

# Image Segmentation

Image Processing

CSE 166

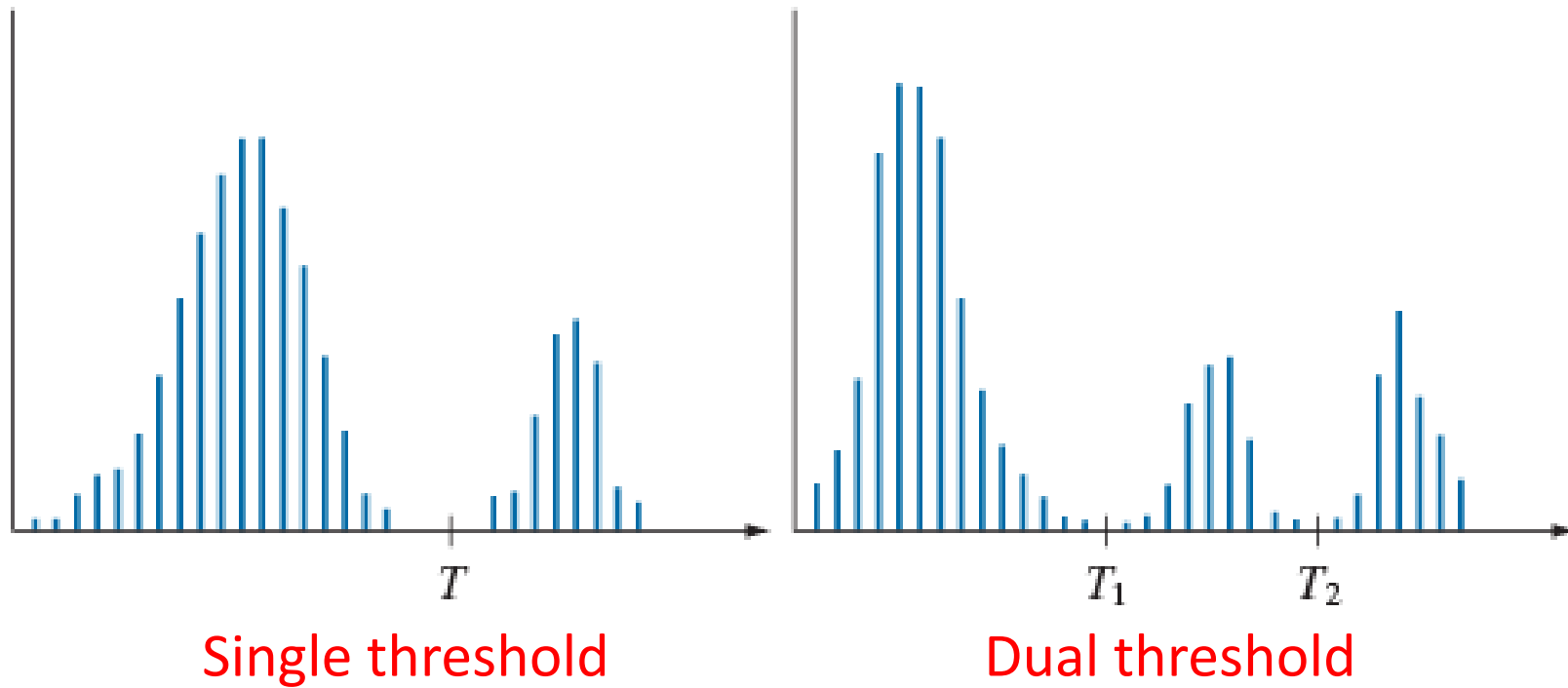
Lecture 17

# Reading

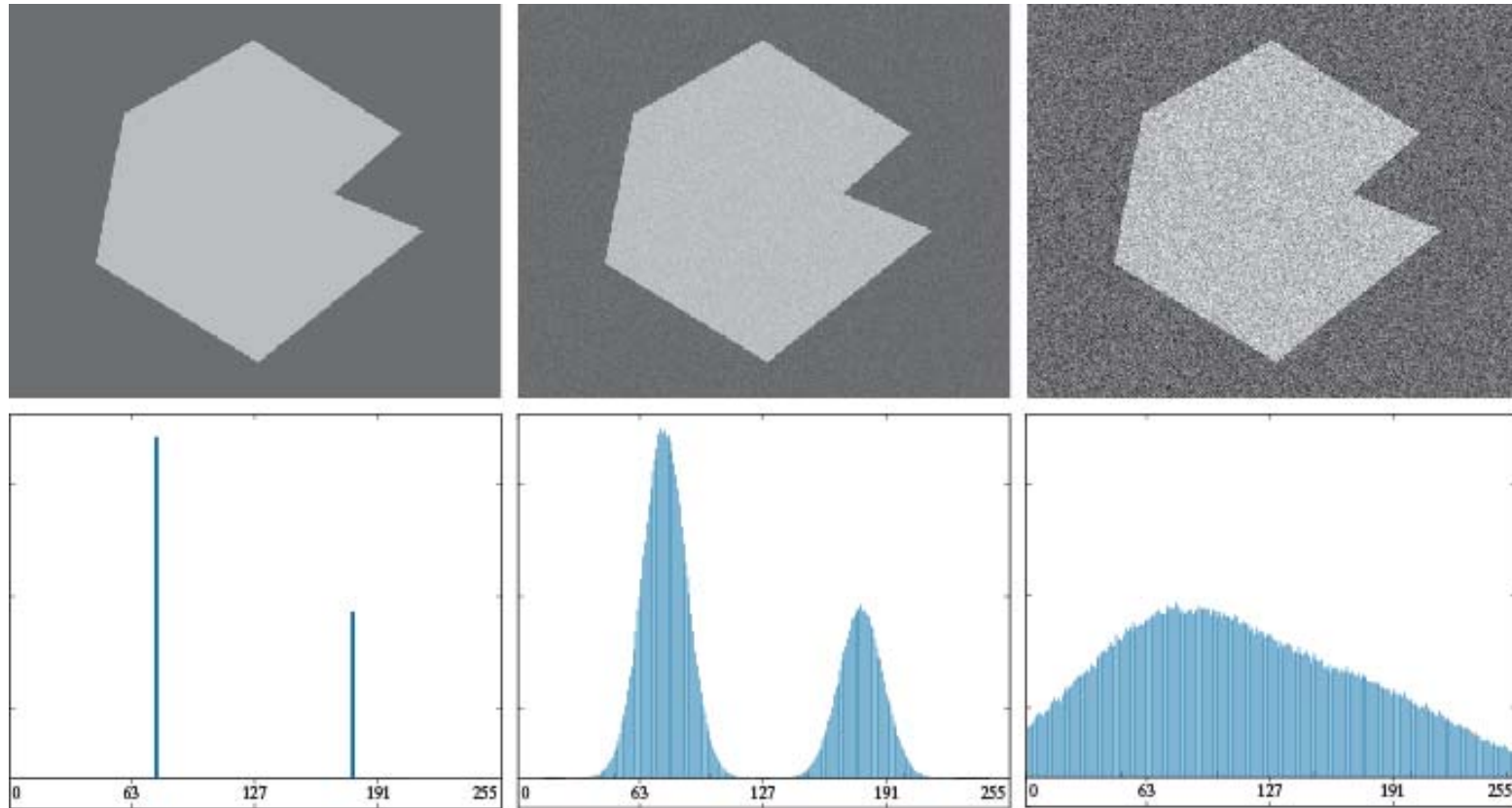
- Digital Image Processing, 4th edition
  - Chapter 10: Image segmentation I: edge detection, thresholding, and region detection

# Thresholding

## Histograms

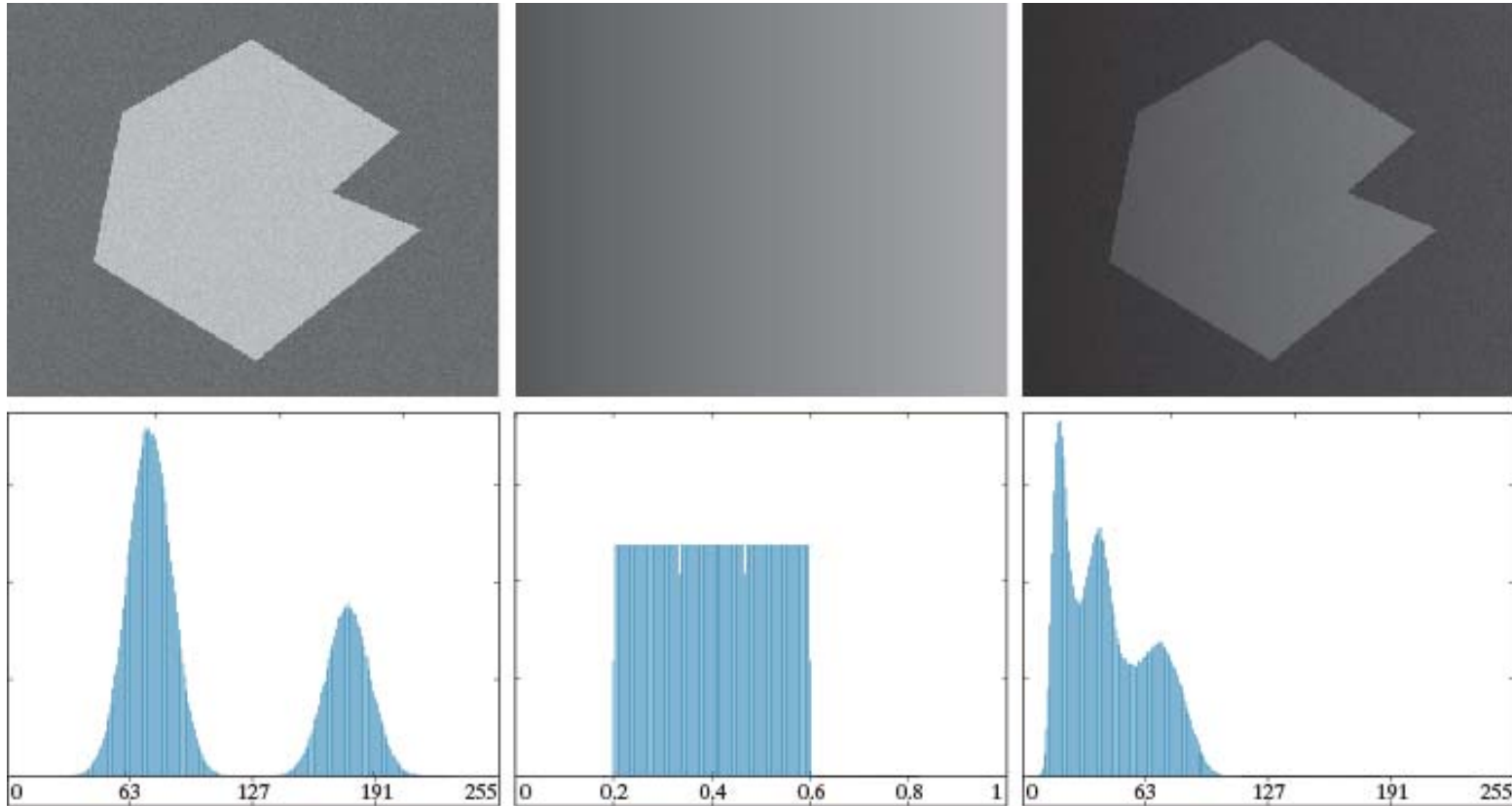


# Noise and thresholding



Noise

# Varying background and thresholding



Input

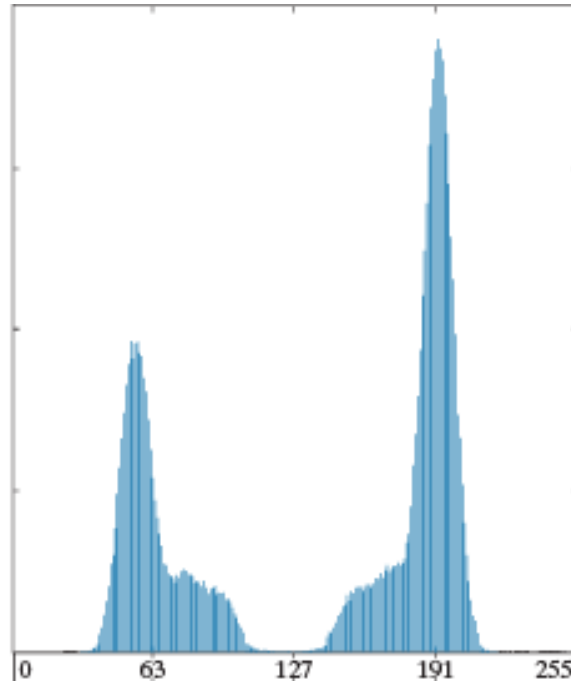
Intensity ramp

Product of input  
and intensity ramp

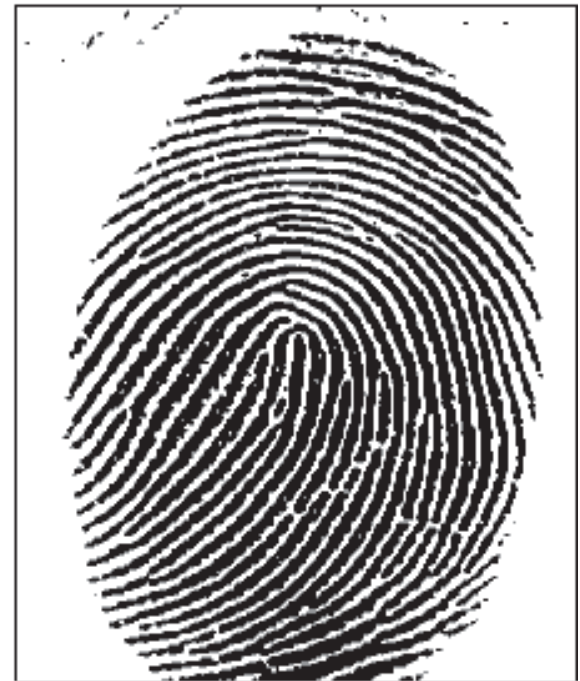
# Basic global thresholding



Input



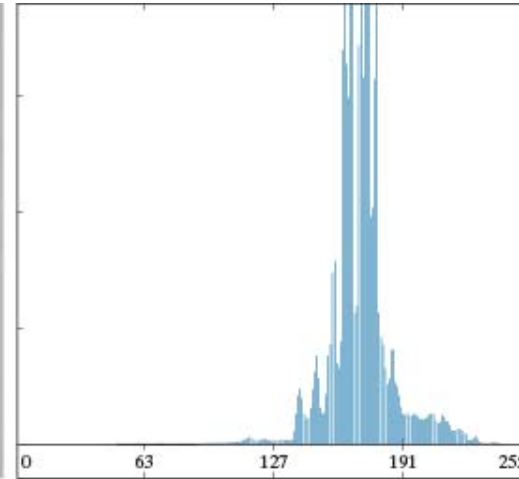
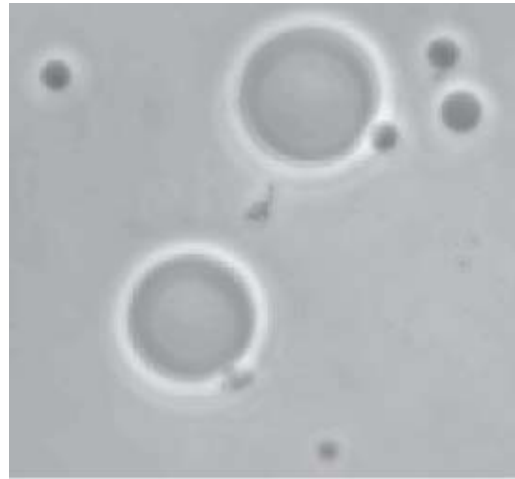
Intensity ramp



Threshold

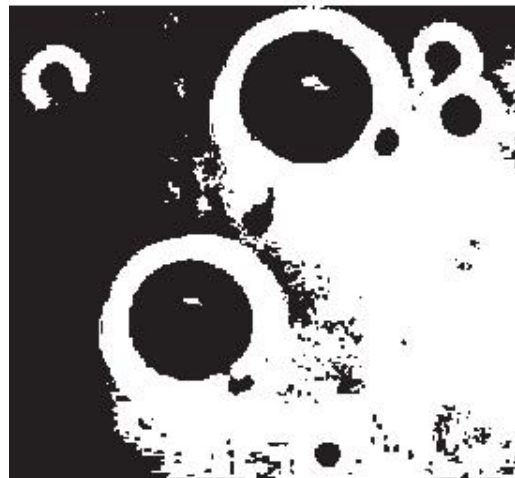
# Optimum global thresholding

Input



Histogram

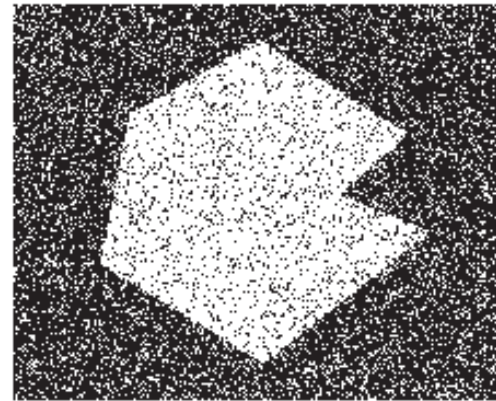
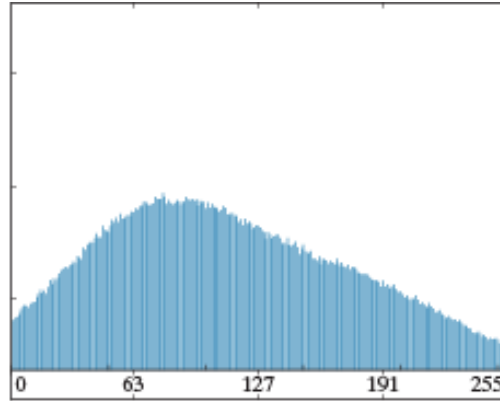
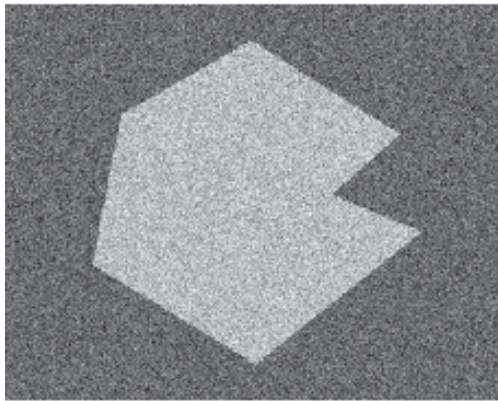
Basic global thresholding



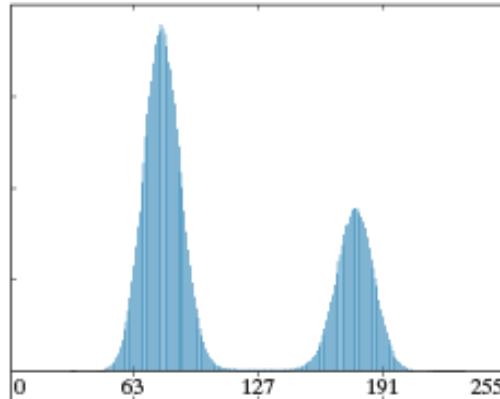
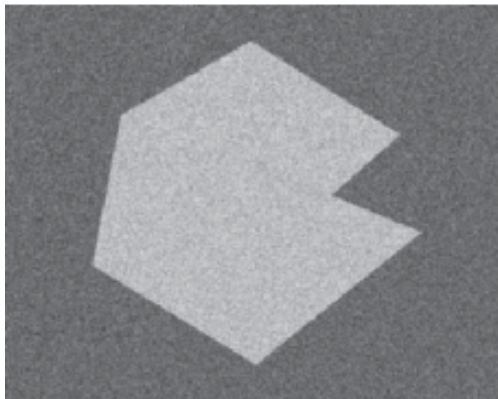
Optimum global thresholding using Otsu's method

# Image smoothing to improve global thresholding

Otsu's method



Without smoothing

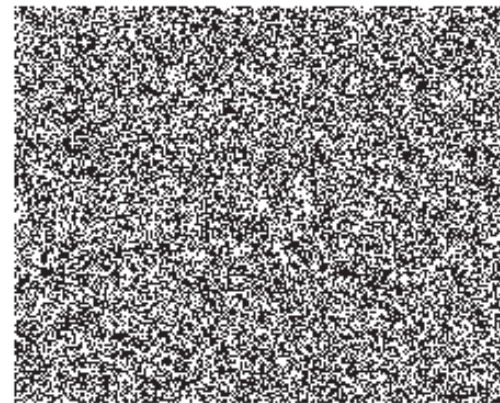
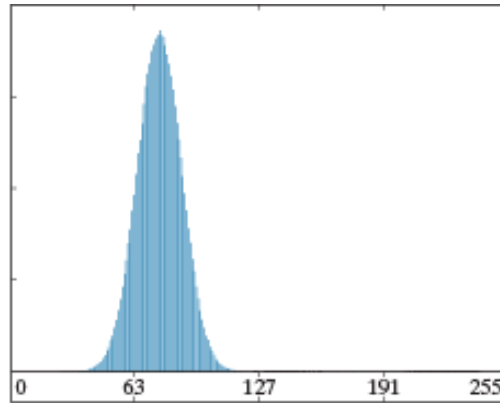
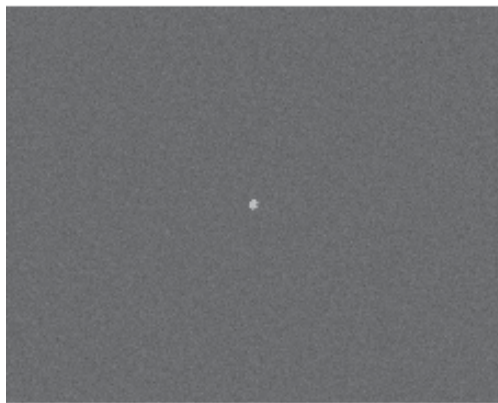


With smoothing

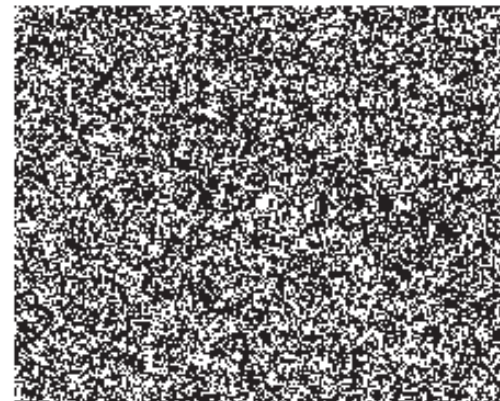
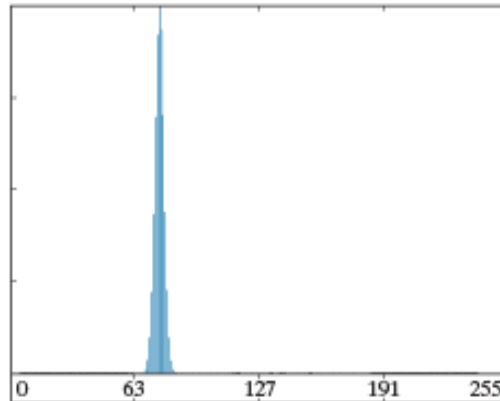


# Image smoothing does not always improve global thresholding

Otsu's method



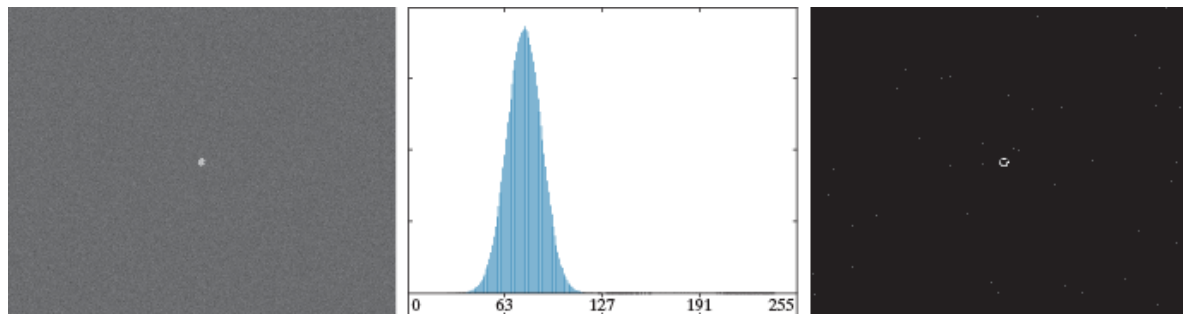
Without smoothing



With smoothing

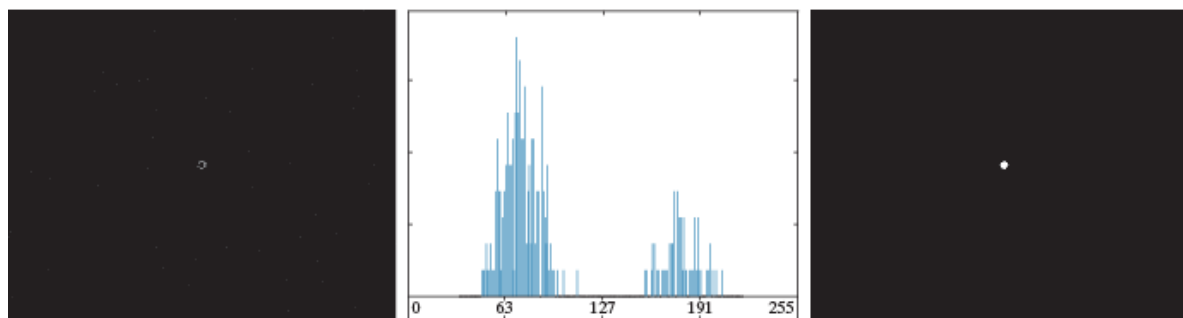
# Edges to improve global thresholding

Input



Mask image  
(thresholded  
gradient  
magnitude)

Masked  
input

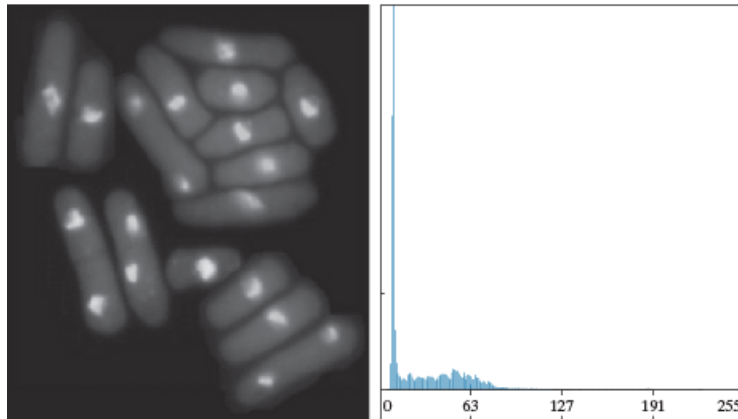


Optimum  
global  
thresholding  
using Otsu's  
method

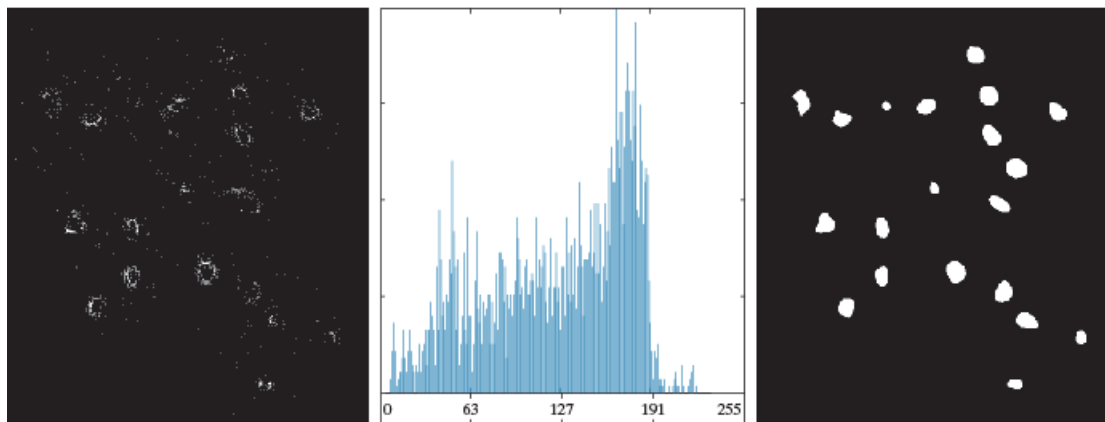
# Edges to improve global thresholding

Mask image (thresholded absolute Laplacian)

Input



Masked input



Optimum  
global  
thresholding  
using Otsu's  
method

# Variable thresholding

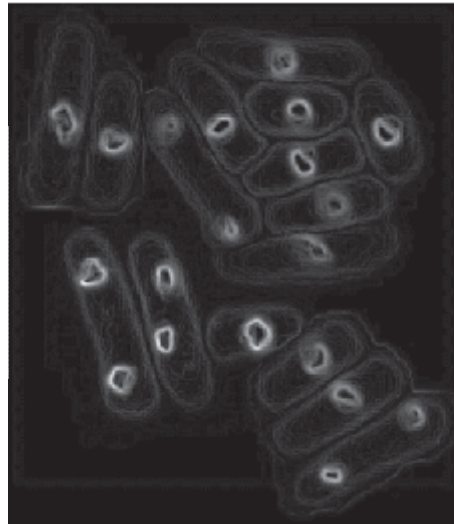
Input



Global  
thresholding



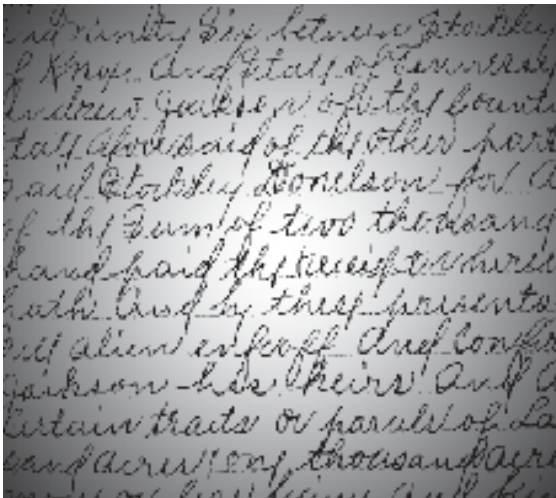
Local  
standard  
deviations



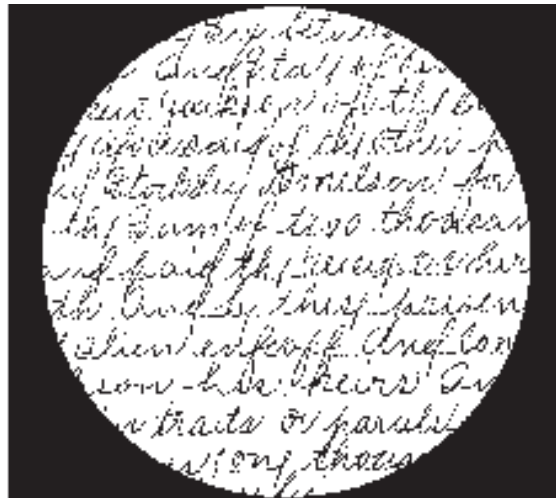
Local  
thresholding  
using  
standard  
deviations



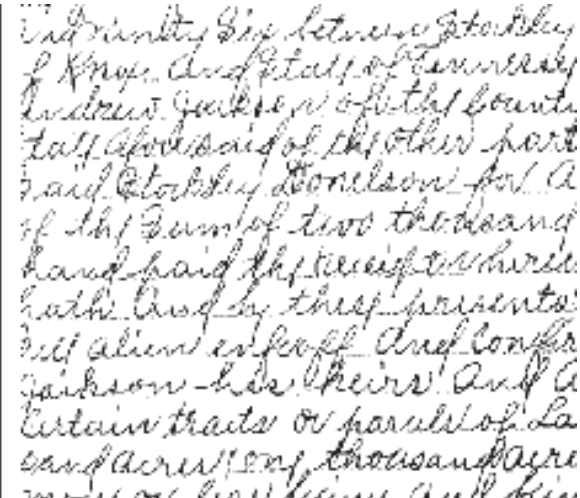
# Variable thresholding



Input  
(spot shading)

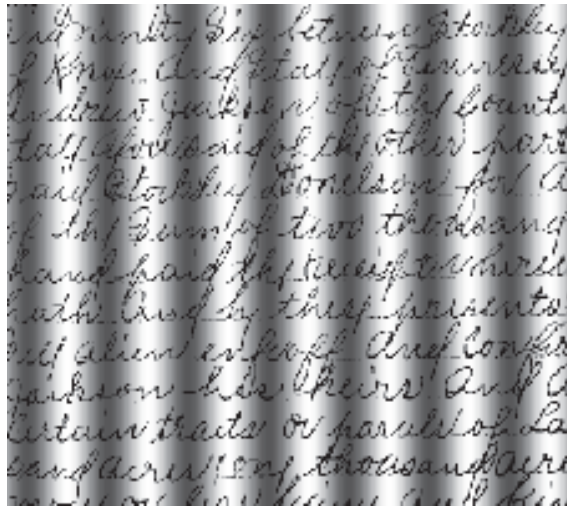


Global  
thresholding



Local  
thresholding  
using moving  
averages

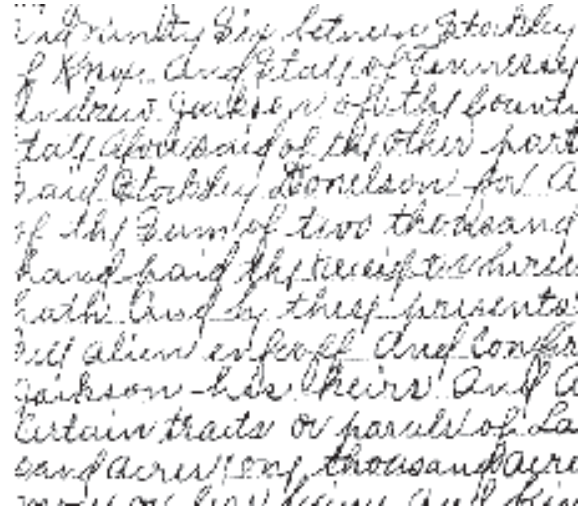
# Variable thresholding



**Input**  
(sinusoidal shading)



**Global**  
thresholding

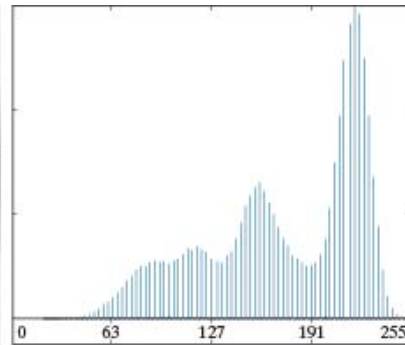
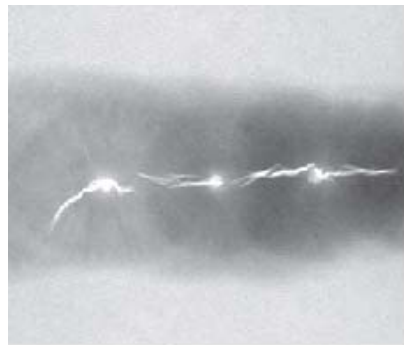


**Local**  
thresholding  
using moving  
averages



# Segmentation by region growing

Input  
X-ray  
image



Initial  
seed  
image



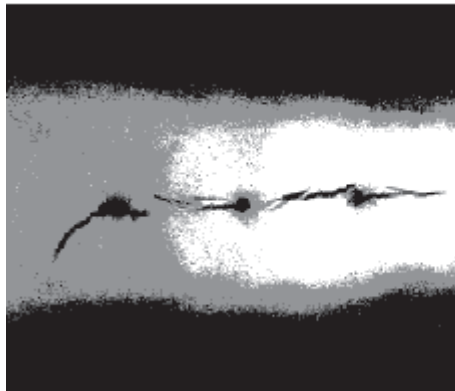
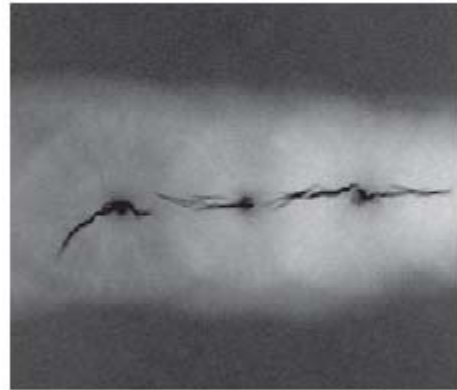
Final  
seed  
image



Output  
image

# Segmentation by region growing

Difference  
image



Difference image  
thresholded using  
dual thresholds



Difference image  
thresholded with the  
smallest of the dual  
thresholds



Segmentation by  
region growing



# Advanced segmentation methods

- *k*-means clustering
- Superpixels
- Graph cuts

# Segmentation using *k*-means clustering



Input

Segmentation using  
*k*-means,  $k = 3$

# Superpixels



Input image of  
480,000 pixels



Image of 4,000  
superpixels with  
boundaries



Image of 4,000  
superpixels

# Superpixels



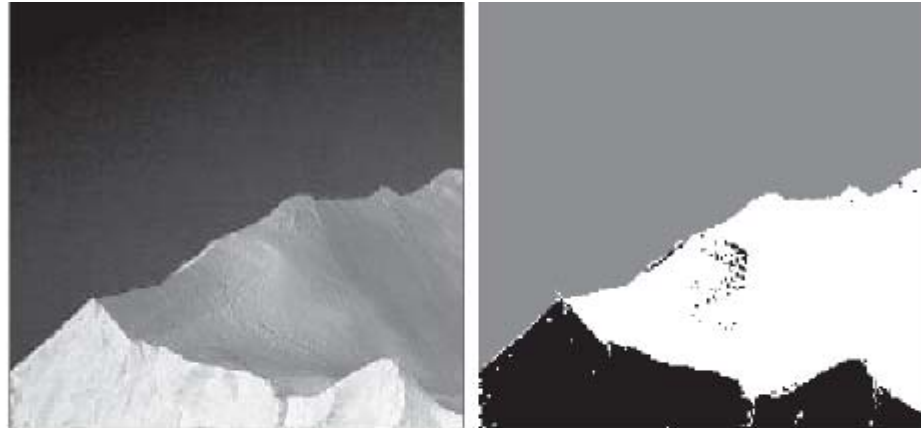
1,000 superpixels

500 superpixels

250 superpixels

# Superpixels for image segmentation

Input image of  
301,678 pixels



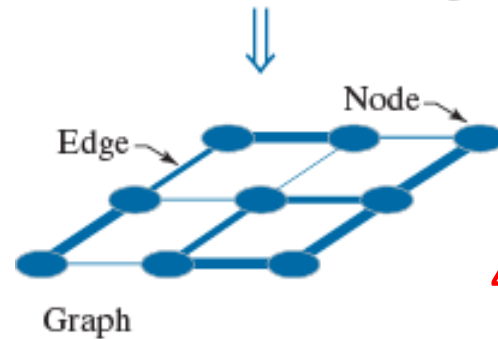
Segmentation using  
 $k$ -means,  $k = 3$



Superpixel image  
(100 superpixels)

Segmentation using  
 $k$ -means,  $k = 3$

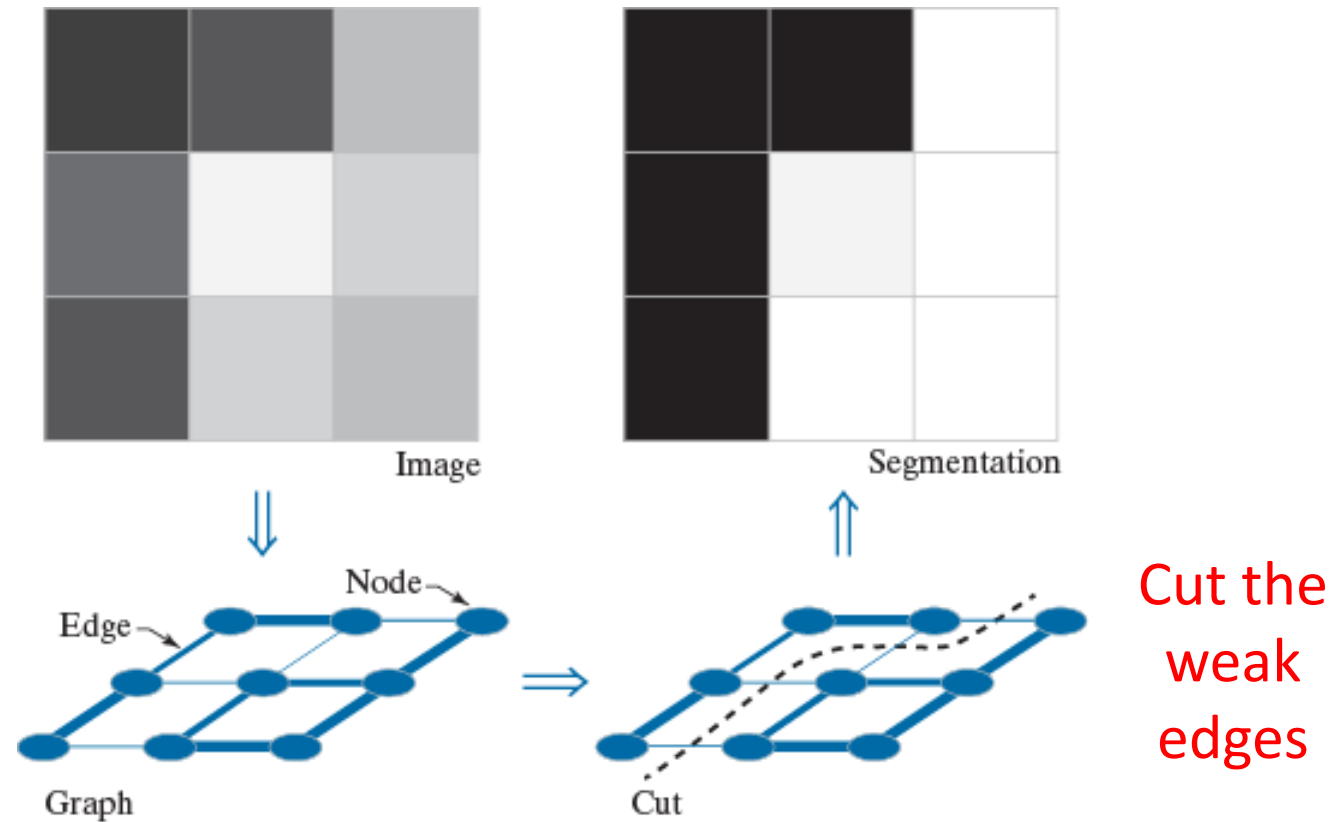
# Images as graphs



Simple graph with  
edges only between  
4-connected neighbors

Stronger (greater weight)  
edges are darker

# Graph cuts for image segmentation



# Graph cuts for image segmentation



Input



Smoothed input



Graph cut  
segmentation