7.4 Region-Oriented Segmentation

- 7.1, 7.2 : finding boundaries between regions based on intensity *discontinuities*
- 7.3 : via *thresholds* based on the distribution of pixel properties such as intensity or color
- 7.4 : based on finding the regions directly

7.4.1 Basic Formulation

- R : entire image region

  $R_1, R_2, ..., R_n$: n subregions

  (a) $\bigcup_{i=1}^{n} R_i = R$

  (b) R_i : connected regions i=1,2,…,n

  (c) $R_i \cap R_j = \emptyset$ for all i and j, $i \neq j$

  (d) $P(R_i) = TRUE$ for i=1,2,…,n and

  (e) $P(R_i \cup R_j) = FALSE$ for $i \neq j$

  where $P(R_i)$: logical predicate over the points in set R_i

- Condition (d)
  - properties that must be satisfied by the pixels in a segmented region

  ex.) $P(R_i) = TRUE$ if all pixels in R_i : the same intensity

- Condition (e)
  - region R_i, R_j : different in the sense of predicate P

7.4.2 Region Growing by Pixel Aggregation

- Pixel aggregation
  - start with a set of seed pixels
  - append to each seed point those neighboring pixels that have similar properties (ex. Gray level, texture, color)

ex.)

	1	2	3	4	5
1	0	0	5	6	7
2	1	1	5	8	7
3	0	1	6	7	7
4	2	0	7	6	6
5	0	1	5	6	5

(a)

a	a	b	b	b
a	a	b	b	b
a	a	b	b	b
a	a	b	b	b
a	a	b	b	b

(b)

a	a	a	a	a
a	a	a	a	a
a	a	a	a	a
a	a	a	a	a
a	a	a	a	a

(c)

- ✓ seed points : $(3,2)$, $(3,4)$
- ✓ property P : gray level difference less than threshold
- ✓ if T=3 : fig. 7.35 (b) → two regions R_1, R_2
- ✓ if T=8 : fig. 7.35 (c) → single region

- Difficulties
  - selection of initial seeds that properly represent region of interest and selection of suitable properties
  - based on the nature of problem

    ex.) military appli. of infrared imaging
    - ✓ target : hotter than background → brighter

      ∴ the brightness pixel → seed

    if priori information is not available

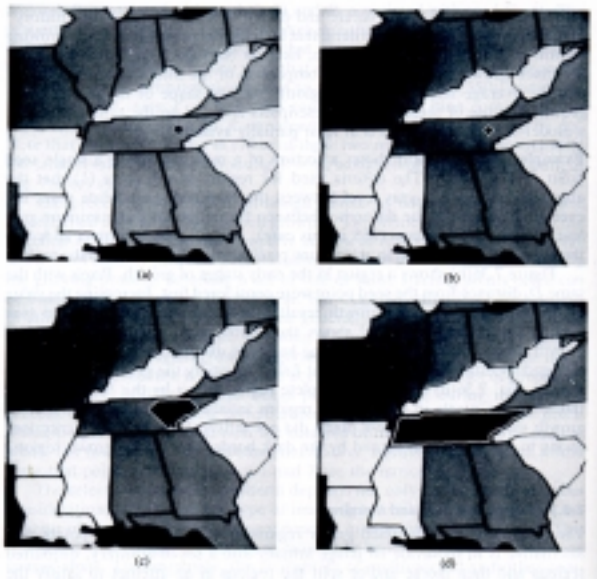
- ✓ the cluster of values : exist
  → the center pixels of the clusters : seeds

- selection of similarity criteria depends on
  - ✓ dependent on the problem
  - ✓ type of image data available

- typically, region analysis
  carried out with a set of descriptors based on intensity and spatial properties
  ex) moments, texture of a single image source

- Description
  - descriptor + connectivity or adjacency information
    → meaningful result
- Stopping rules
  - basically, stop when no more pixels satisfy the criteria
  - intensity, texture, color : local criteria
  - history
    - ✓ size of region
    - ✓ likeness between a candidate pixel and the pixels grown so far (ex. Intensity of candidate and average intensity of the grown region)
    - ✓ shape of region being grown
  - assumption
    - ✓ model of expected result : at least partially available

    ex.)



criteria (1), (2)

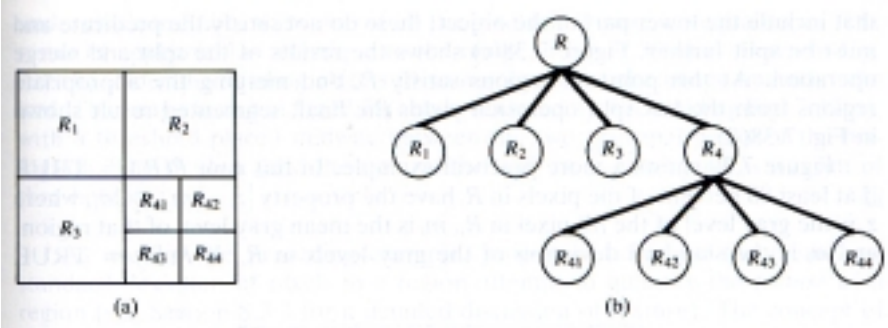
7.4.3 Region Splitting and Merging

- i) subdivide an images initially into a set of arbitrary, disjointed regions
  ii) then merge and/or split the regions to satisfy the Sec. 7.41 condition
- square image R $\xrightarrow[Successibely]{Subdivide}$ quadrant regions

  so that for any region $P(R_i) = TRUE$

  that is if $P(R) = FALSE$, divide the image into quadrant

  splitting procedure

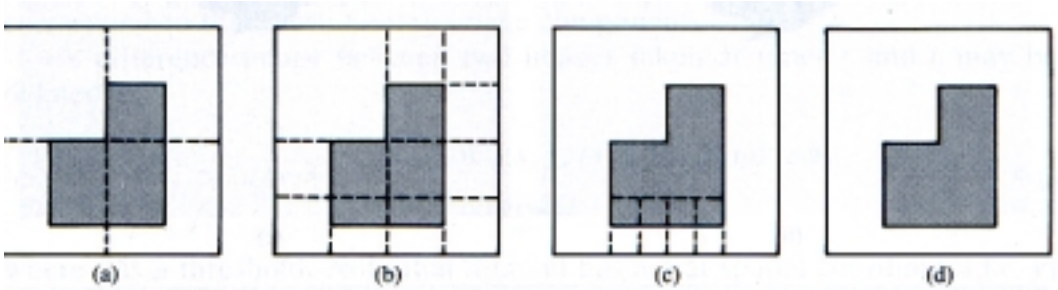


- after splitting, the final partition -> adjacent regions with identical properties

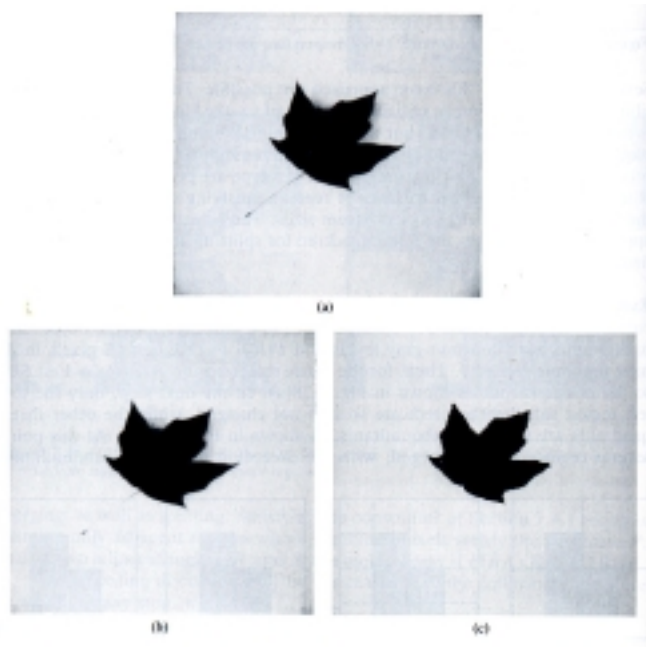
  merging, only adjacent regions that satisfy the predicate P that is two adjacent region R_i and R_j :

  merged, if $P(R_i \text{ Y } R_j) = T$
- summary
  - image : splitted into a set of square block
  -

  ex.)



ex.)



- criteria

  $P(R_i) = T$ if at least 80% of the pixels in R_i have the property $\left|z_j - m_i\right| \le 2\sigma_i$

  where z_j : the gray level of j th pixels in R_i

  m_i : mean gray level of that region

  σ_i : standard deviation of gray levels in R_i

- value of all pixels in $R_i \rightarrow m_i$
- (b) : result of above criteria
- (c) : histogram thresholding

7.5 The use of Motion in Segmentation

- motion : powerful cue for objects
- spatial and freq. Domain analysis

7.5.1 Spatial Techniques

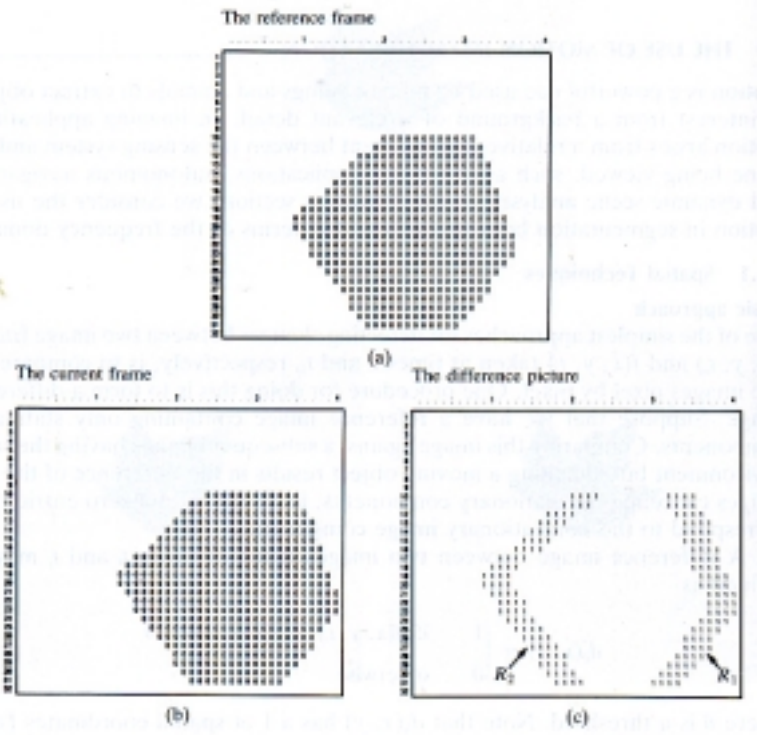
1) Basic Approach

- Detection of change between two image frames $f(x, y, t_i), f(x, y, t_j)$

- pixel-by-pixel comparison → difference image
  - ✓ $d_{ij}(x,y) = \begin{cases} 1 & if \quad |f(x,y,t_i) - f(x,y,t_j)| > \theta \\ 0 & otherwise \end{cases}$

    where θ : threshold
  - ✓ result of noise

    → removal : form 4-or 8-connected regions of 1's in $d_{ij}(x,y)$ and then ignore any region that has less than a predetermined no. of entries
- ex.)

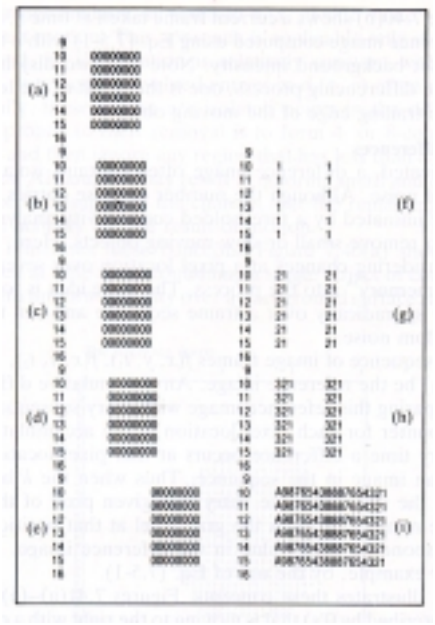


  - ✓ object with constant intensity
  - ✓ constant velocity
  - ✓

2) Accumulative differences

- Changes at a pixel location over several frames
  - random noise(changes that occur only sporadically)
- A sequence of images $f(x,y,t_1), f(x,y,t_2),..., f(x,y,t_n)$
  - $f(x,y,t_i)$: reference image
  - Accumulative Difference Image (ADI)
    - ✓ A counter for each pixel location in accumulative image

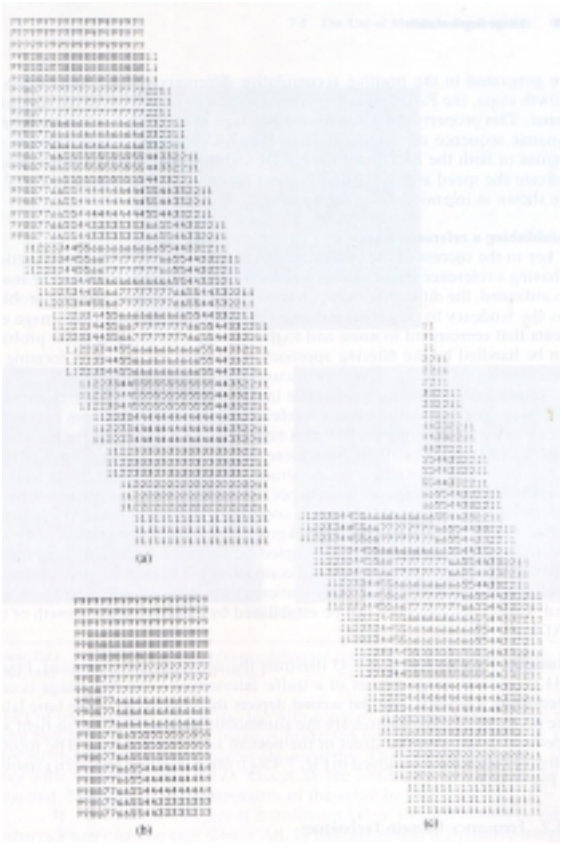
      : incremented every time a diff. occurs at that pixel location between the ref. and an image in sequence



- three types of ADI
  - absolute (AADI), positive (PADI), negative (NADI)
  - PADI, NADI : in eg. 7.5.1

$$| f(x,y,t_i) - f(x,y,t_j) | \rightarrow f(x,y,t_i) - f(x,y,t_j)$$

ex.)



- object
  - ✓ intensity : greater than the background
  - ✓ constant velocity in a SE direction