

Region-Based Image Segmentation

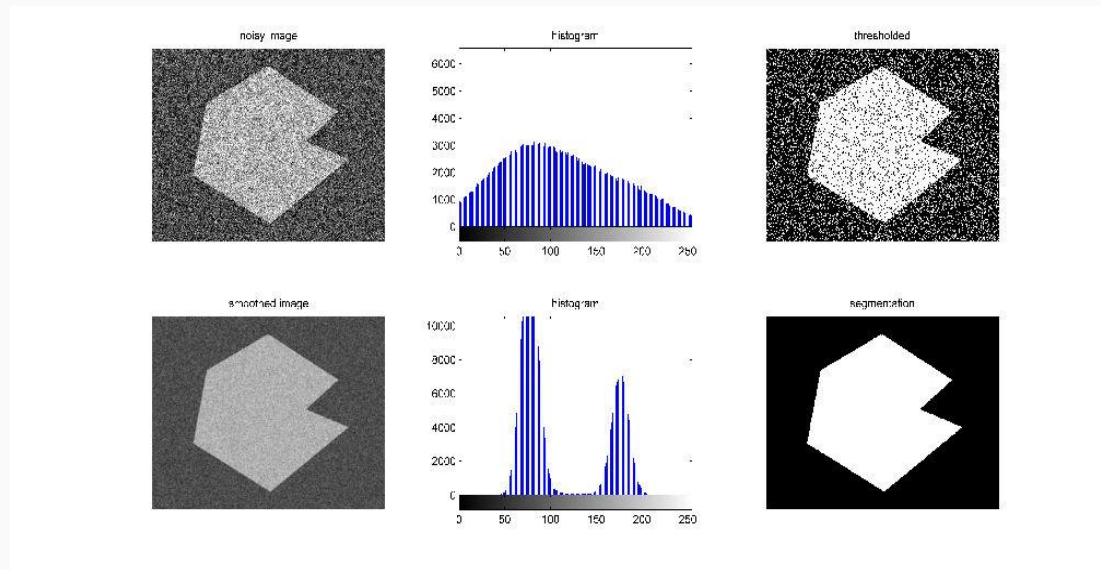
CSC 442 Digital Image Processing
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Overview

- Thresholding
 - Basic Threshold
 - Otsu Threshold
- Pixel Aggregation
 - Seed-fill (Scanline)
 - Size filtering
- Split and Merge
 - Quadtree

Thresholding

- Auto thresholding
- Bimodal Histogram
- Global vs Adaptive Thresholding

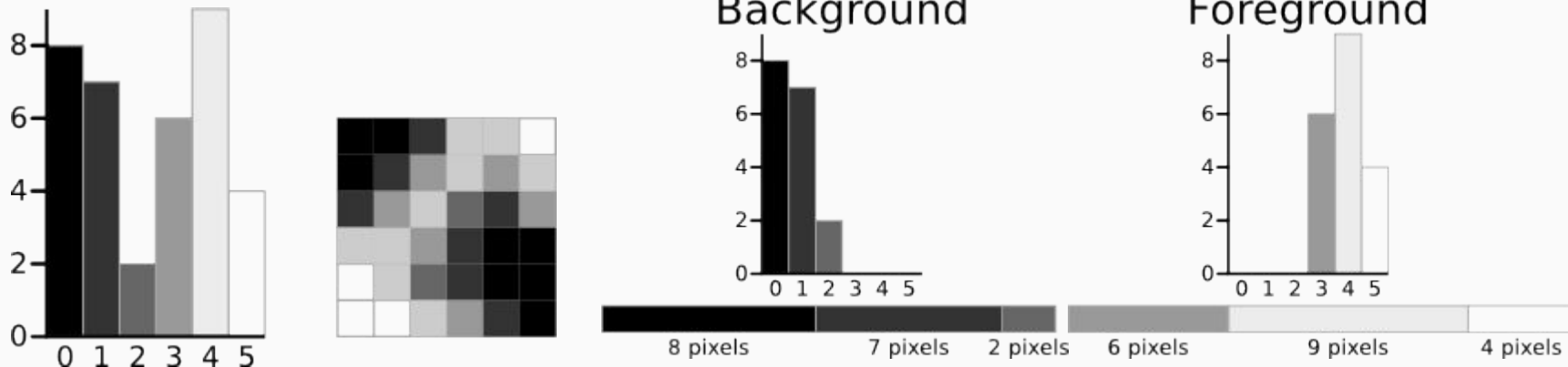


Basic Global Threshold - Algorithm

1. Select initial estimate (global average commonly used)
2. Segment the image into two groups - foreground and background
3. Compute average intensity of each group respectively
4. Compute new threshold with the average of the two averages.
5. Repeat steps 2-4 until threshold change is less than a predefined parameter ΔT

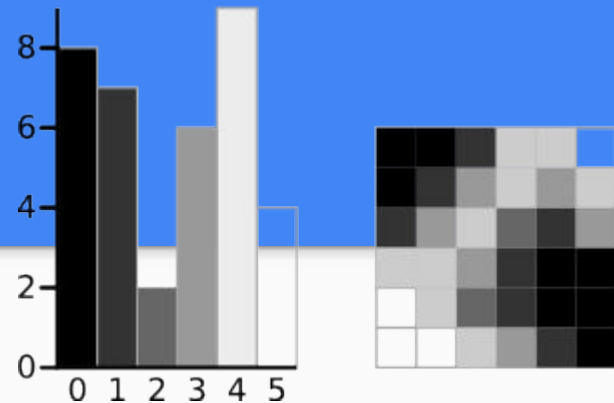
Otsu Threshold

- Splitting an image into foreground and background classes
- Maximizing between class variance

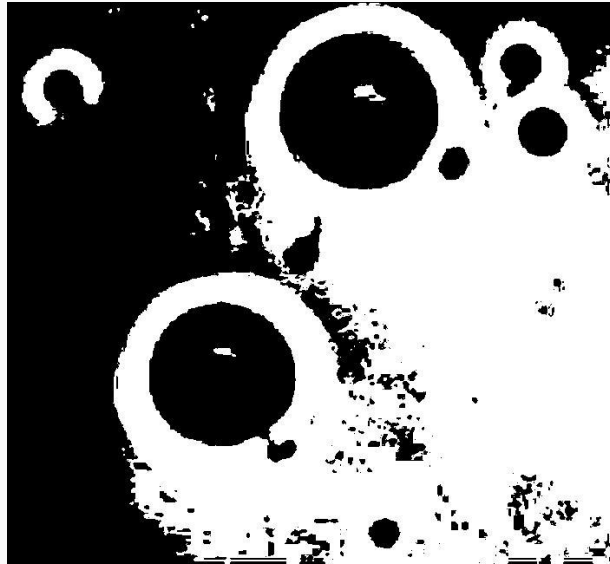
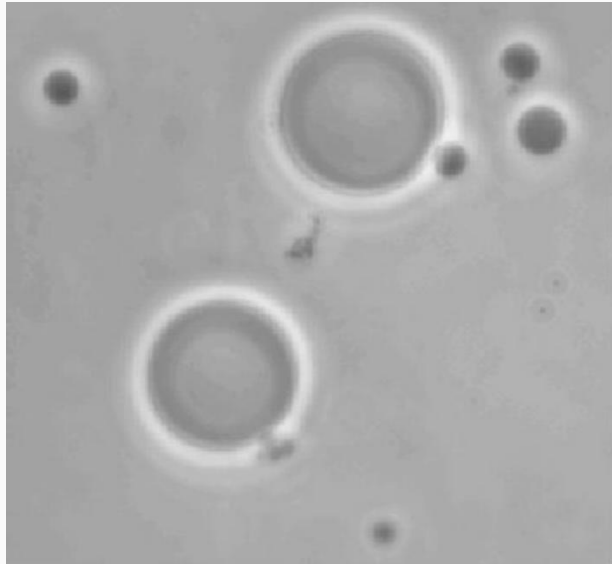
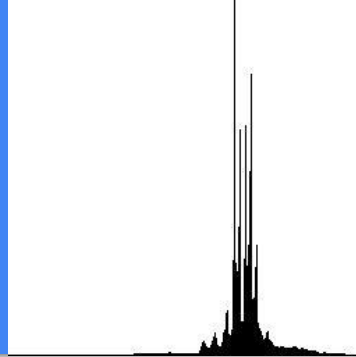


Otsu threshold - Algorithm

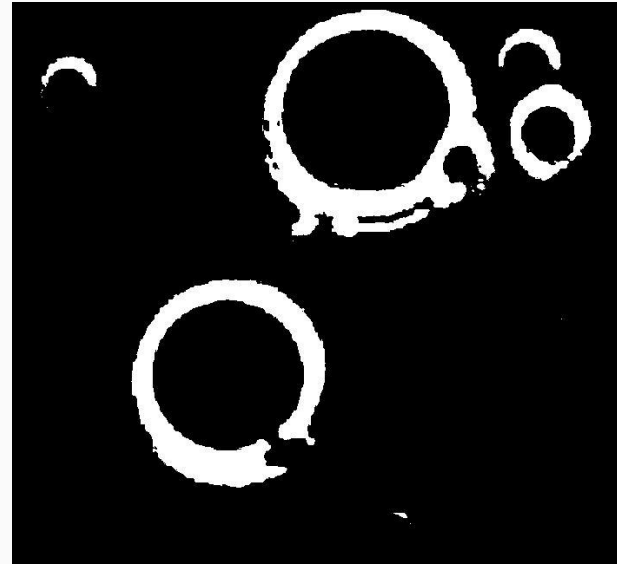
1. Compute histogram
2. For every possible threshold
 - a. Compute cumulative weights by summing the histogram values on both sides of the threshold
 - b. Compute background and foreground means
 - c. Compute between class variance $\sigma_b^2(t) = \omega_0(t)\omega_1(t)[\mu_0(t) - \mu_1(t)]^2$
3. Use threshold value with the highest between class variance



Comparison



Threshold = 173



Threshold = 182

Pixel Aggregation

Region Growing

The process of finding the boundaries of a region based on a given seed point/pixel.

- All pixels inside those boundaries are in the same region.
- This can be automated to split the image into many segments instead of one region.

What is a Region?

An area of pixels that share similar characteristics. Such as gray-scale intensity, colors, or repeating patterns.

Seed fill

The Idea

Grow(find) a region from a single point, the Seed pixel.

Automate finding new seed pixels so every region in the image is found.

Algorithm (Scan-line fill for a single region)

1. Start with the seed pixel. Record the intensity.
2. Begin the row scan, find leftmost and rightmost boundary
 - a. For each pixel inside this row, check to see if it matches the seed pixel.
3. Then recurse upwards and downwards for each pixel in the row, using the initial intensity still.

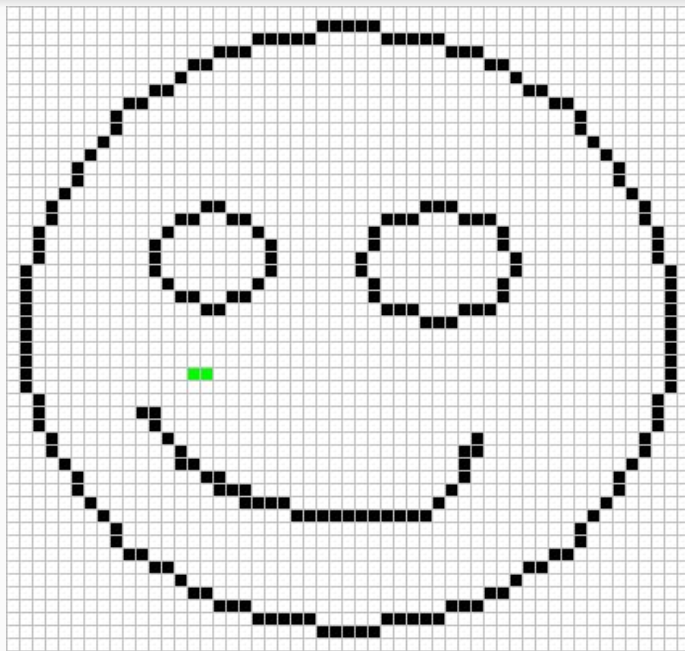
Example scan-line for a row
(Pixel intensities)

82	183	168	175	170	195	172	174
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Initial Pixel: 175

Offset: 10

Seed fill

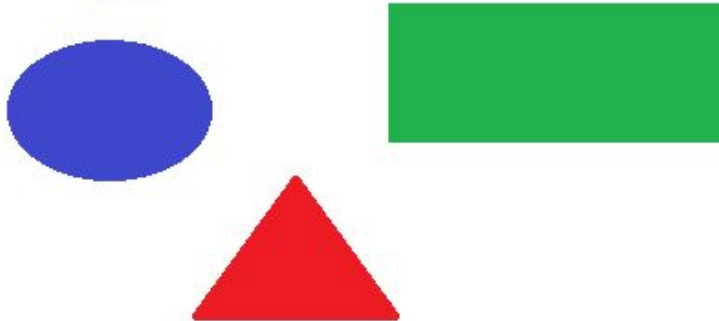


Seed fill

Finding multiple regions

- Use a Label array that is the size of the image. Initialize elements to -1
- Each pixel is assigned its region's label

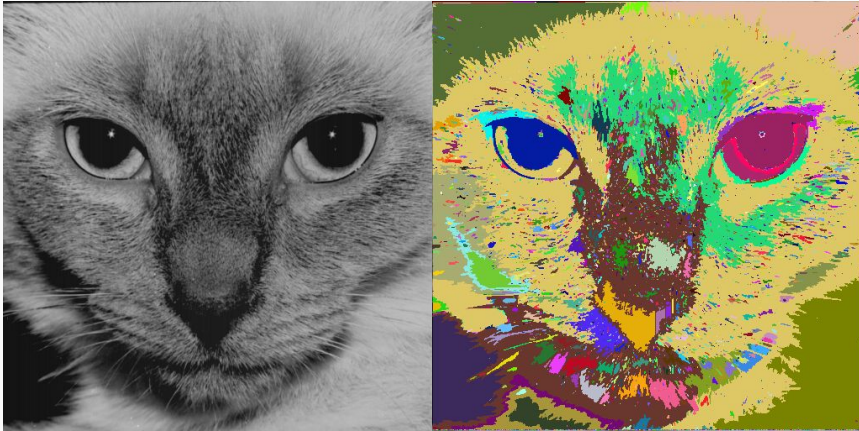
Start at point (0,0). Scan through the image, left to right, top to bottom.
Use the scan-line fill to grow a region when an unlabeled pixel is found.



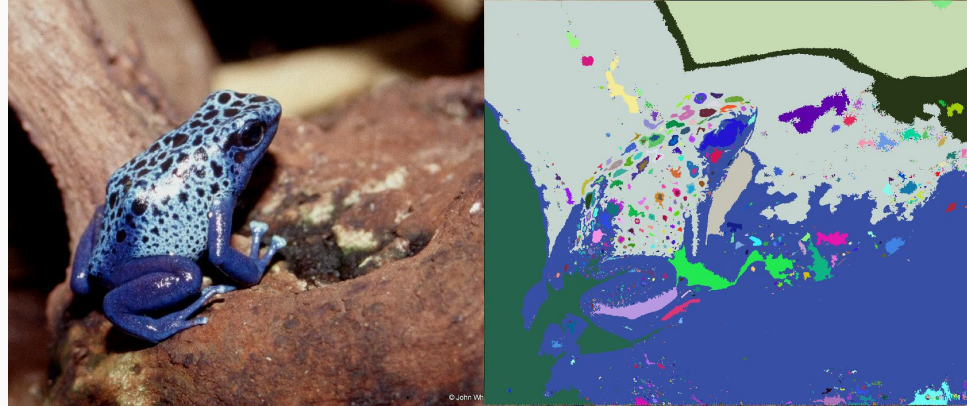
Label Array

0	0	0	0	0	0	0	0
0	0	1	0	0	2	2	2
0	1	1	1	0	2	2	2
0	0	1	0	0	0	0	0
0	0	0	0	3	0	0	0
0	0	0	3	3	3	0	0

Seed fill Examples



Offset: +/- 30



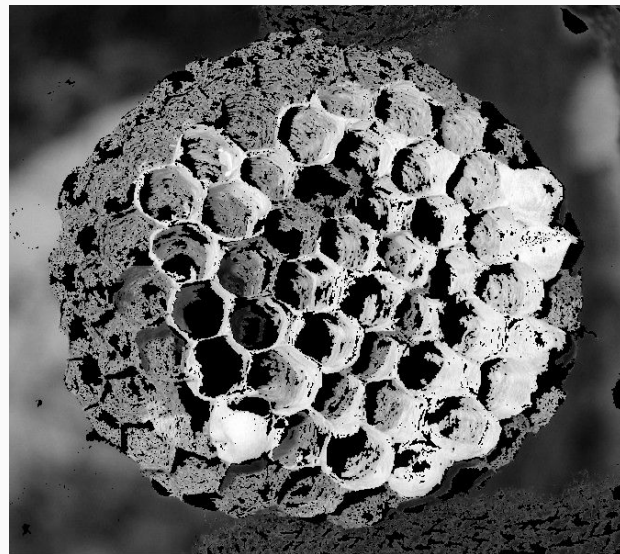
Offset: +/- 70

Size filtering

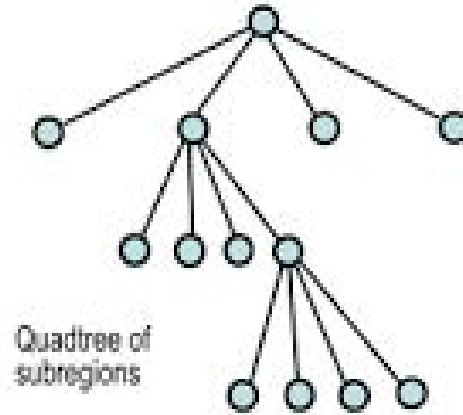
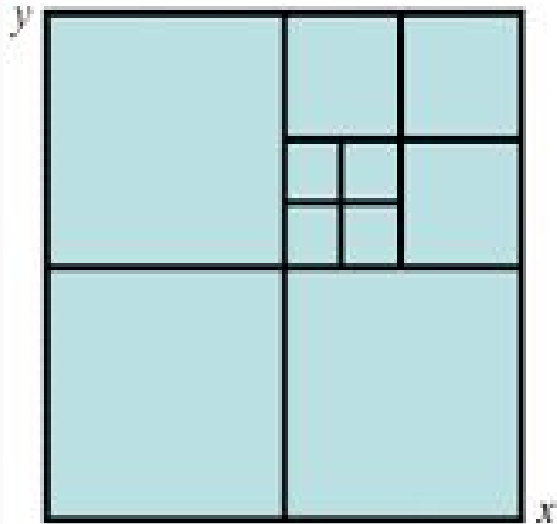
- A way to highlight certain regions by size.
- If a region's area is under a certain threshold, set it to some color.



If,
`region_size < 500`.
Then set region to
black.



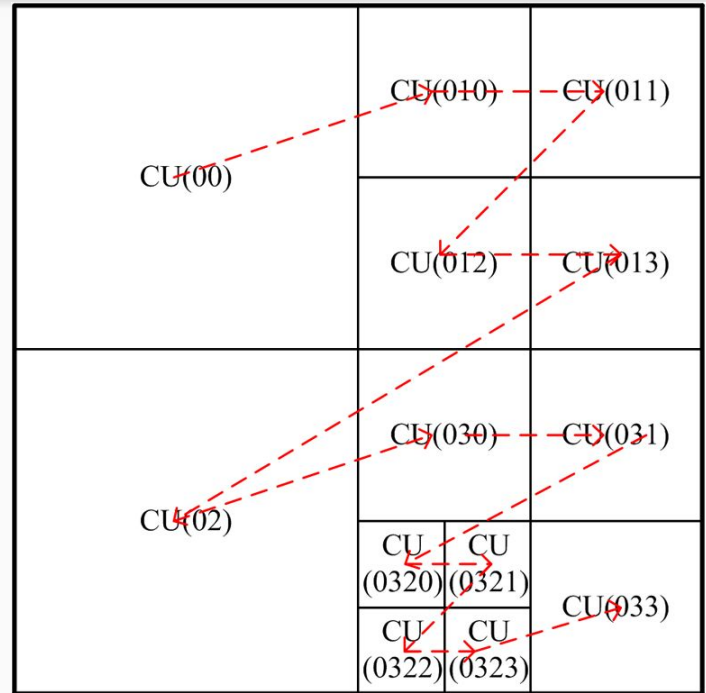
Split and Merge



- Check if region is homogeneous
 - Split if intensity values are outside of the region average \pm delta
- Merge once splitting is complete
 - If average value is within a given delta, the regions gain the same value

Split and Merge - Splitting the Region

- Max, min, and midpoints are calculated for the x and y axis
- 2D array holds the coordinates for the split region
- For loop cycles through the array to check each region
 - If homogeneous, it is counted
 - If nonhomogeneous, it is split further down



Split and Merge - Checking the Region

- Coordinates of the region as well as the image are passed in
- The average is computed for the region
- Is there a pixel intensity outside of the average \pm delta?
 - If no, then the region is homogeneous
 - If yes, then the region is needs to split further

Split and Merge - Merging the Regions

- Check the x and y coordinates
 - Are the regions next to each other?
- If the regions are within a delta value, they get the same intensity
- Once the regions are merged, the list is looped through to update the image

Split and Merge - Results



Original Image



Delta = 5



Delta = 30

Demo