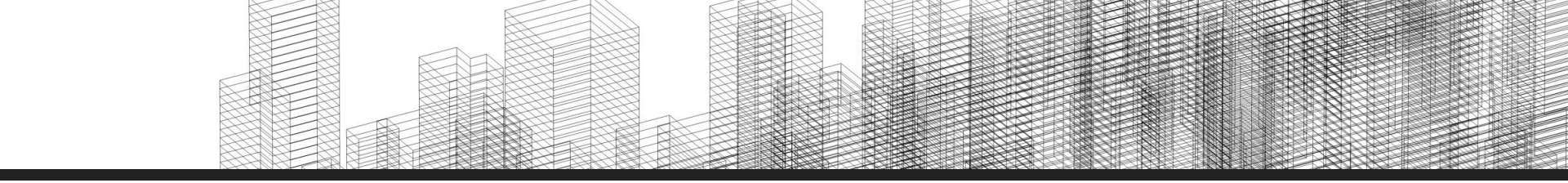

Image Segmentation

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Introduction

- Point, Line, and Edge Detection
- Thresholding
- **Segmentation by Region Growing and by Region Splitting and Merging**
- Region Segmentation Using Clustering and Superpixels
- Region Segmentation Using Graph Cuts
- Segmentation Using Morphological Watersheds

1. Basic Formulation

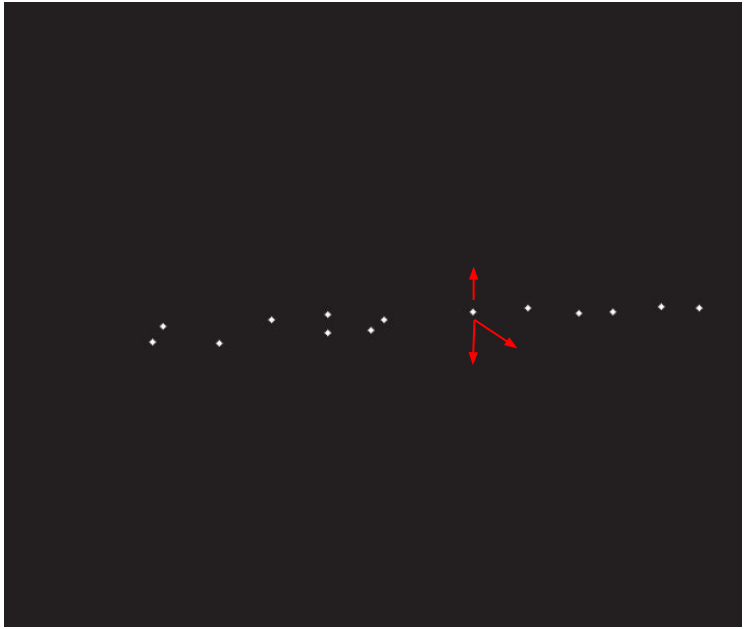
Let R represent the entire image region. We may view segmentation as a process that partitions R into *n* subregions, R_1, R_2, ... , R_n. such that

1. $\bigcup_{i=1}^{n} = R$
2. R_i *is a connected region*, $i = 1, 2, ..., n$
3. $R_i \bigcap R_j = \emptyset$ for all i and j, $i \neq j$
4. $P(R_i) = TRUE$ for i = 1, 2, .., n
5. $P(R_i \bigcup R_j) = FALSE$ for any adjacent regions R_i and R_j

2. Region Growing

Idea

Original image



List of seed points

2. Region Growing

A basic region-growing algorithm based on 8-connectivity

Problem :

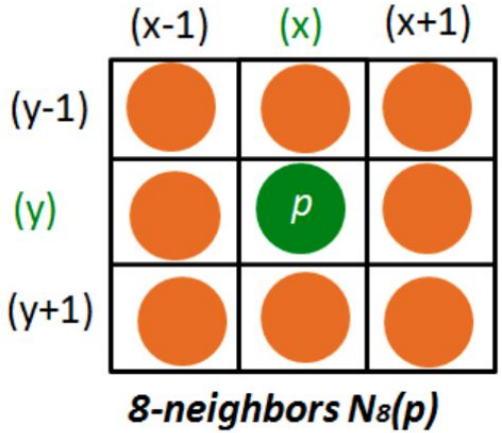
- f(x,y) : input image (shape m x n)
- S(x,y) : 1s at seed point and 0s elsewhere (shape m x n)
- Q : predicate to apply at each location (x,y)

1. Find all connected components in $S(x, y)$ and reduce each connected component 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 each point (x, y), $f_Q(x, y) = 1$ if the input image satisfies a given predicate, Q, at those coordinates, and $f_Q(x, y) = 0$ otherwise.
3. Let g be an image formed by appending to each seed point in S all the 1-valued points in f_Q that are 8-connected to that seed point.
4. Label each connected component in g with a different region label (e.g.,integers or letters). This is the segmented image obtained by region growing.

2. Region Growing

A basic region-growing algorithm based on 8-connectivity

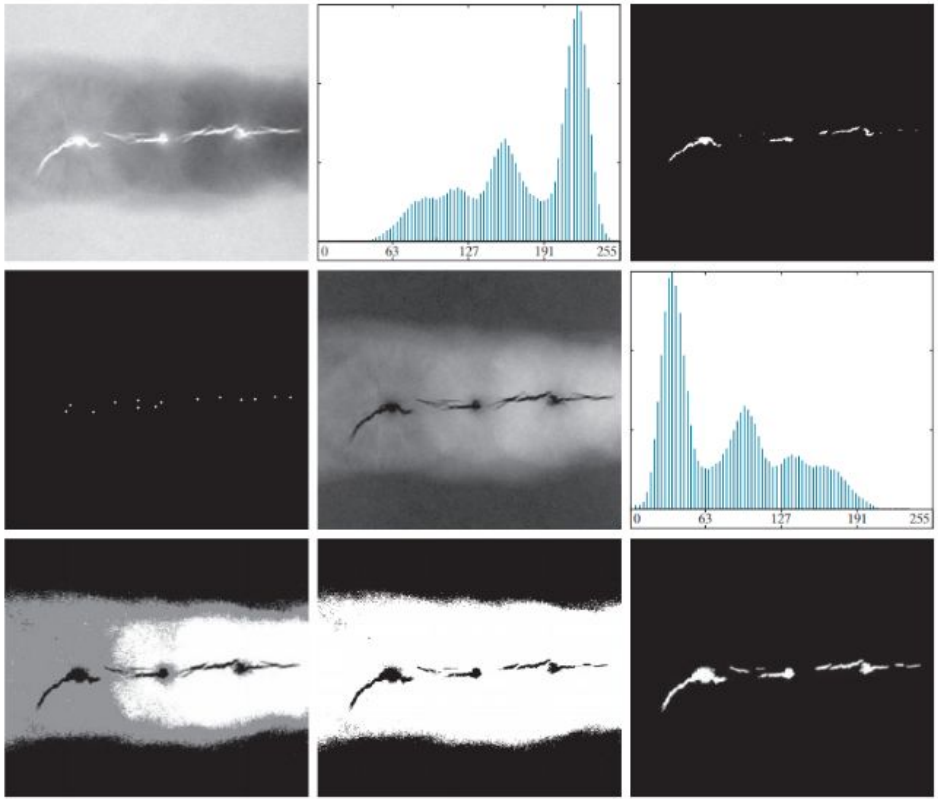
$$Q = \begin{cases} \text{TRUE} & \text{if the absolute difference of intensities between the seed and the pixel at } (x, y) \text{ is } \leq T \\ \text{FALSE} & \text{otherwise} \end{cases}$$



8-neighbors $N_8(p)$

2. Region Growing

Example



a b c
d e f
g h i

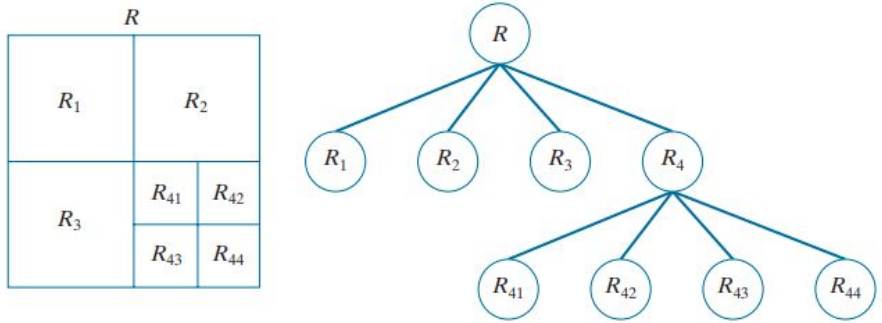
(a) x-ray image of a defective weld.
(b) histogram.
(c) initial seed image.
(d) final seed image (the points were enlarged for clarity).
(e) absolute value of the difference between the seed value (255) and (a).
(f) histogram of (e).
(g) difference image threshold using dual thresholds.
(h) difference image thresholds with the smallest of the dual thresholds.
(i) segmentation result obtained by region growing. (original image courtesy of x-tek systems, ltd.)

3. Region Splitting and Merging

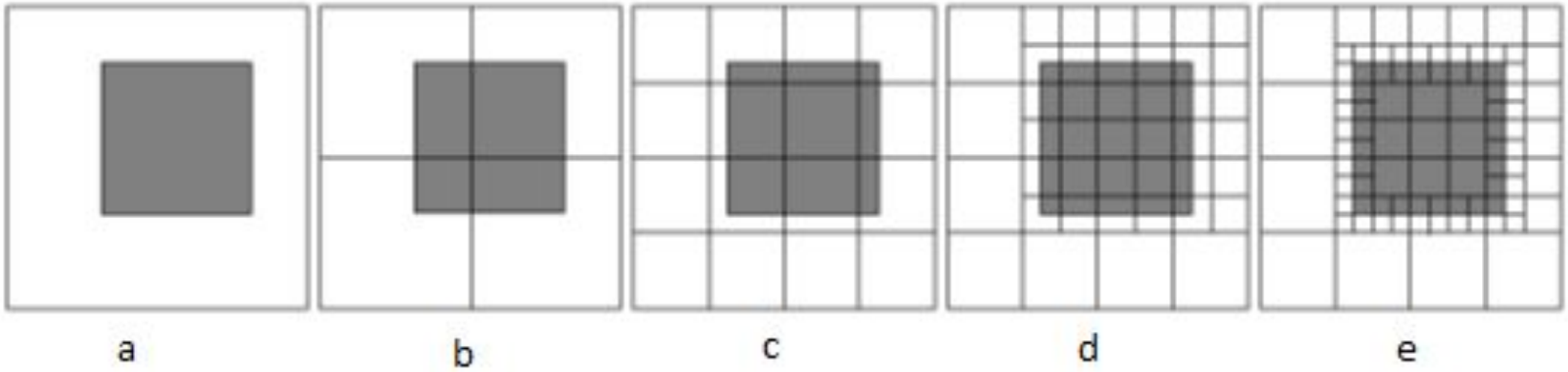
The procedure just discussed grows regions from seed points. An alternative is to subdivide an image initially into a set of disjoint regions and then merge and/or split the regions in an attempt to satisfy the conditions of segmentation stated in Section 10.1

1. Split into four disjoint quadrants any region R_i for which $Q(R_i) = \text{FALSE}$.

2. When no further splitting is possible, merge any adjacent regions R_j and R_k for which $Q(R_j \cup R_k) = \text{TRUE}$.



3. Region Splitting and Merging

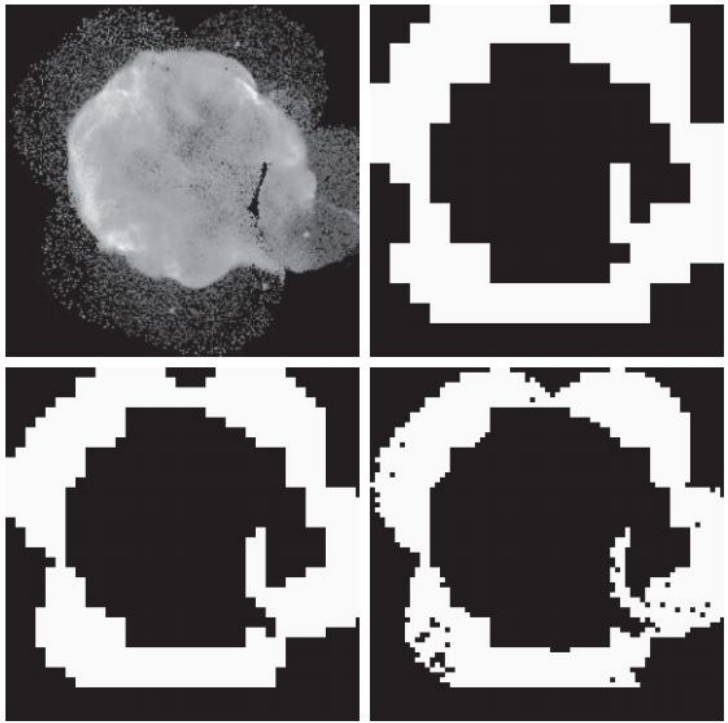


3. Region Splitting and Merging

Example

a b
c d

FIGURE 10.48
(a) Image of the Cygnus Loop supernova, taken in the X-ray band by NASA's Hubble Telescope. (b) through (d) Results of limiting the smallest allowed quadregion to be of sizes of 32×32, 16×16, and 8×8 pixels, respectively. (Original image courtesy of NASA.)



$$Q(R) = \begin{cases} \text{TRUE} & \text{if } \sigma_R > a \text{ AND } 0 < m_R < b \\ \text{FALSE} & \text{otherwise} \end{cases}$$


Thanks for Listening