German University in Cairo

Winter 2019

DMET 901 – Computer Vision

Image Segmentation

Seif Eldawlatly

Image Segmentation

- Image segmentation is the first step in image understanding
- The goal of segmentation is to group together pixels similar in some important way and distinguish groups of pixels that are different
- Image segmentation is the association of a segment label with each pixel
- Example

40	50	60	0	0
50	50	40	0	0
0	0	0	0	0
0	0	0	50	80
0	0	0	60	40

Original Image

1	1	1	0	0
1	1	1	0	0
0	0	0	0	0
0	0	0	2	2
0	0	0	2	2

Segmented Image

Image Segmentation

- Different approaches to image segmentation
    - Threshold-based segmentation
    - Region-based segmentation

Threshold-based Segmentation

- Basic Thresholding Algorithm
  1. Consider each pixel $f(i, j)$
  2. If $f(i, j) > T$, then pixel (i, j) is an object pixel, otherwise, it is a background pixel

- Other variations for the basic algorithm
  - Position-dependent Thresholding

    $T = T(f, f_c)$ where f_c is part of the image for which threshold is selected

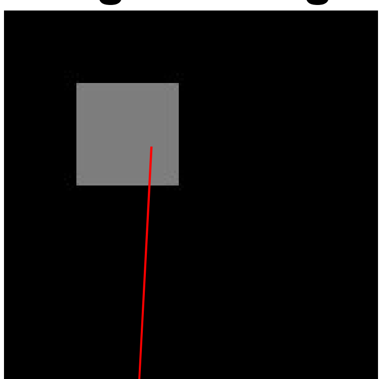
  - Band Thresholding

    A pixel (i, j) is considered an object pixel if $f(i, j) \in$ Band

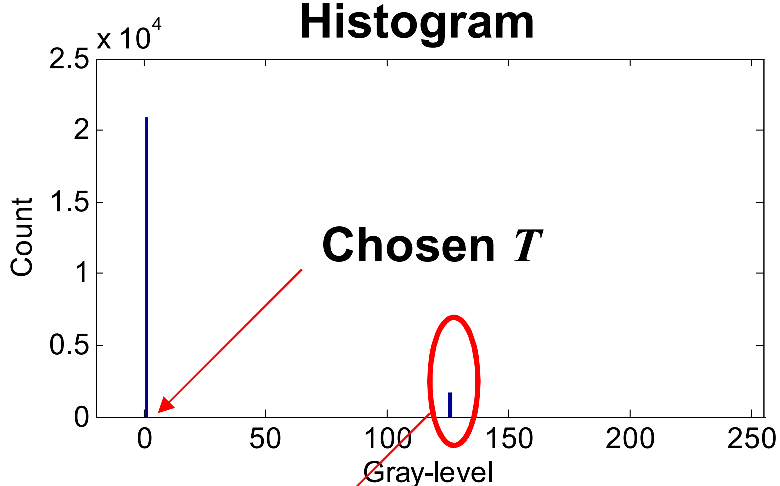
Threshold-based Segmentation

- How to set the threshold?
  - P-tile Thresholding:
    - Used if apriori information is known about the ratio between object area and image area. (e.g: 1/p)
    - From image histogram, choose T such that 1/p of image pixels have gray levels larger than T

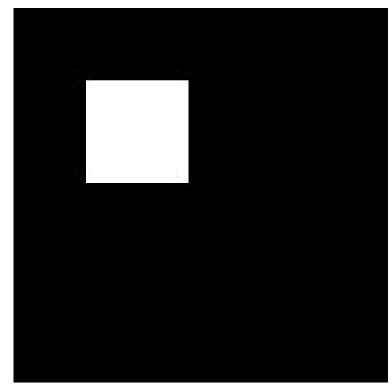
Original Image



Histogram



Segmented Image



Object Size = 7.5%

7.5% of the pixels

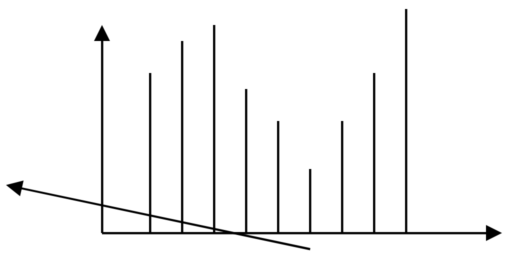
- Usually such information about the size of the object is not available beforehand

Threshold-based Segmentation

- How to set the threshold?
  - Histogram Shape-based:
    - Choose T as the minimum histogram value between 2 maxima if the histogram is bimodal

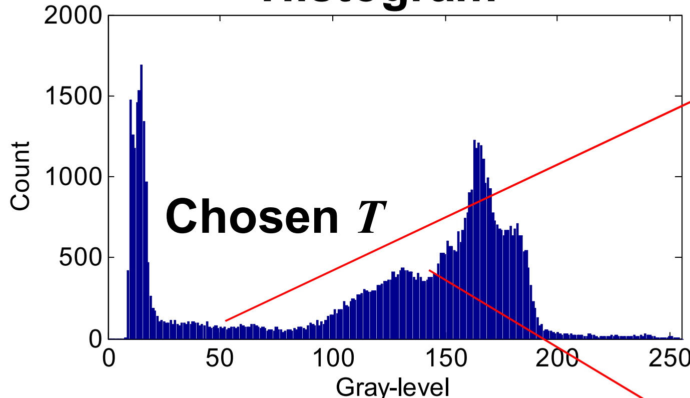
Segmented Image

Chosen T



Original Image

Histogram

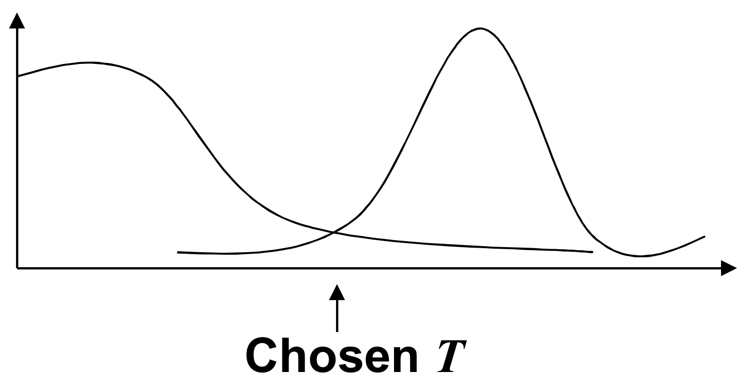


Chosen T

Threshold-based Segmentation

- How to set the threshold?
  - Optimal Thresholding:

    - Based on the assumption that the image consists of a sum of two distributions. (one for background, the other for objects)



Threshold-based Segmentation

- Optimal Thresholding Algorithm
  1. Consider as a first approximation that the 4 corners of the image contain background pixels and the remainder contains object pixels

  2. At step n, compute μ_B^n and μ_O^n as background mean and objects mean respectively where:

$$\mu_B^n = \frac{\sum_{(i,j)\in B} f(i,j)}{No.of\ background\ \ pixels}$$

$$\mu_O^n = \frac{\sum_{(i,j)\in O} f(i,j)}{No.of\ object\ \ pixels}$$

  3. Let $T_{n+1} = \frac{\mu_B^n + \mu_O^n}{2}$, where T_{n+1} provides a new background-object distinction.

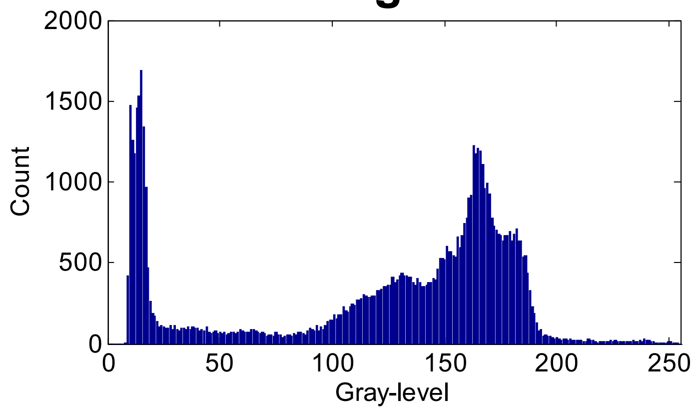
  4. If $T_{n+1} = T_n$, stop; otherwise, go to step 2

Threshold-based Segmentation

- Example

Original Image

Histogram



Optimal $T = 89$

Segmented Image

Region-based Segmentation

- Defines as distinct segments sets of connected pixels whose properties are sufficiently similar to one another and sufficiently dissimilar from neighboring segments

- Similarity or dissimilarity is measured by a **homogeneity criterion** *H* . It may be based on color, gray level, rate of change of gray level, ……

- Split-Merge Segmentation is an example of Region-based segmentation

Split-Merge Segmentation

- It consists of two phases

  Phase 1: To create homogeneous regions

  Phase 2: To group together the homogeneous regions

- Example: Consider the following example where *H* is defined as follows:

  A region is considered homogeneous if the difference between maximum and minimum brightness within it is less than 2

Split-Merge Segmentation

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

Split-Merge Segmentation

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

Split-Merge Segmentation

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

Split-Merge Segmentation

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

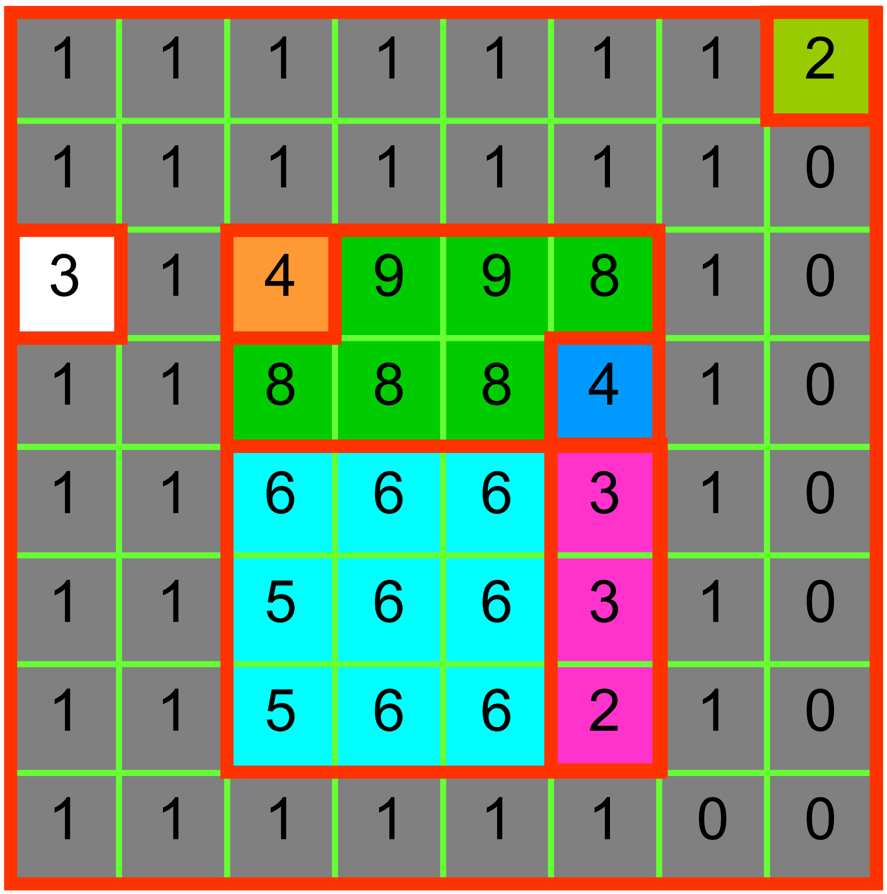
- Third split

Split-Merge Segmentation

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

Split-Merge Segmentation



- Final result