Lecture 4:

Image Segmentation

Introduction to image segmentation

- The purpose of image segmentation is to partition an image into some regions (connected pixels) which are ***similar*** in some property and are ***dissimilar*** with their adjacent pixels.
- Part of the image for which the user would be interested about will depend on the type of application and the type of image acquired.
- The segmentation is based on measurements taken from the image and might be ***graylevel***, ***colour***, ***texture***, ***depth*** or ***motion***

Cont..

- Segmentation plays an important role for higher level image processing.
- Image understanding and contextualization requires different parts of an image be segmented and annotated(labeled).
- **Images Segmentation: Find group of pixels that go together**

Cont..

- Segmentation is the ***compliment*** of edge detection.
  - Edge detection is interested about identifying the ending points of a region, while
  - Segmentation is interested about the inside part of the detected edges.

- Edge Detection
  - **Basic idea:** look for a neighborhood with strong signs of change.
  - **Problems**:
    - *neighborhood size*
    - *how to detect change*

81	82	26	24
82	33	25	25
81	82	26	24

Edge Based Image Segmentation

- There are three basic types of gray-level discontinuities in a digital image: **points**, **lines**, and **edges**
- The most common way to look for discontinuities is to run a mask through the image.
- We say that a point, line, and edge has been detected at the location on which the mask is centered if $R \geq T$,where

$$R = w_1 z_1 + w_2 z_2 + \ldots\ldots + w_9 z_9$$

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

Edge Based Image Segmentation

- Point detection

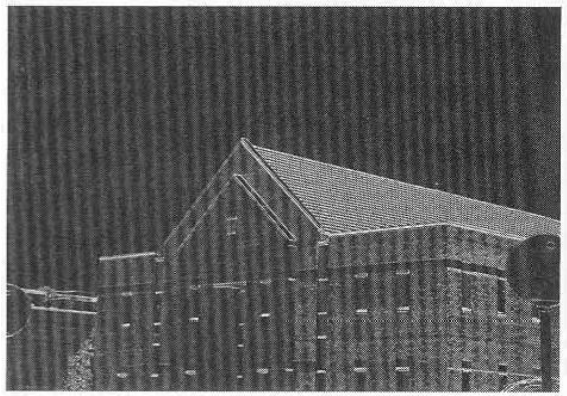
-1	-1	-1
-1	8	-1
-1	-1	-1

a point detection mask

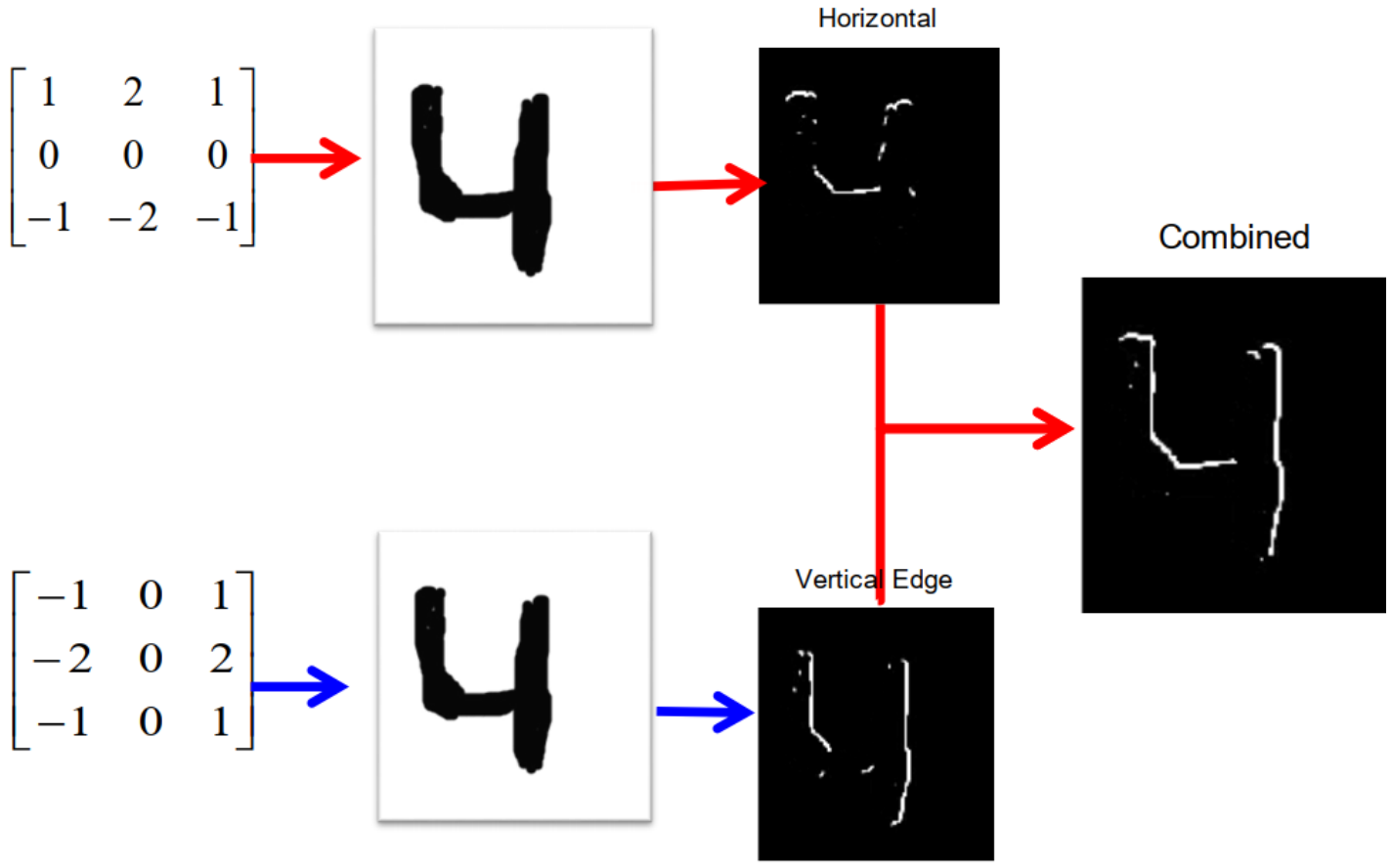
- Line detection

-1	-1	-1
2	2	2
-1	-1	-1

a line detection mask



Edge Detection Example:



More Line Detection

Horizontal Line

-1	-1	-1
2	2	2
-1	-1	-1

45 degree inclined Line

-1	-1	2
-1	2	-1
2	-1	-1

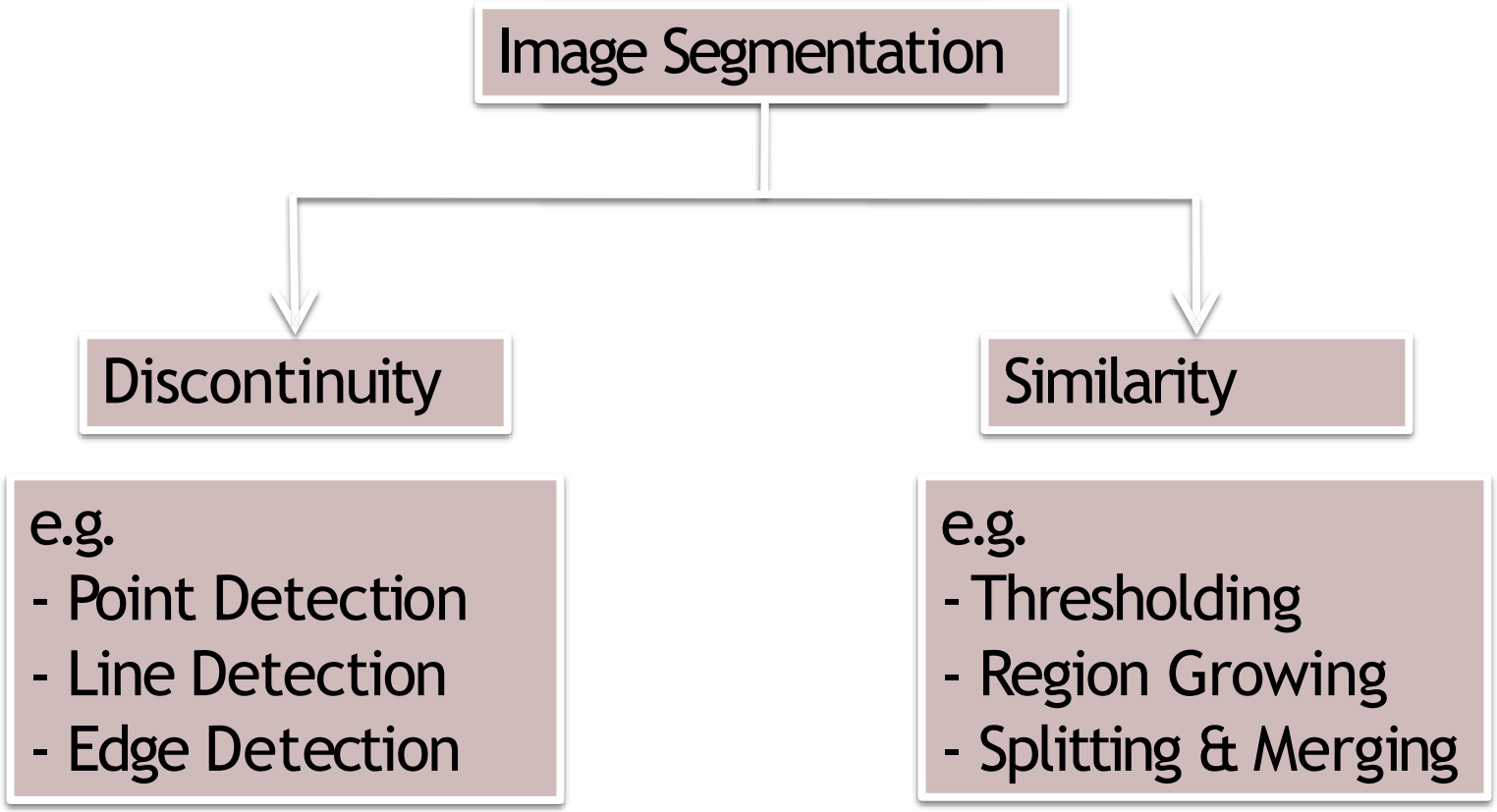
Vertical Line

-1	2	-1
-1	2	-1
-1	2	-1

-45 degree inclined Line

2	-1	-1
-1	2	-1
-1	-1	2

Segmentation techniques

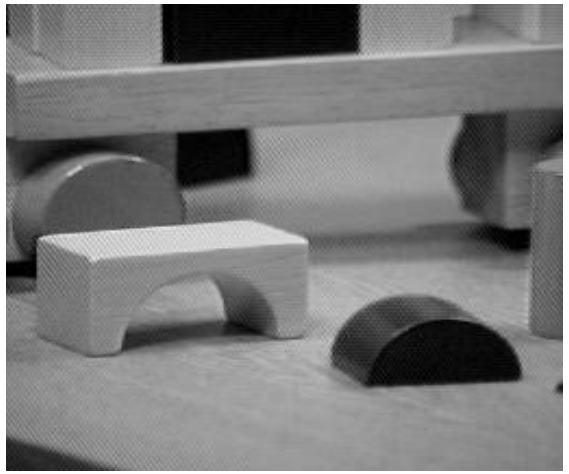


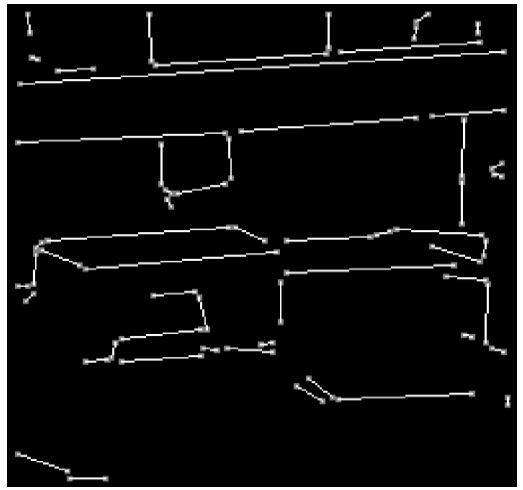
Overview of Image Segmentation

- Image segmentation is the operation of ***partitioning*** an image into a collection of connected sets of pixels.
- The segmentation might be at:
  1. Region Level: which usually cover the image
  2. Linear structures: such as
     - Line segments
     - Curve segments
  3. 2D shapes: such as
     - Circles
     - Ellipses

Examples

Region



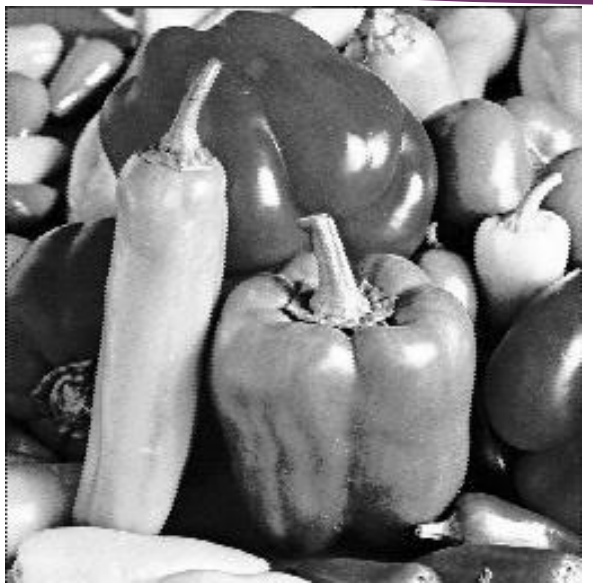


Straight Line

Examples

Lines and Circular Arcs

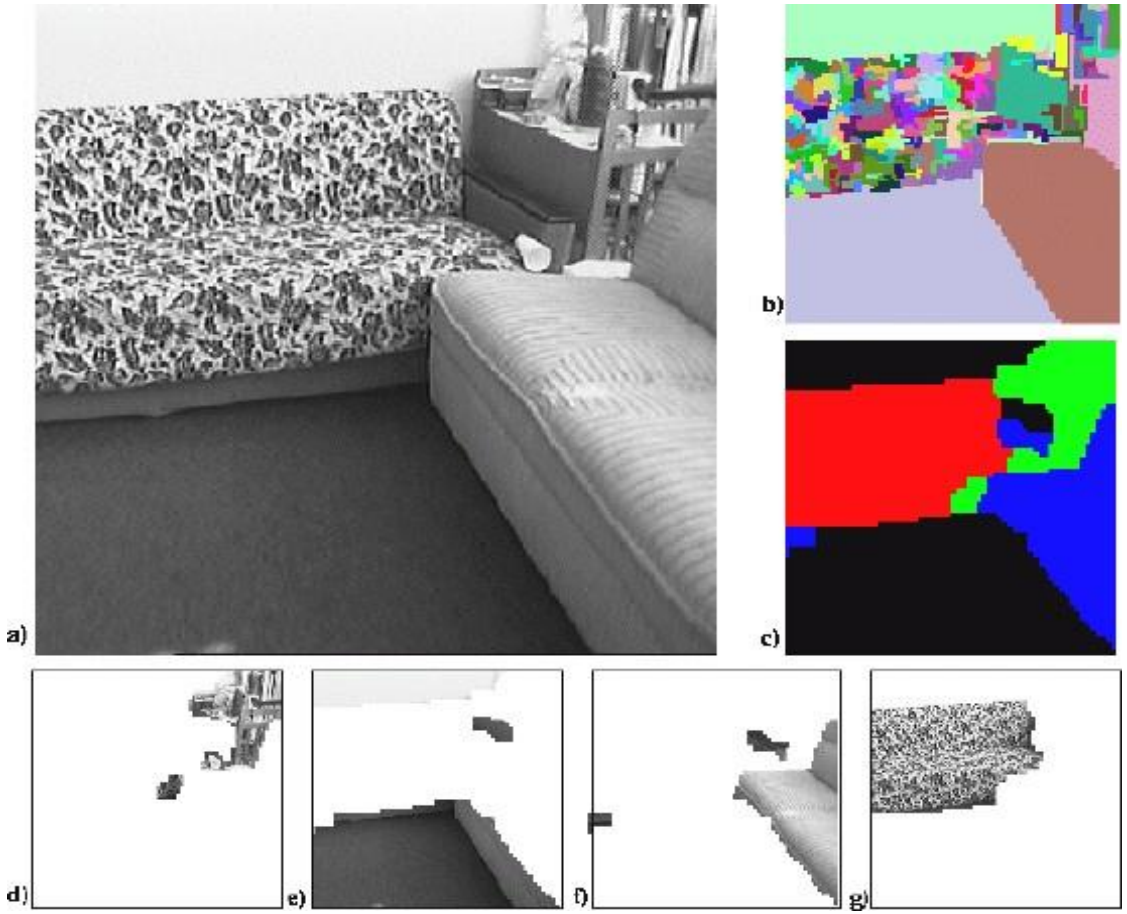
Overview of Image Segmentation



- Segmentation based on **graylevel**: object surfaces with varying different intensity of graylevel are segmented.
- General assumption: area of an object might have similar intensity (not always true).

Overview of Image Segmentation

Segmentation based on **texture**: object surfaces with varying patterns of gray to be segmented



Detection of Discontinuities Gradient Operators

Roberts cross-gradient operators →

−1	0	0	−1
0	1	1	0

Roberts

Prewitt operators →

−1	−1	−1	−1	0	1
0	0	0	−1	0	1
1	1	1	−1	0	1

Prewitt

Sobel operators →

−1	−2	−1	−1	0	1
0	0	0	−2	0	2
1	2	1	−1	0	1

Sobel

Region Segmentation

Methods of Region Segmentation

1. ***Region Growing***
   - Region growing techniques start with one pixel of a potential region and try to grow it by adding adjacent pixels till the pixels being compared are too dissimilar
2. ***Clustering***
   - For some clusters, assign each pixel to the existing clusters by considering the distance of the pixel from each cluster centroids.
3. ***Split and Merge***
   - Start with the whole image and if the variance between adjacent pixels is too high, break into quadrants. Merge any adjacent regions that are similar enough (less variance).

Region Growing

- Region growing techniques start with one pixel of a potential region and try to grow it by adding adjacent pixels till the pixels being compared are too dissimilar.
- The first pixel selected can be just the first unlabeled pixel in the image or a set of seed pixels can be chosen from the image.
- Usually a statistical test is used to decide which pixels can be added to a region.

Region-based segmentation

- **Advantage**:
  - Works well for regions with good connectivity
  - Simple formulation
- **Disadvantage**:
  - Selecting the initial seed-points:
    - different sets of initial seed-point cause different segmented result
  - Process is time-consuming

Region-based segmentation

- Region growing: grow a group of pixels or sub-region into larger regions.
  - **Step1:**
    - Start with a set of "seed" points from the image and from these points grow regions by appending to each seed those neighboring pixels that have properties similar to the seed.
  - **Step2:**
    - Region splitting and merging

Region-based segmentation

- **Fast Scanning Algorithm:**
  - Start the scanning from the first pixel of the image.
  - Tag each pixels to an intensity level which is created by discretization of the actual range of intensities based on closeness.
  - The number of clusters of pixels would not be decided before image passing through them.

255	250	254	80	150	149	152	150
250	82	81	85	88	149	151	149
84	85	82	84	89	188	193	152
79	81	83	80	79	195	191	155
81	83	123	121	123	120	122	124
40	85	120	125	120	230	235	229

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Cont..

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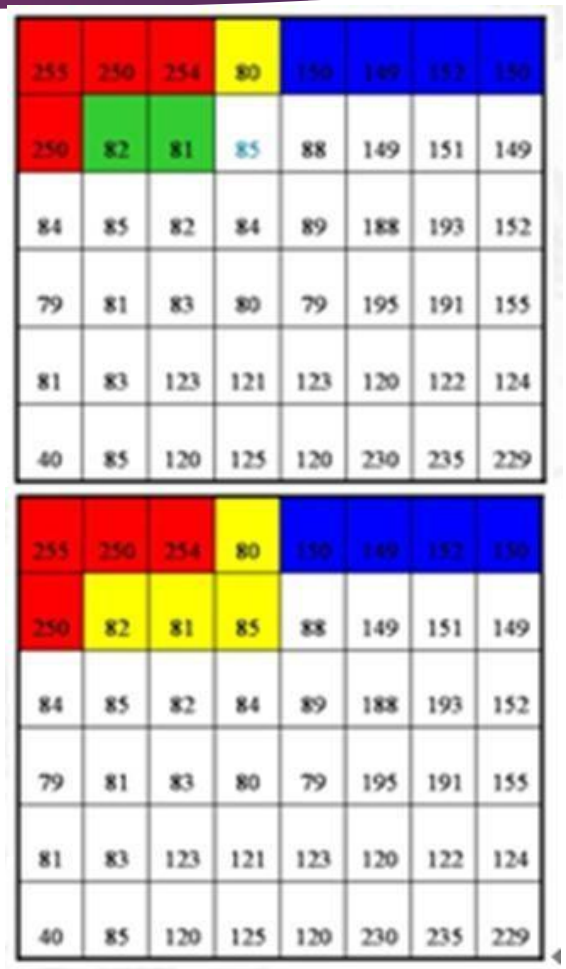

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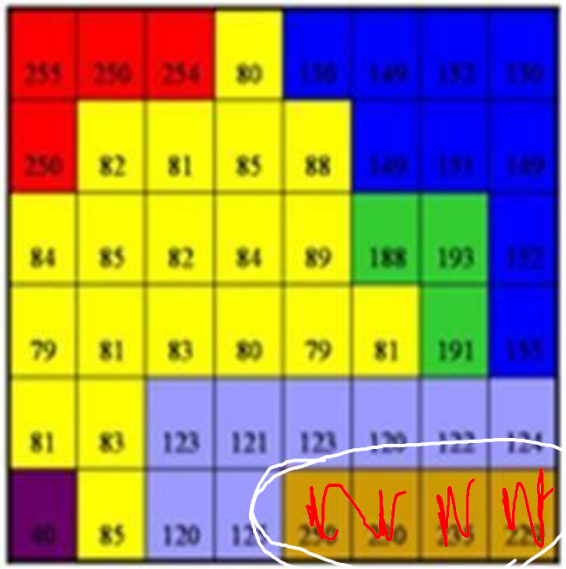
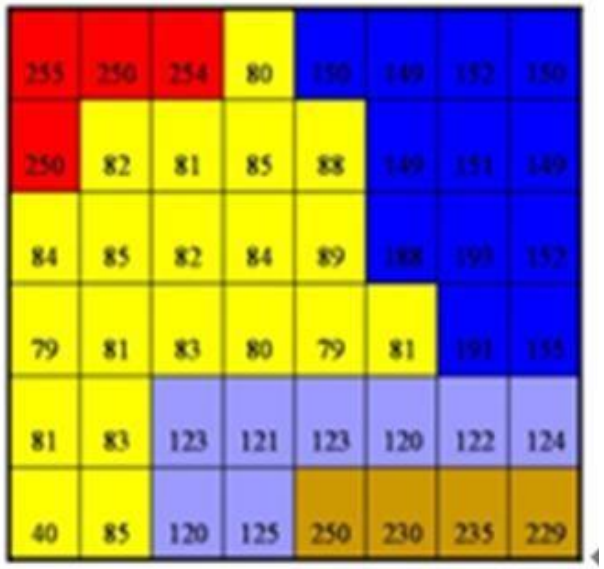
Region-based segmentation

- **Last step:**
  - After all pixels are tagged, merge small region to the nearby bigger region
  - This might help to identify color intensity created abnormally or noisy pixels.





Region-based segmentation

- ***Advantage***:
  - The speed is very fast
  - The result of segmentation will be intact with good connectivity as it considers intensity similarity.
- ***Disadvantage***:
  - The matching of physical object is not good
    - It can be improved by morphology and geometric mathematics

Region Splitting and Merging

- Region splitting is the opposite of region growing.
  - First there is a large region (possible the entire image).
  - Then, a predicate (measurement) is used to determine if the region is uniform…… one can take **least-square-error** measure
  - If not, then the method requires that the region be split into two or more regions.
  - Then each of these regions is independently tested by the predicate (measurement of variation or similarity like least square error).
  - This procedure continues until all resulting regions are relatively uniform.

Region Splitting and Merging

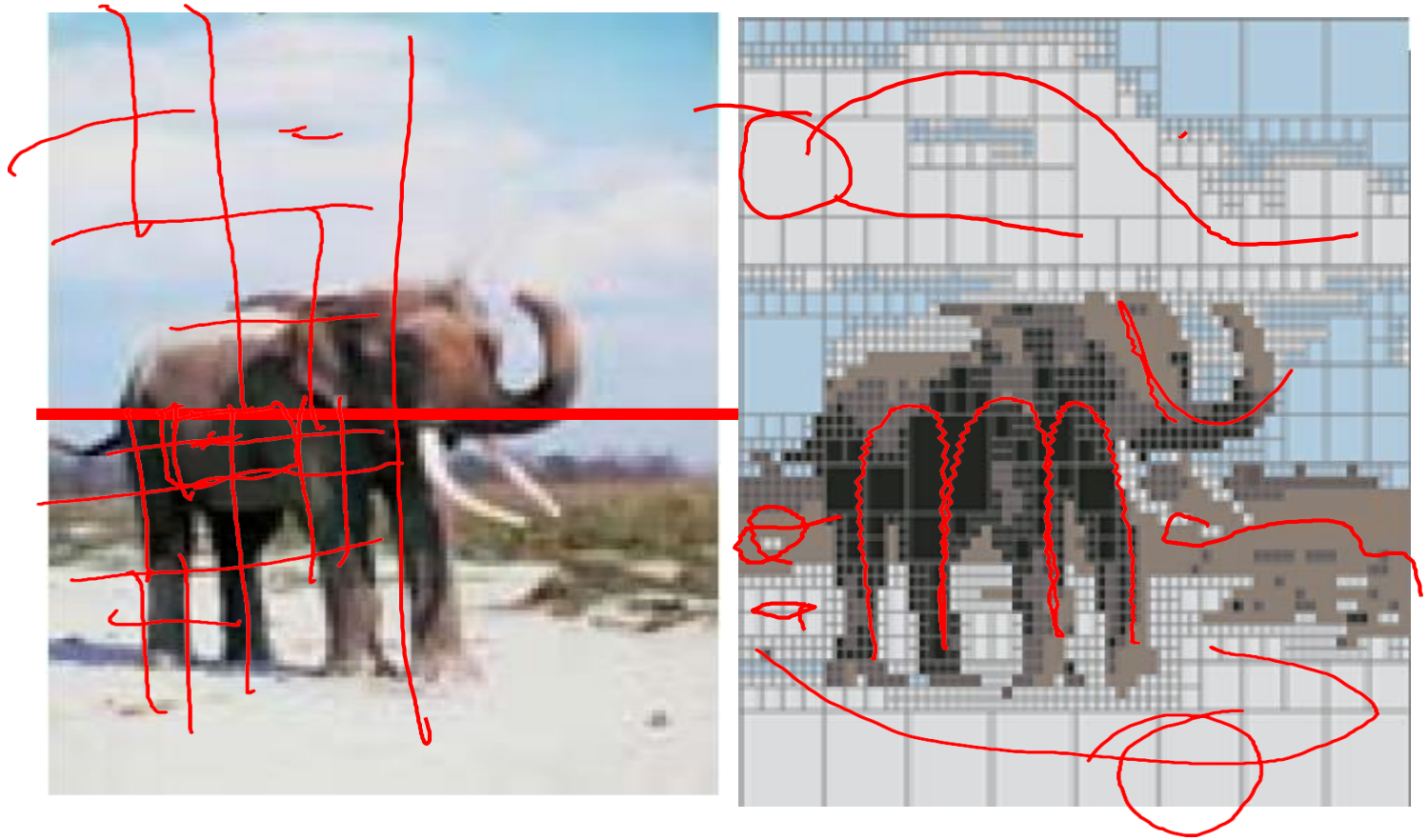
General Procedure

1. Start with the whole image.
2. If the variance is too high, break into quadrants.
3. Merge any adjacent regions that are similar enough.
4. Repeat steps 2 and 3, iteratively until no more splitting or merging occur.

Method: Split-and-Merge is based on simple idea and can iteratively break a larger block into smaller one or combine (merge) smaller blocks into one.

Limitation: Final result is in a form of blocks. Not natural object shape (not every thing is block like)

Split-and-merge



The End