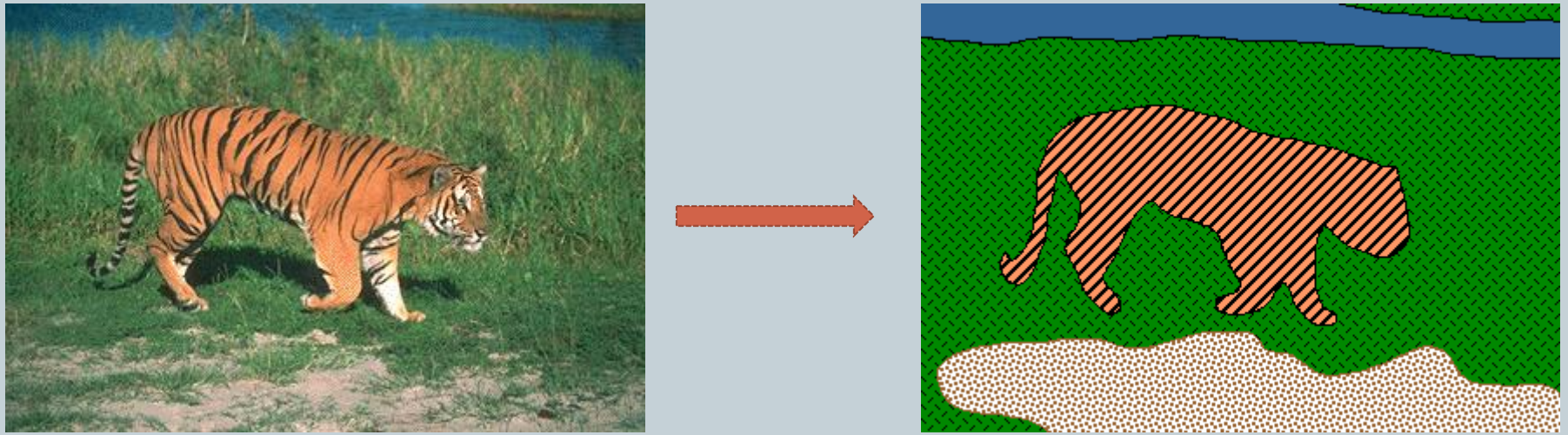
ELEC 474 – Machine Vision

REGION-BASED SEGMENTATION



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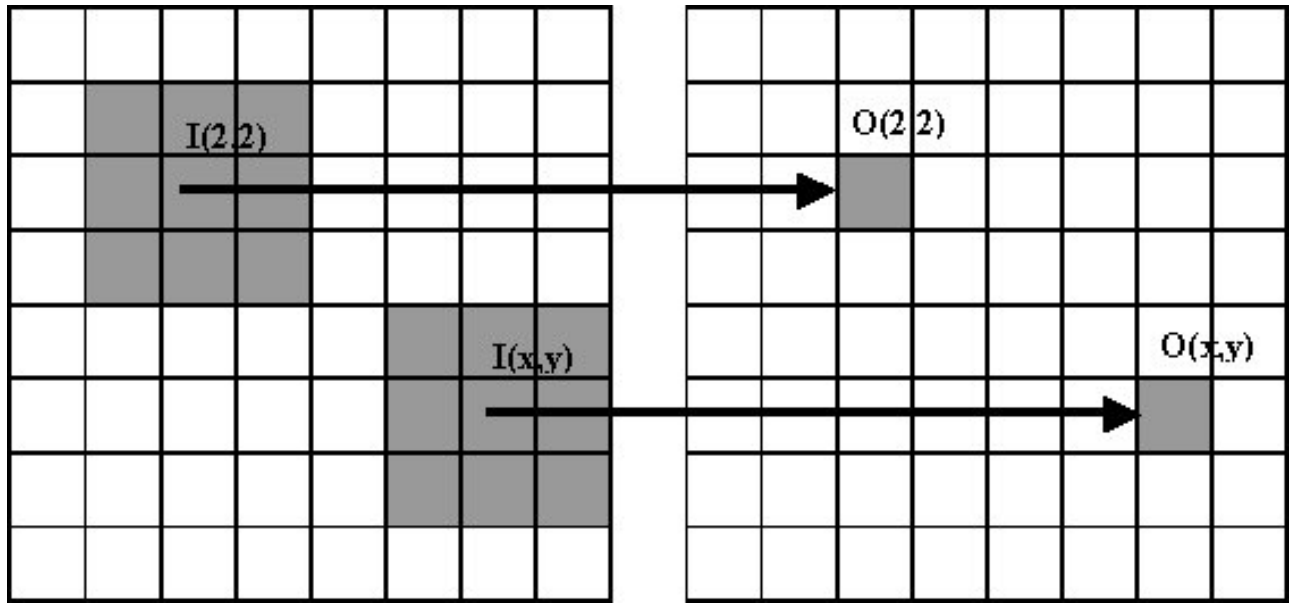
Region-Based Segmentation

- Each pixel has a local neighborhood
- Information in each local neighborhood of the original input image is used to determine the value of the central pixel in the output processed image



Original input image *I* Processed output image *O*

Region-Based Segmentation

- Region-Grouping
  - Group pixels or sub-regions into larger regions based on predefined criteria

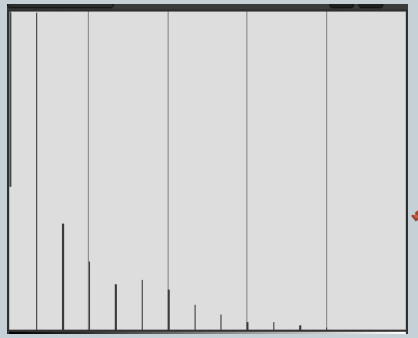
- Basic Formulation: Let I represent the entire image.

  Segmentation partitions I into n subregions, $R_1, R_2, \ldots, R_n$ such that:

  1. Segmentation must be complete: $\bigcup_{i=1}^{n} R_i = I$
  2. R_i is a connected region, in some predefined sense
  3. $R_i \cap R_j = \emptyset$ for all i and j such that $i \neq j$
  4. $P(R_i) =$ TRUE using some *homogeneity* criterion
  5. $P(R_i \cup R_j) =$ FALSE for adjacent regions R_i, R_j

Region-Based Segmentation

- Examples of homogeneity criteria for region R
  - Monochrome images:
    - difference between max and min grey values for all pixels within R is small
      - range of grey values within R is small
    - difference between any pixel and mean grey value within R is small
      - variance of grey values within R is small
  - Color images:
    - Same as above, except for color space



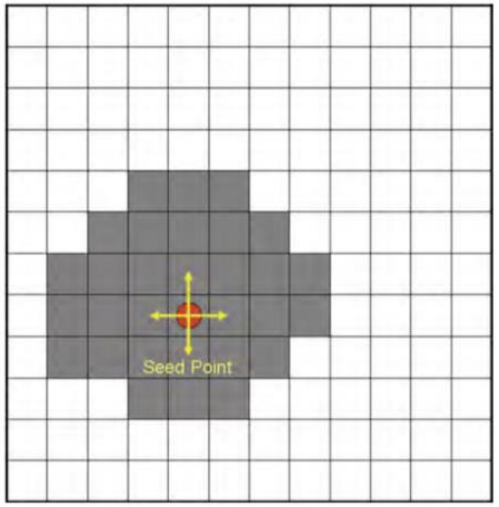
https://www.pinterest.ca/pin/239605642651959121/

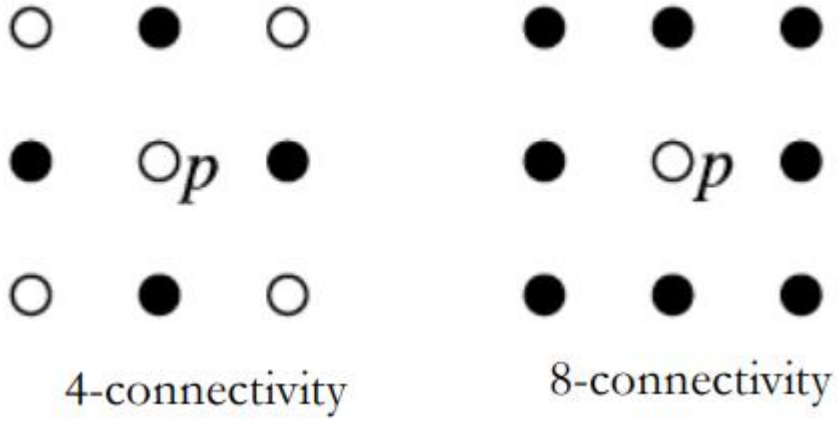
Region Growing

- Group pixels or sub-regions into larger regions based on predefined criteria.
- Starting from one or more "*seed points*" and look for similarity between the seed points and their neighbours based on the defined homogeneity criterion
- Two variants:
  1. Select seeds from the whole range of pixel values in the image.
     - Grow regions until all pixels in image belong to a region.
  2. Select seeds only from objects of interest (e.g. bright structures, dark structure, color range, etc).
     - Grow regions only as long as the similarity criterion is fulfilled.

Region Growing

- Algorithm
  1. Choose the seed pixel(s)
  2. Check the neighboring pixels and add them to the region if they are similar to the seed
  3. Repeat step 2 for each of the newly added pixels; stop if no more pixels can be added.





Region Growing

0	0	5	6	7
1	1	5	8	7
0	1	6	7	7
2	0	7	6	6
0	1	5	6	5

image, 2 seeds

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

result for $T = 4$

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

result for $T = 8$

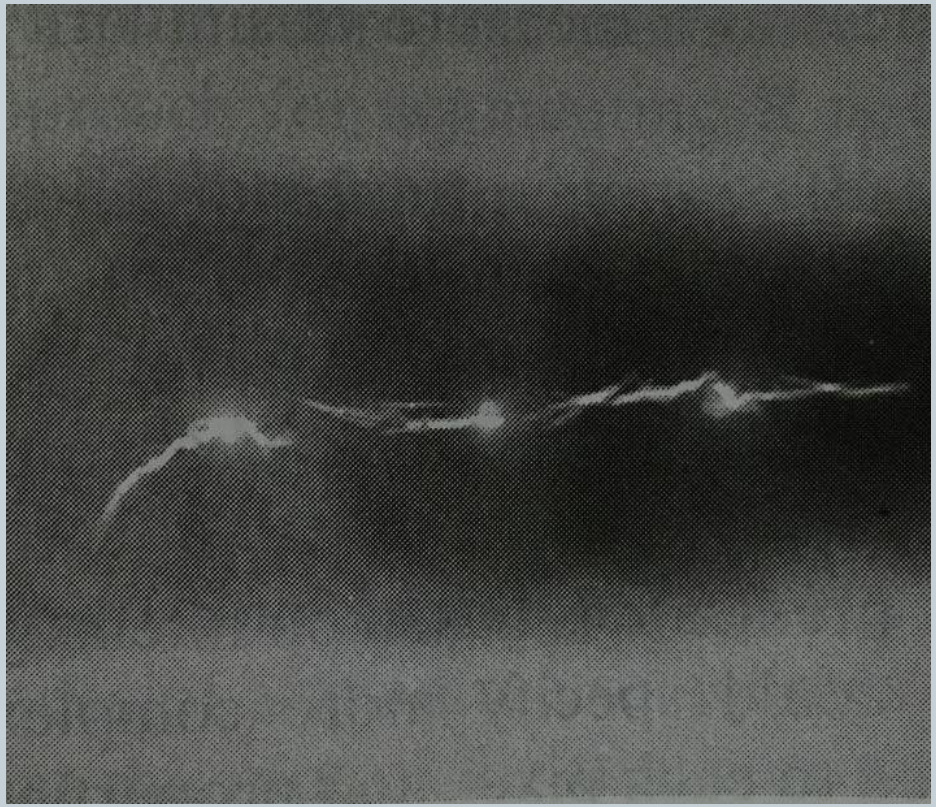
Homogeneity criterion: maximum allowed absolute difference T within region

How do we choose the seed(s) in practice ?

- It depends on the nature of the problem.
  - Segments are regions with some homogeneous characteristics, compared to other regions
    - Pixels within a segment are “similar” to their neighbors, with respect to these characteristics
    - Seeds ideally are the most representative of these characteristics
  - Seeds can be identified using local neighborhood operations
    - E.g., if similarity of color is the characteristic, then choose seeds with lowest color variance among local neighborhood
  - Seeds can also be identified without reference to local neighborhood
    - E.g., if targets need to be detected using infrared images for example, choose the brightest pixels
  - Without a-priori knowledge, compute the histogram and choose the gray-level values corresponding to the strongest peaks

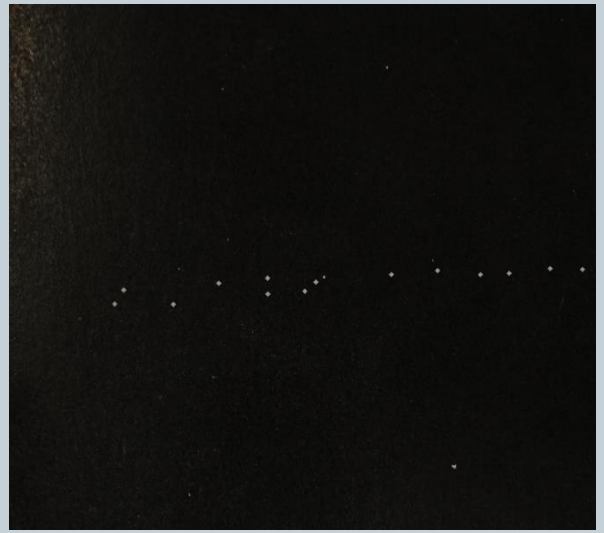
Region Growing

- Example: Weld failure region segmentation
  - Can be used for
    - Inspection
    - Controlling an automated welding system
  - Find the seed points
    - Histogram of the image
    - Its an x-ray so select pixels > 254



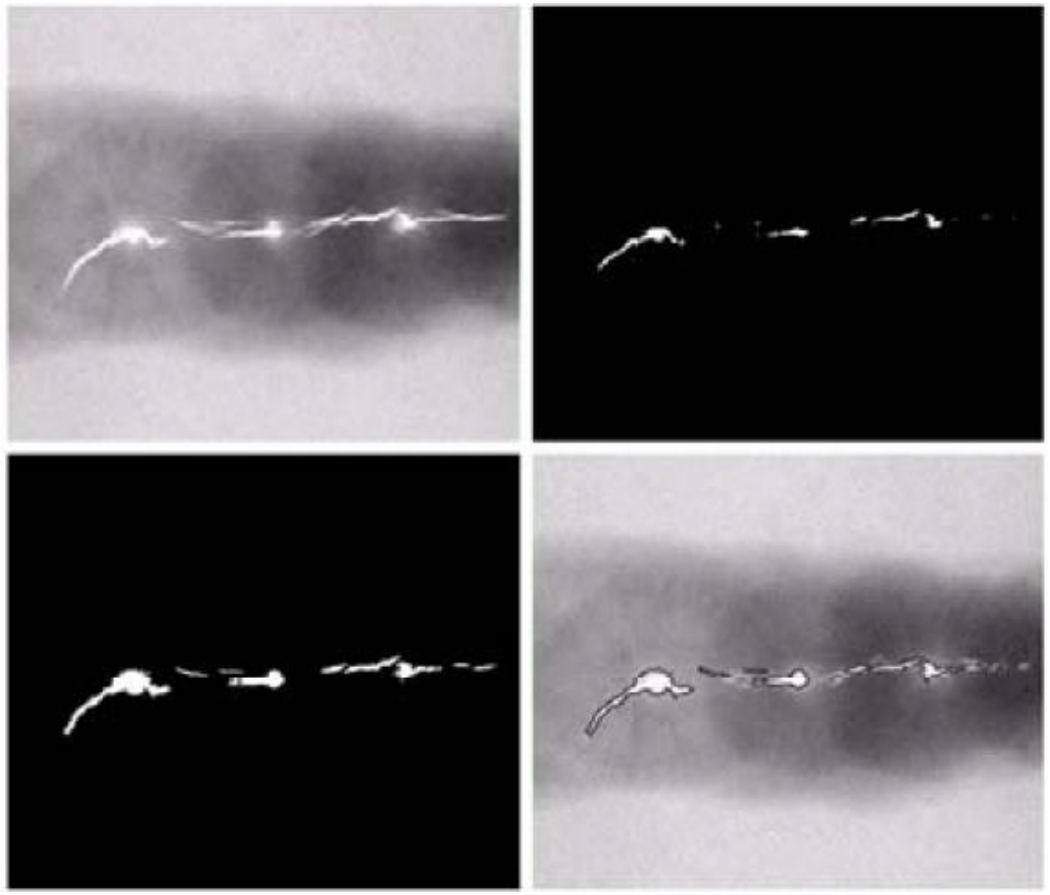
Region Growing

- Seed points
  - Many points in the seed region, we can use several schemes to reach to the seed
    - Use all of them
    - Erosion
    - Centroid

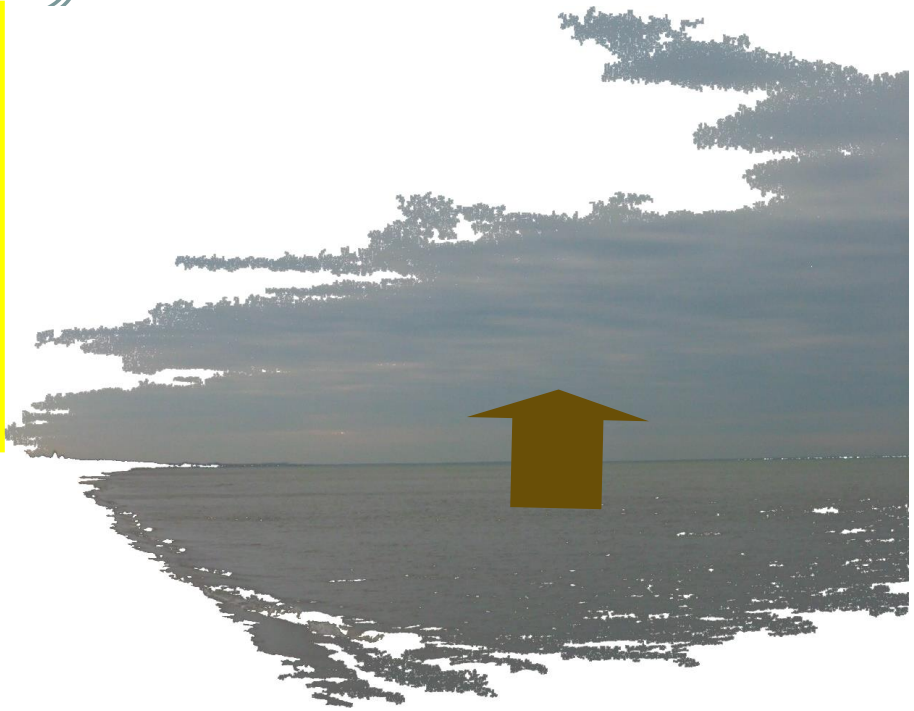


Region Growing

- Predicate is based on two criteria
  - Absolute gray level difference
  - 8-Connected
- Region Growing Disadvantages
  - Its not trivial to find good seed points
    - Different seed points will give different results
  - Region growth may “leak” through a single weak spot in the boundary



Region Growing

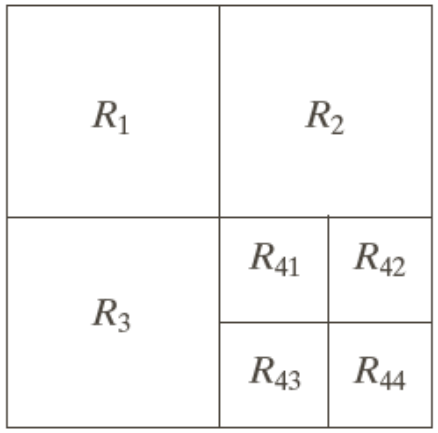


Region growth may “leak” through a single weak spot in the boundary

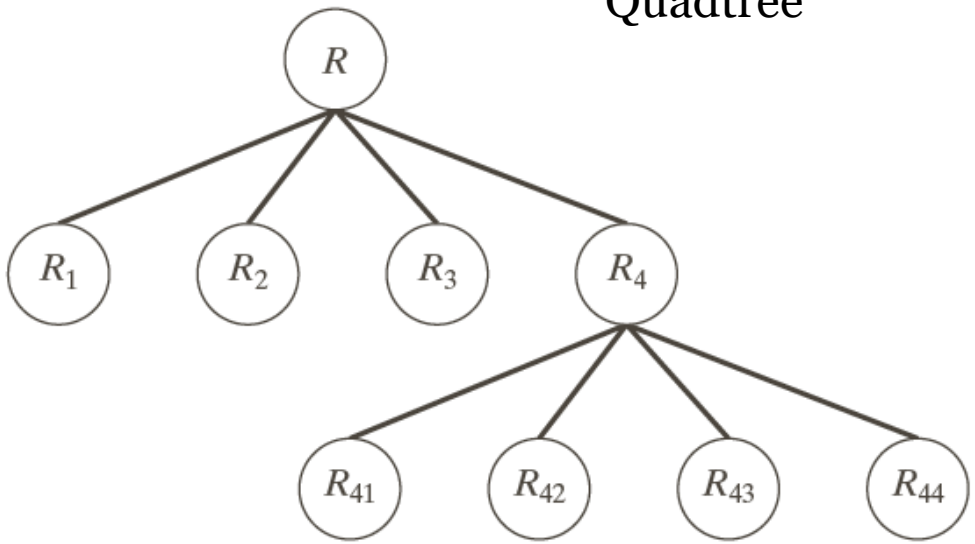
Region Splitting and Merging

START: consider entire image as one region

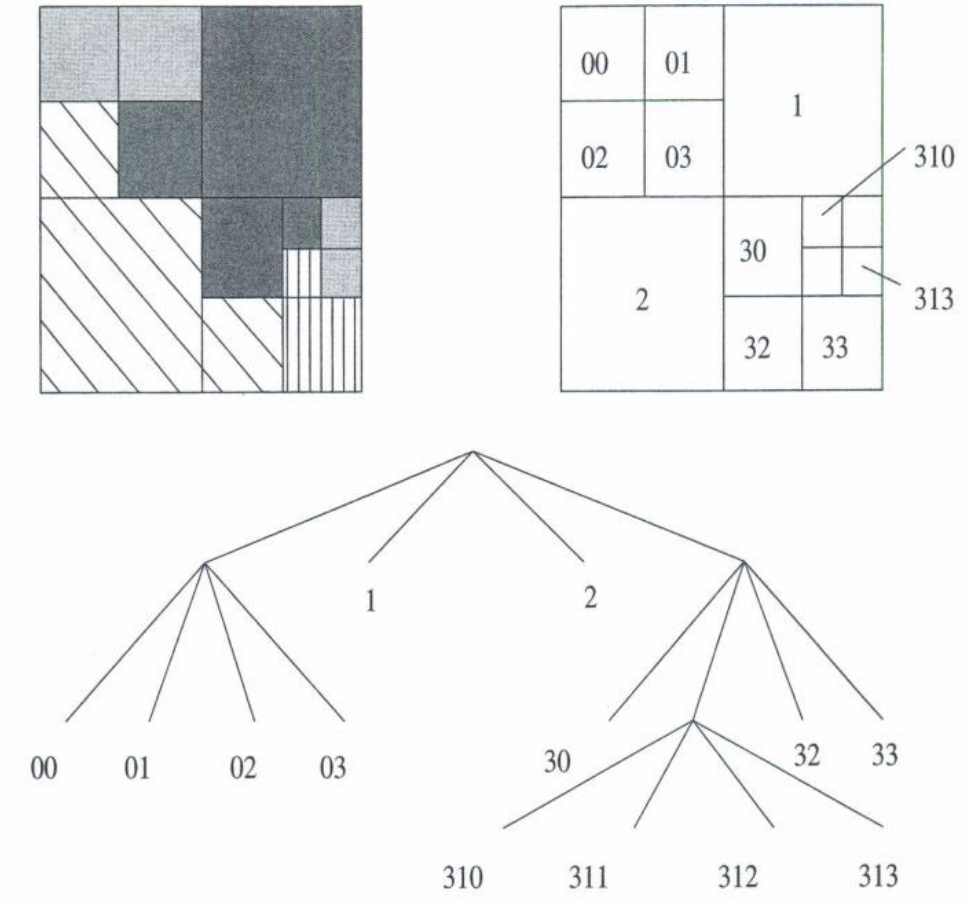
- If region satisfies homogeneity criteria, leave it unmodified
- If not, split it into four quadrants and recursively apply 1 and 2 to each newly generated region. STOP when all regions in the quadtree satisfy the homogeneity criterion
- If any two adjacent regions R_i , R_j can be merged into a homogeneous region, merge them. STOP when no merging is possible anymore.



Quadtree



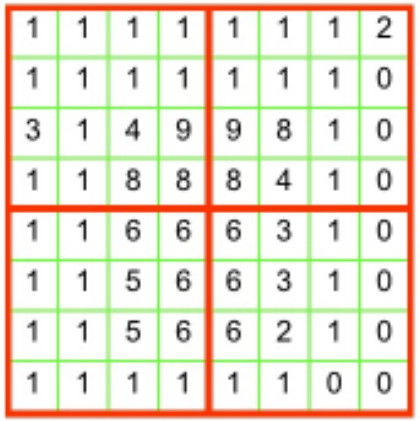
Segmentation Quadtree



Region Splitting and Merging

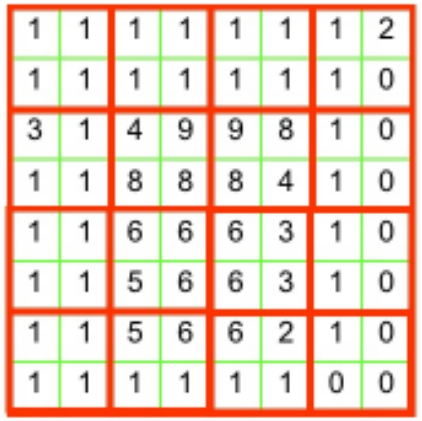
1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	0
3	1	4	9	9	8	1	0
1	1	8	8	8	4	1	0
1	1	6	6	6	3	1	0
1	1	5	6	6	3	1	0
1	1	5	6	6	2	1	0
1	1	1	1	1	1	0	0

Sample image



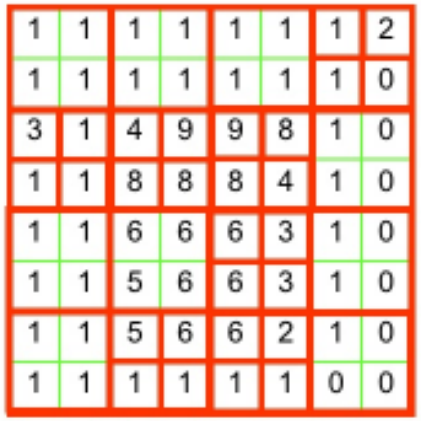
1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	0
3	1	4	9	9	8	1	0
1	1	8	8	8	4	1	0
1	1	6	6	6	3	1	0
1	1	5	6	6	3	1	0
1	1	5	6	6	2	1	0
1	1	1	1	1	1	0	0

First split



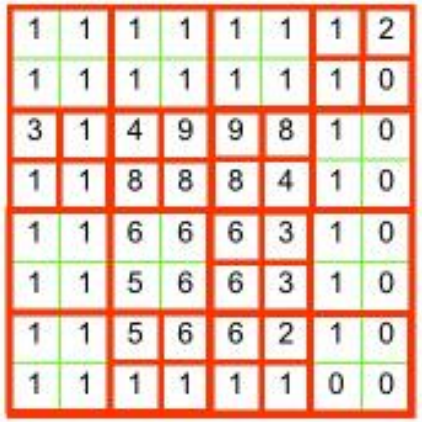
1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	0
3	1	4	9	9	8	1	0
1	1	8	8	8	4	1	0
1	1	6	6	6	3	1	0
1	1	5	6	6	3	1	0
1	1	5	6	6	2	1	0
1	1	1	1	1	1	0	0

Second split



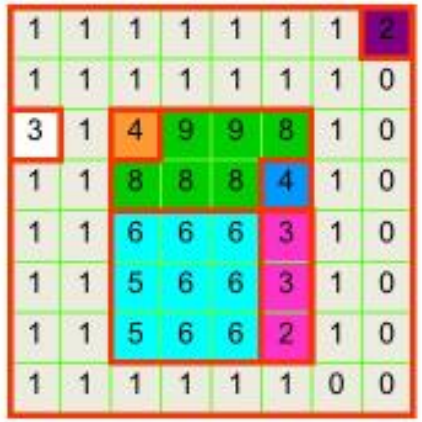
1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	0
3	1	4	9	9	8	1	0
1	1	8	8	8	4	1	0
1	1	6	6	6	3	1	0
1	1	5	6	6	3	1	0
1	1	5	6	6	2	1	0
1	1	1	1	1	1	0	0

Third split



1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	0
3	1	4	9	9	8	1	0
1	1	8	8	8	4	1	0
1	1	6	6	6	3	1	0
1	1	5	6	6	3	1	0
1	1	5	6	6	2	1	0
1	1	1	1	1	1	0	0

Merge

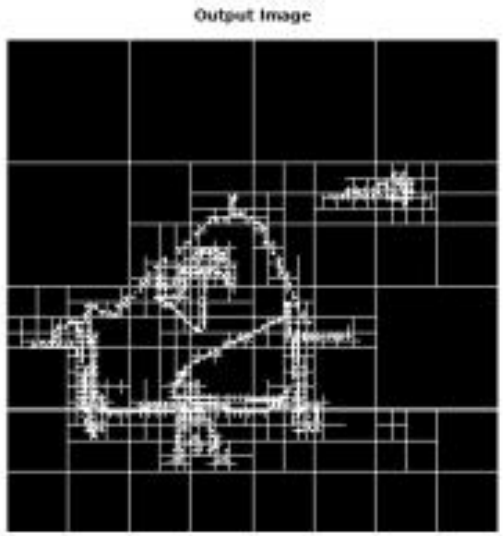


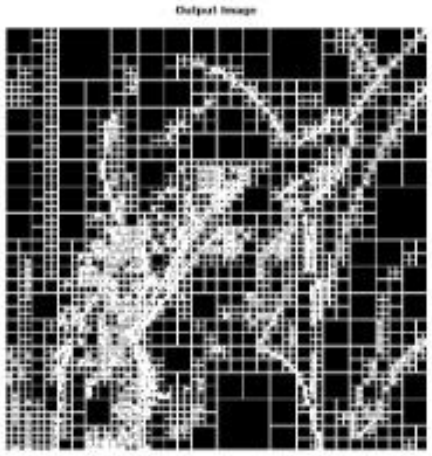
1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	0
3	1	4	9	9	8	1	0
1	1	8	8	8	4	1	0
1	1	6	6	6	3	1	0
1	1	5	6	6	3	1	0
1	1	5	6	6	2	1	0
1	1	1	1	1	1	0	0

Final result

https://nirantak.com/image-processing-region-splitting

Region Splitting and Merging





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