SNS COLLEGE OF TECHNOLOGY

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Department of Biomedical Engineering

Course Name: 19BMB304 & Biomedical Image Processing

III Year : VI Semester

Unit III –IMAGE RESTORATION AND SEGMENTATION

Topic : Region based segmentation

Region-Based Segmentation

- Segmentation may be regarded as **spatial clustering:**
  - *clustering in the sense that pixels with similar values are grouped together, and*
  - *spatial in that pixels in the same category also form a single connected component.*

- Region Growing (Bottom-up approach)
- Region Split-and-merge (Top-down approach)

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.

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

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 cen image. Region is grown in horizontal and vertical directions, and when the difference between 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	60	70	10	62
10	60	59	65	67	10	65
10	10	10	10	10	10	10
10	10	10	10	10	10	10

4-connectivity

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 cen image. Region is grown in horizontal and vertical directions, and when the difference between pixel values is less than or equal to 5.

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

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59	10	60	64	59	56	60
10	59	10	60	70	10	62
10	60	59	65	67	10	65
10	10	10	10	10	10	10
10	10	10	10	10	10	10

8-connectivity

Example: Region Growing based on 8-connectivity

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

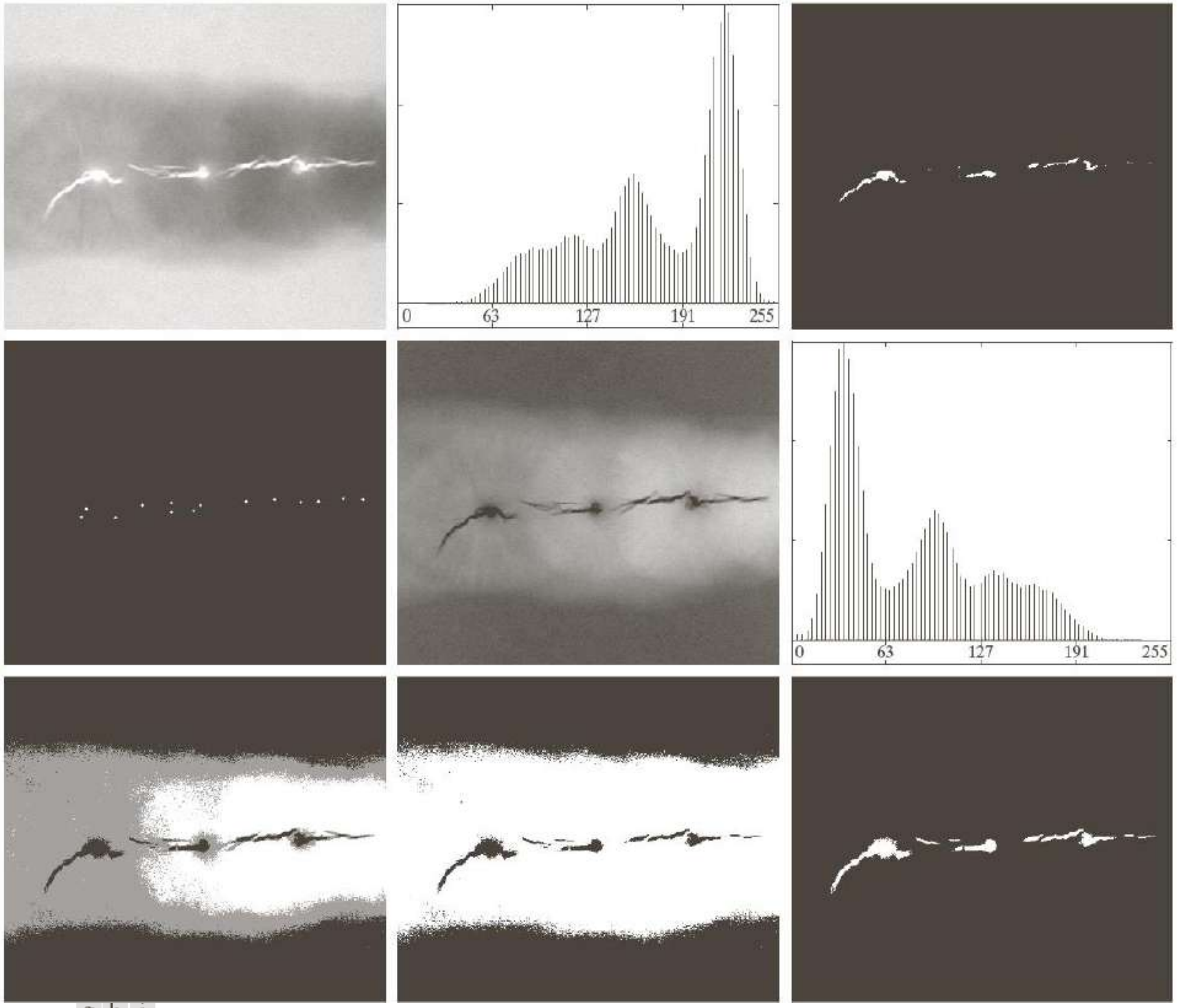
$S(x, y)$: seed array containing 1s (seeds) and 0s

$Q(x, y)$: predicate

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

Example: 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.



g h i

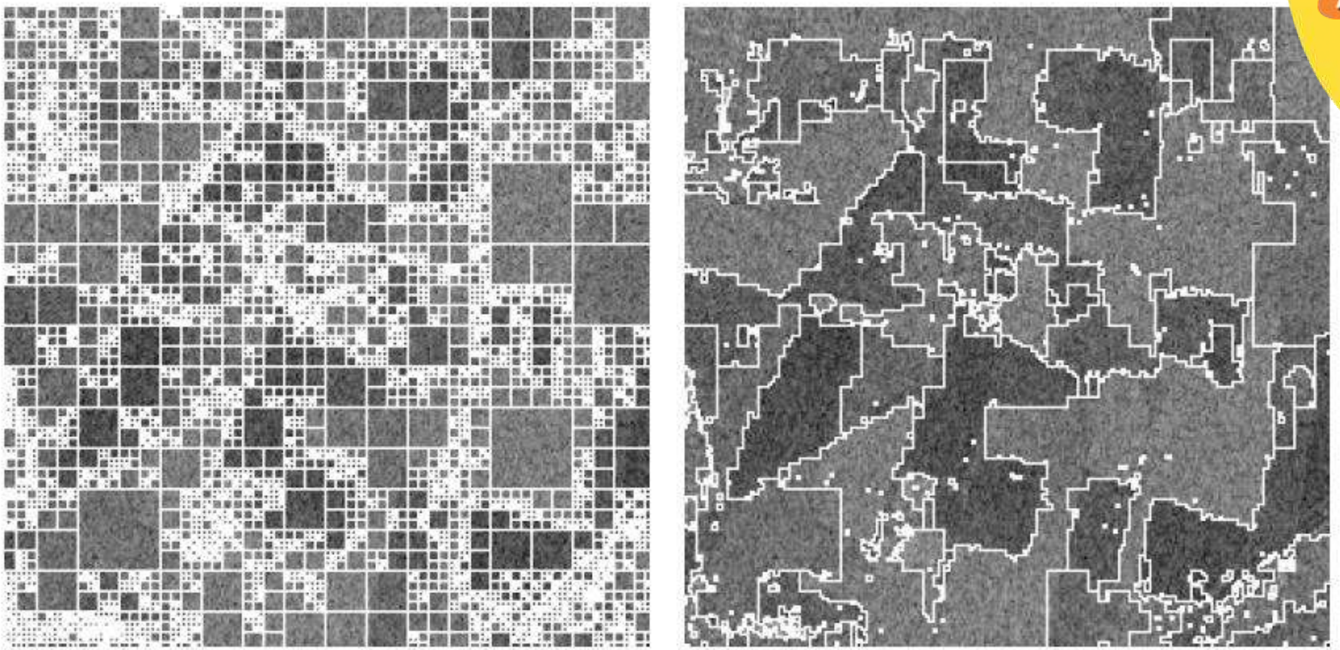
FIGURE 10.51 (a) X-ray image of a defective weld. (b) Histogram. (c) Initial seed image. (d) Final seed image (the points were enlarged for clarity). (e) Absolute value of the difference between (a) and (c). (f) Histogram of (e). (g) Difference image thresholded using dual thresholds. (h) Difference 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 Split-and-Merge

- The algorithm operates in two stages:
- The first stage is the *splitting one. Initially, the variance of the whole image is calculated.* If this variance exceeds the specified limit, then the image is subdivided into four quadrants. Similarly, if the variance in any of these four quadrants exceeds the limit it is further subdivided into four. This continues until the whole image consists of a set of squares of varying sizes, all of which have variances below the limit.
- Squares are smaller in non-uniform parts of the image.

Region Split-and-Merge

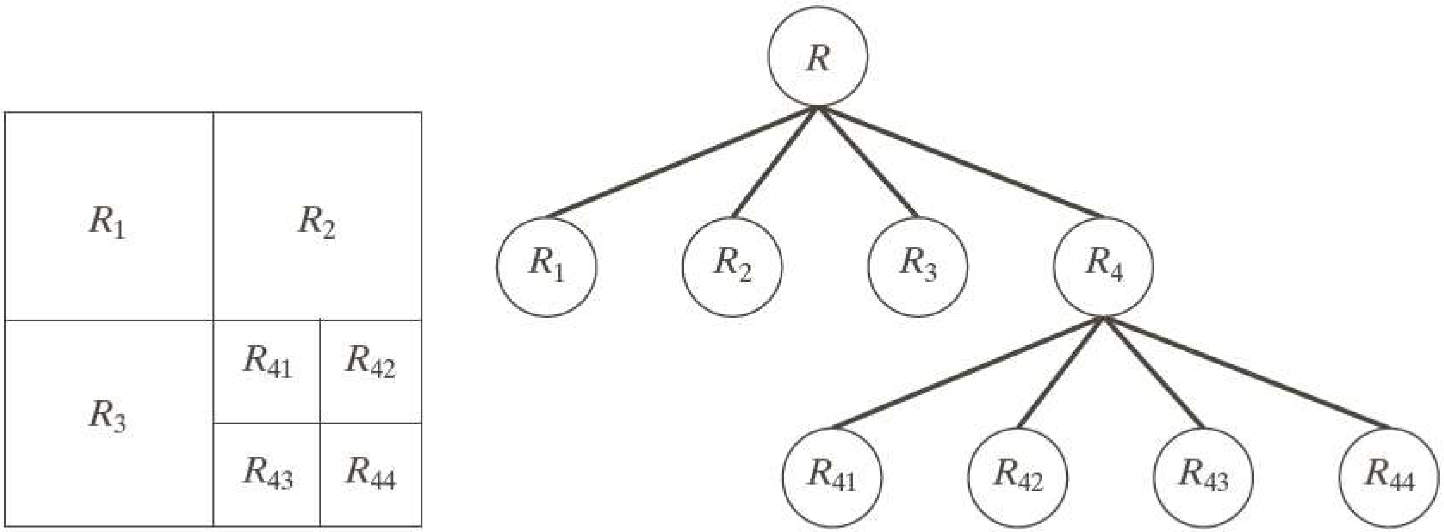
- The second stage of the algorithm, the *merging one,* involves amalgamating squares which have a common edge, provided that by so doing the variance of the new region does not exceed the limit. Once all amalgamations have been completed, the result is a segmentation in which every region has a variance less than the set limit.
- However, although the result of the first stage in the algorithm is unique, that from the second is not - it depends on the order of which squares are considered.



(a) (b)

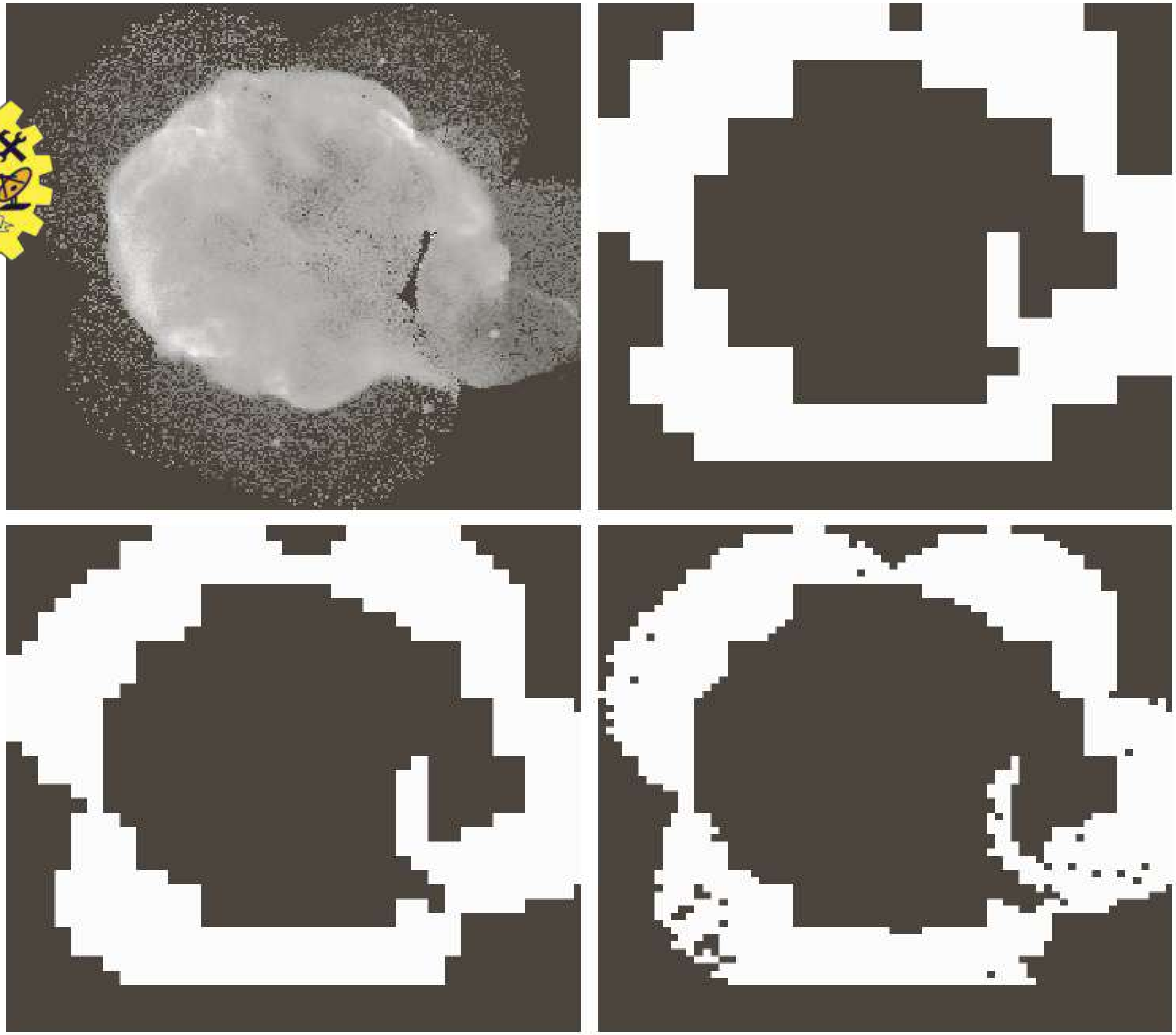
Figure 4.15: Region-growing segmentation of log-transformed SAR image: (a) division of image into squares with variance less than 0.60, obtained as first step in algorithm, (b) final segmentation, after amalgamation of squares, subject to variance limit of 0.60.

Quadtree Algorithm



a b

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



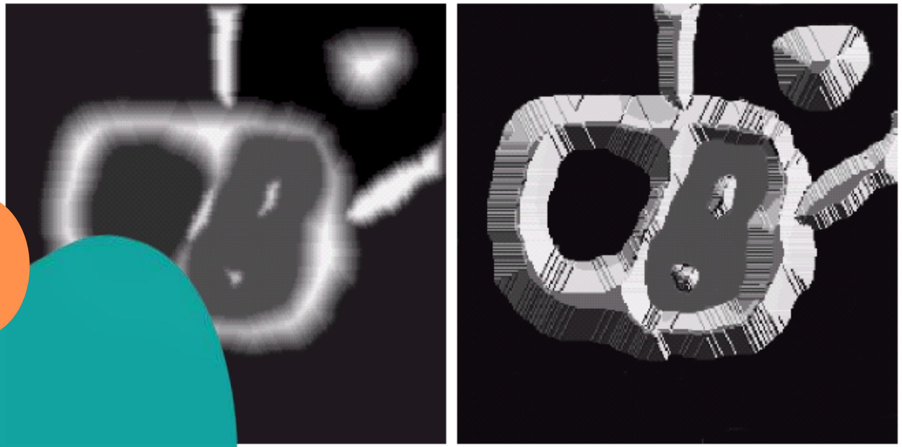
a b
c d

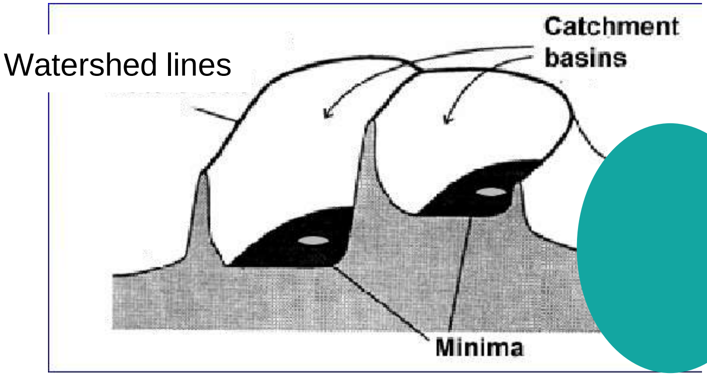
FIGURE 10.53
(a) Image of the Cygnus Loop supernova, taken in the X-ray band by NASA's Hubble Telescope. (b)–(d) Results of limiting the smallest allowed quadregion to sizes of 32×32, 16×16, and 8×8 pixels, respectively. (Original image courtesy of NASA.)

$$Q = \begin{cases} \text{TRUE}, & \text{if } \sigma(std) > a \text{ AND } 0 < m(\text{mean}) < b \\ \text{FALSE}, & \text{otherwise} \end{cases}$$

Segmentation Using Watershed Transform

- 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 Watersheds: Backgrounds

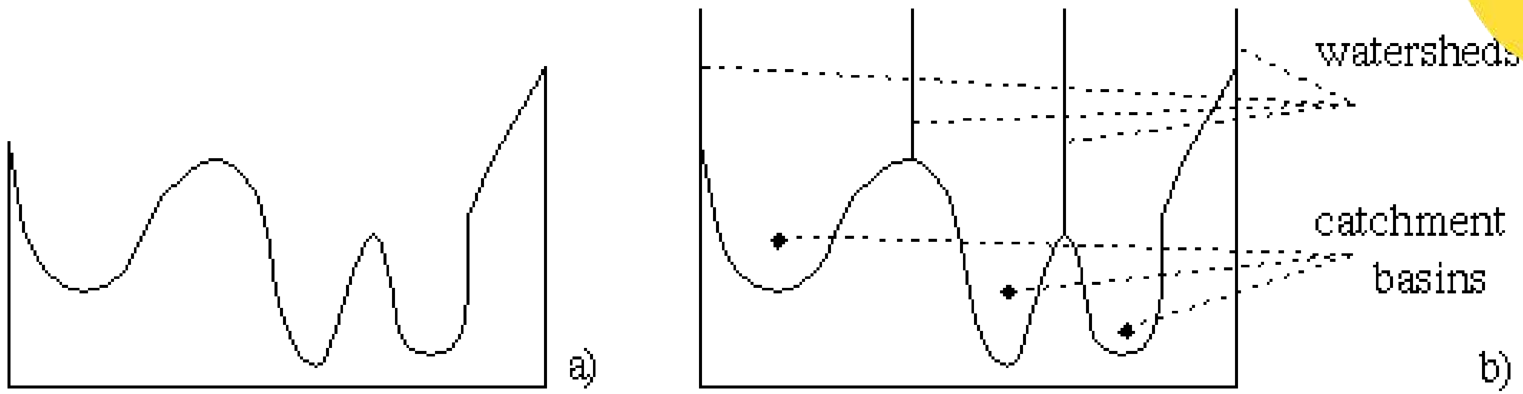
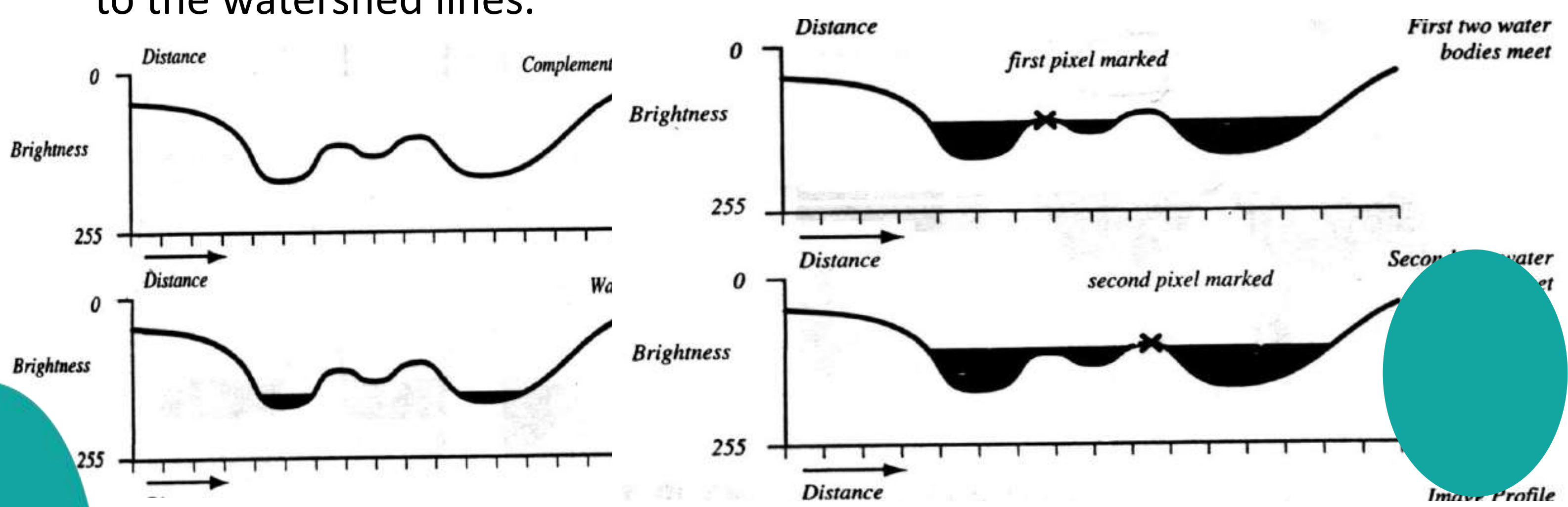
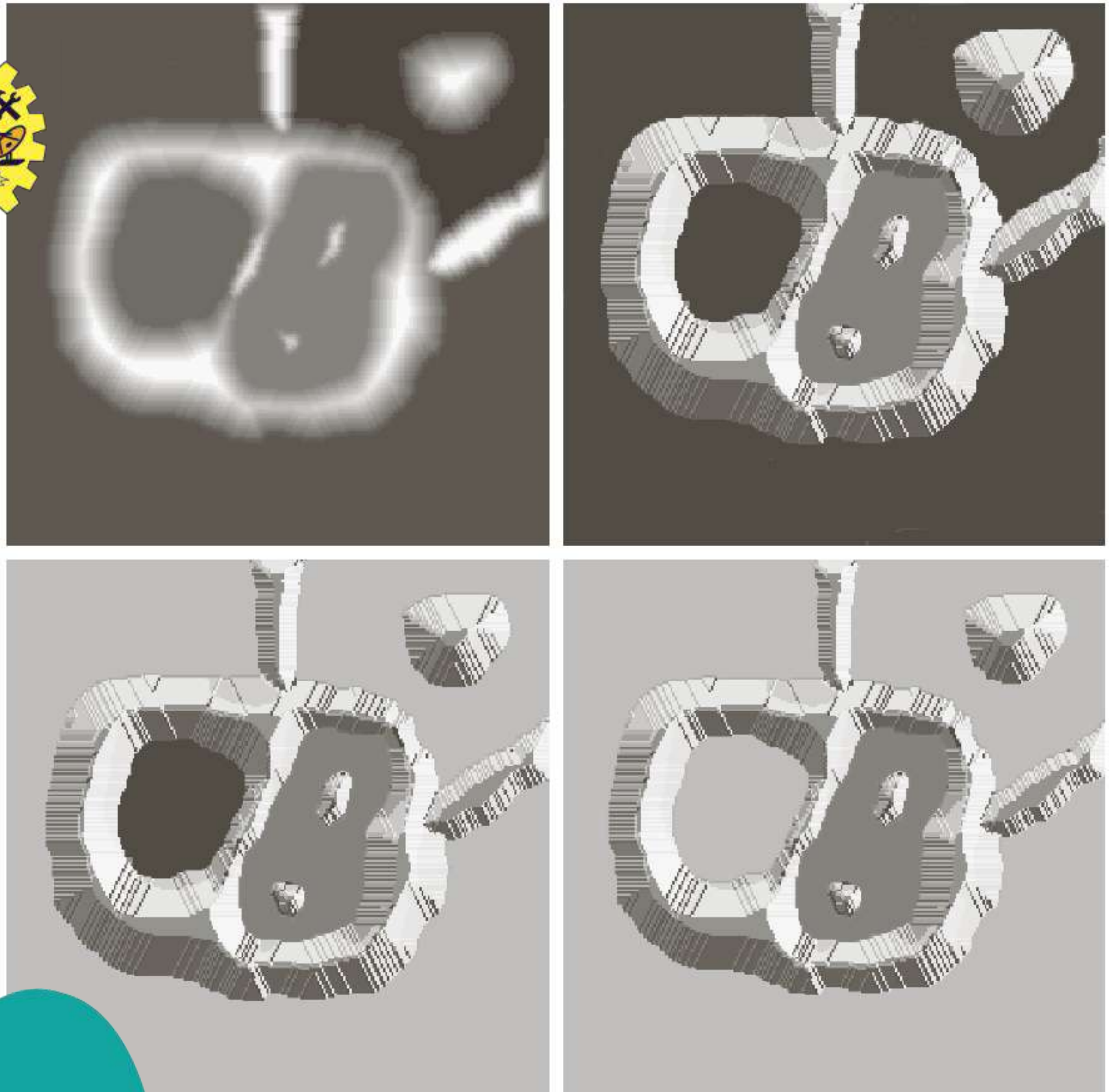


Figure 5.47 *One-dimensional example of watershed segmentation. (a) Gray level profile of image data. (b) Watershed segmentation – local minima of gray level (altitude) yield catchment basins, local maxima define the watershed lines.*

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

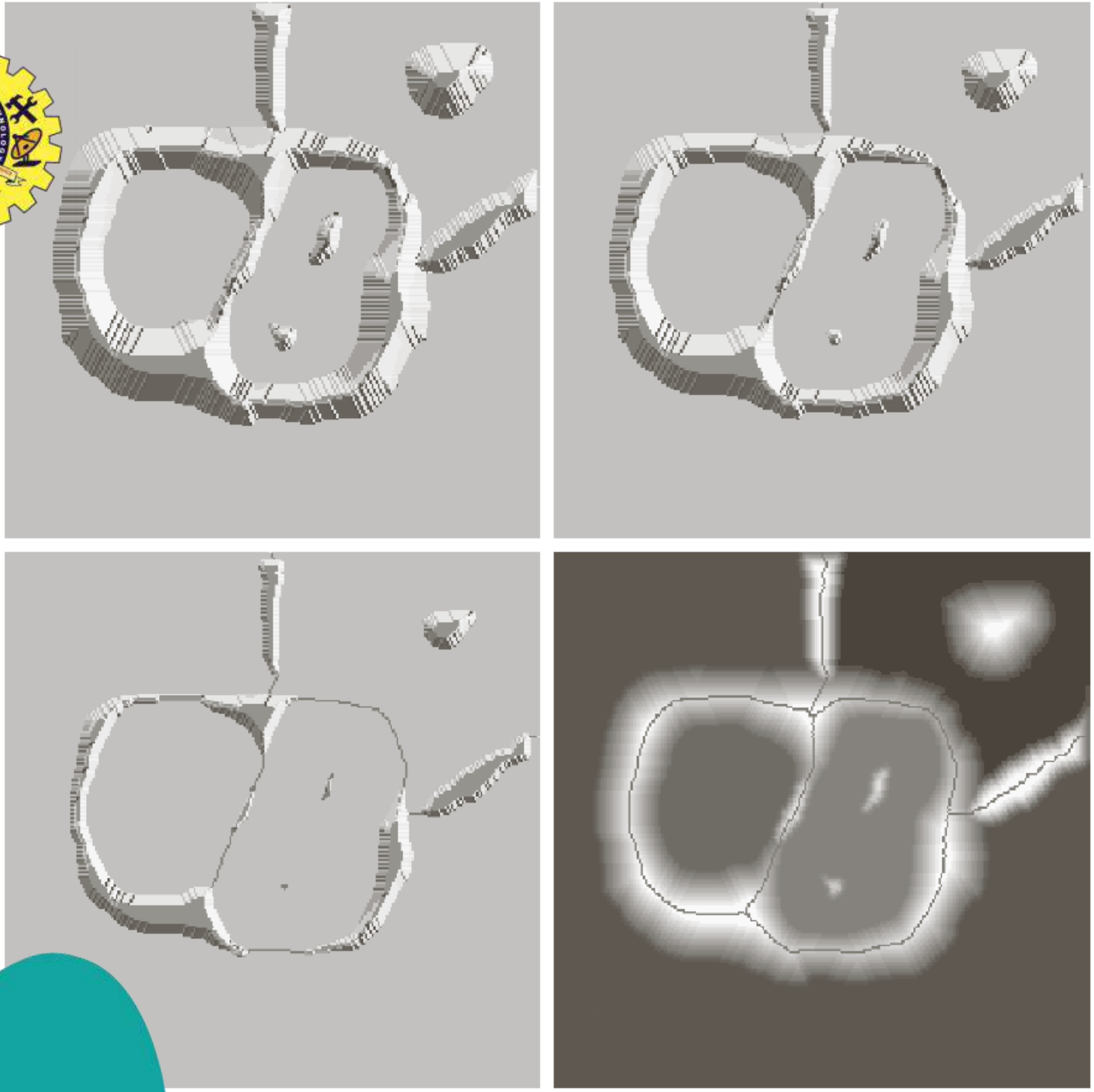
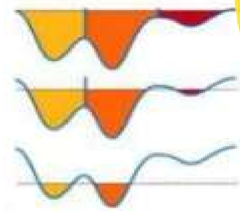


FIGURE 10.54 *(Continued)* (e) Result of further flooding. (f) Beginning of merging of water from two catchment basins (a short dam was built between them). (g) Longer dams. (h) Final watershed (segmentation) lines. (Courtesy of Dr. S. Beucher, CMM/Ecole des Mines de Paris.)

Watershed Segmentation Algorithm -immersion analogy

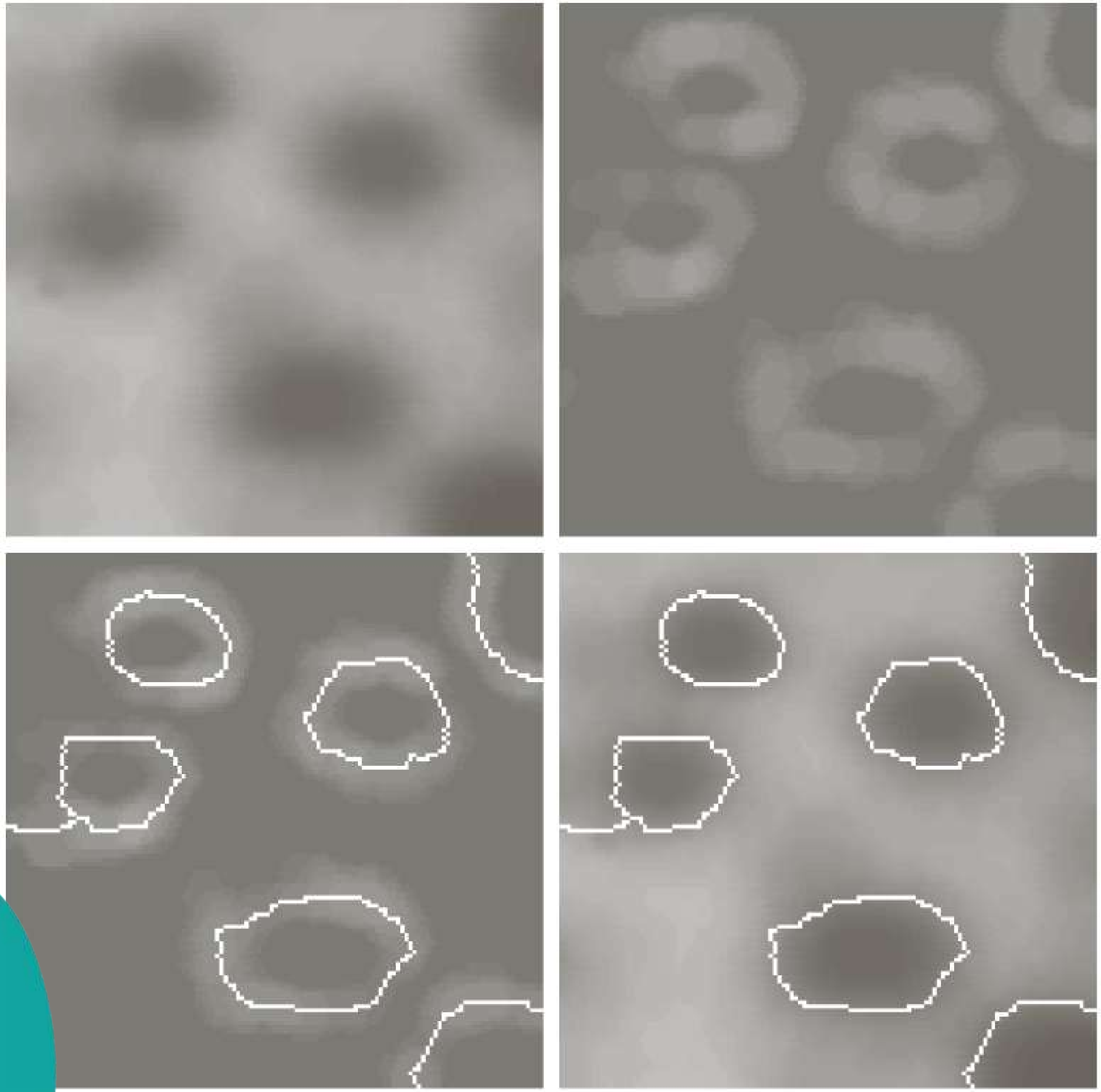


- Pixel values are sorted.
- Pixels are accessed in an ascending order.
  - These form the basis for initial catchment basins.
- At each level k:
  - For each group of pixels at level k
    1. If adjacent to exactly one existing region, add these pixels to that region
    2. Else if adjacent to more than one existing regions, mark as boundary
    3. Else start a new region

Another Analogy is the rain-fall.

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.)

Thank You