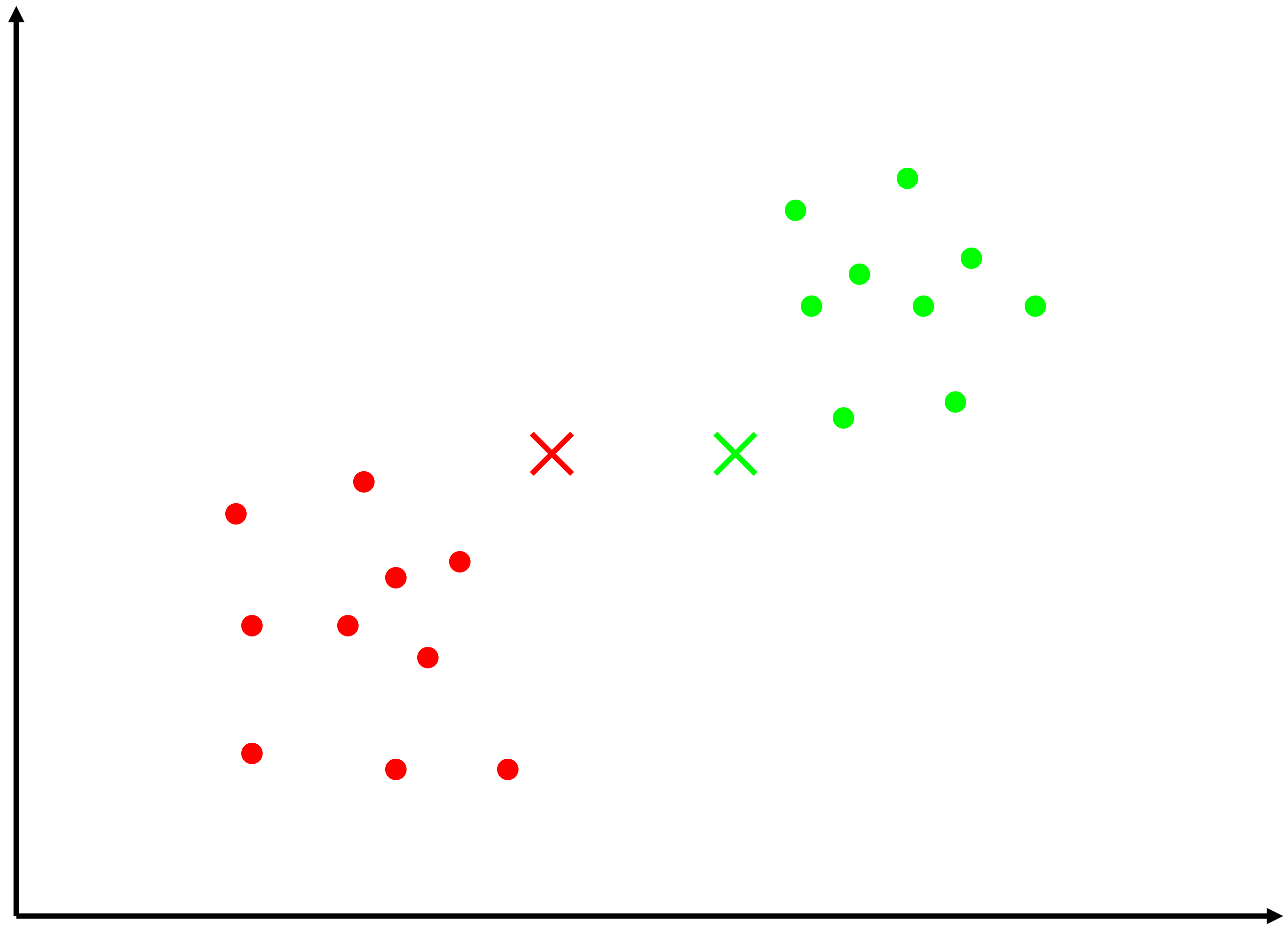

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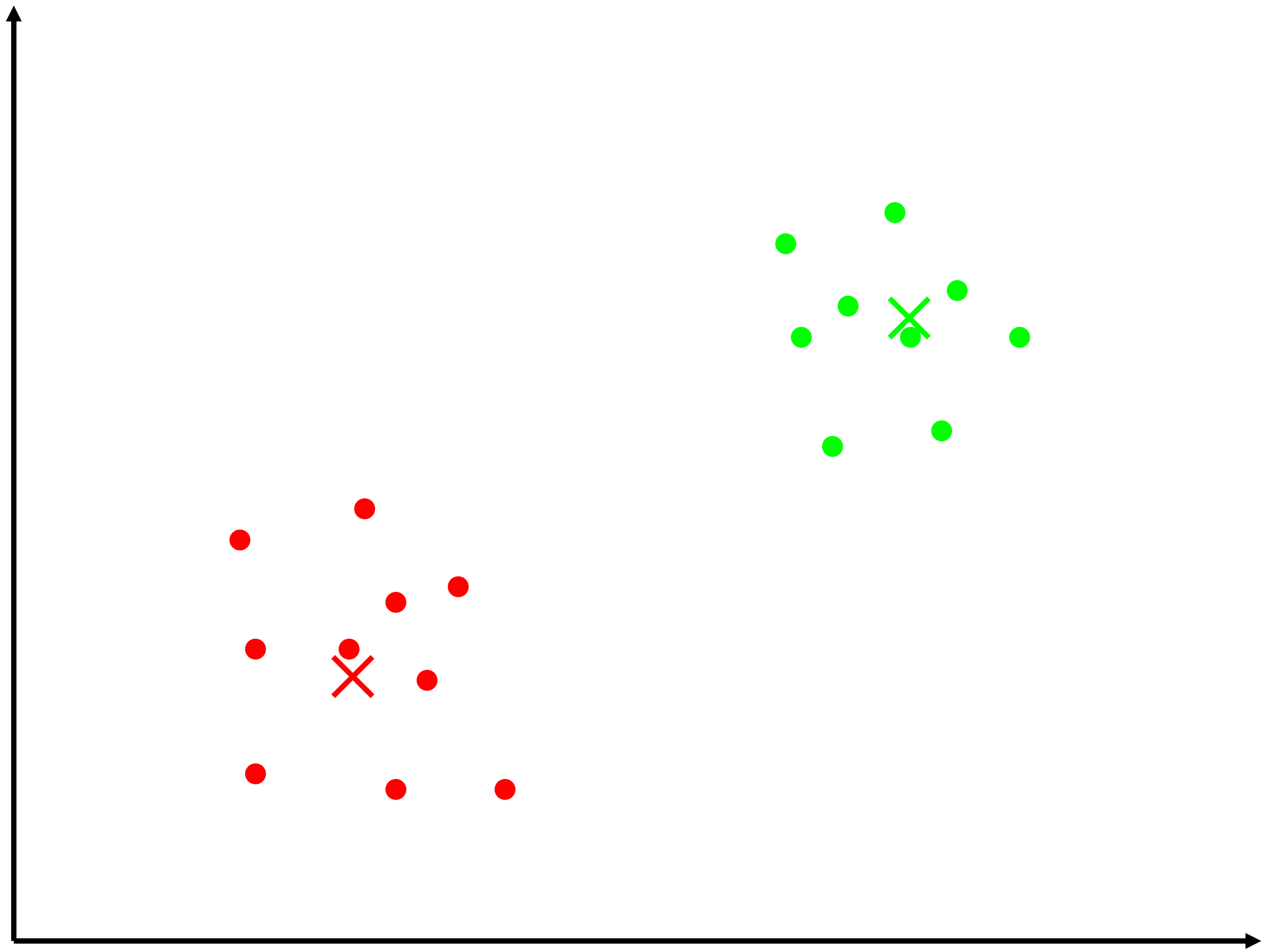
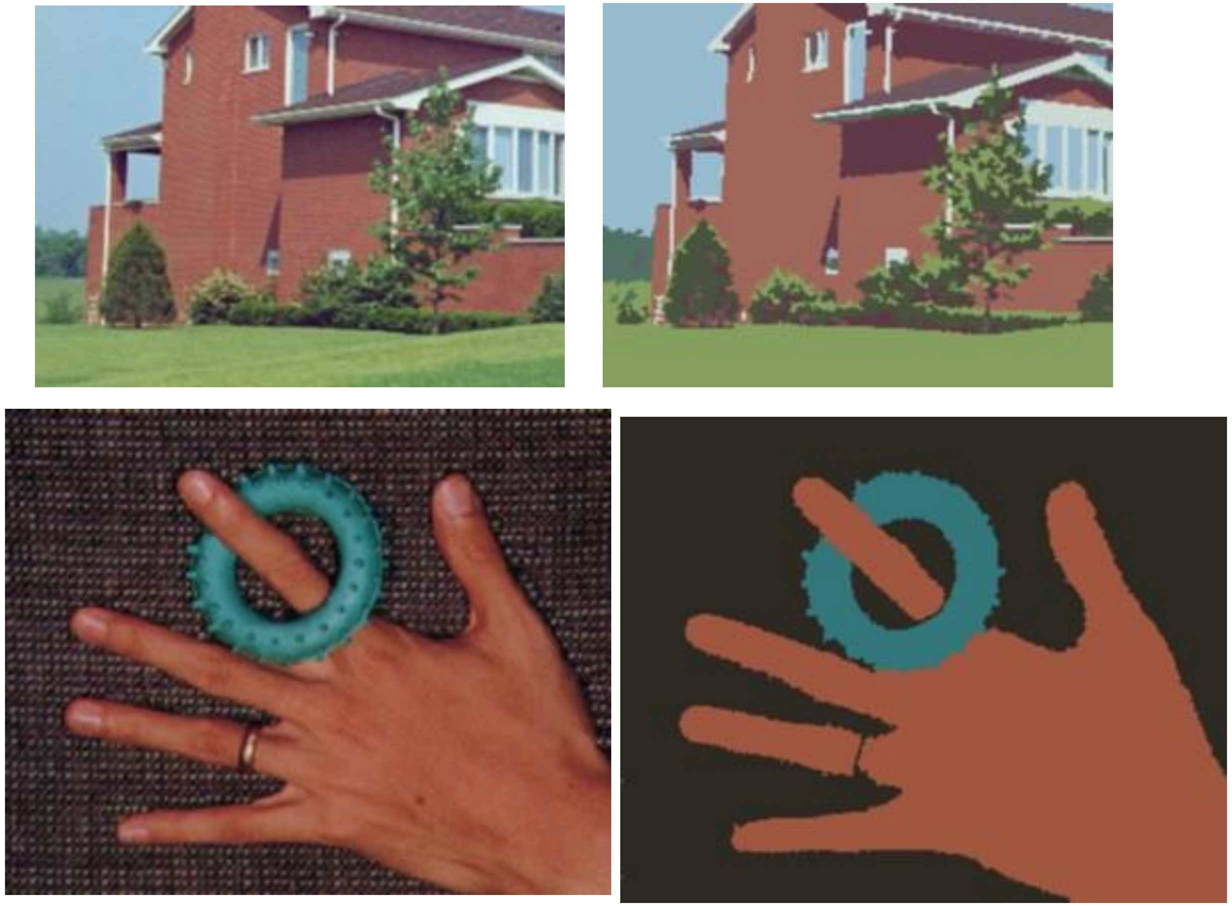


Clustering

- Example



D. Comaniciu and P. Meer, *Robust Analysis of Feature Spaces: Color Image Segmentation*, 1997.