Digital Image Processing

Image Segmentation: Thresholding

Contents

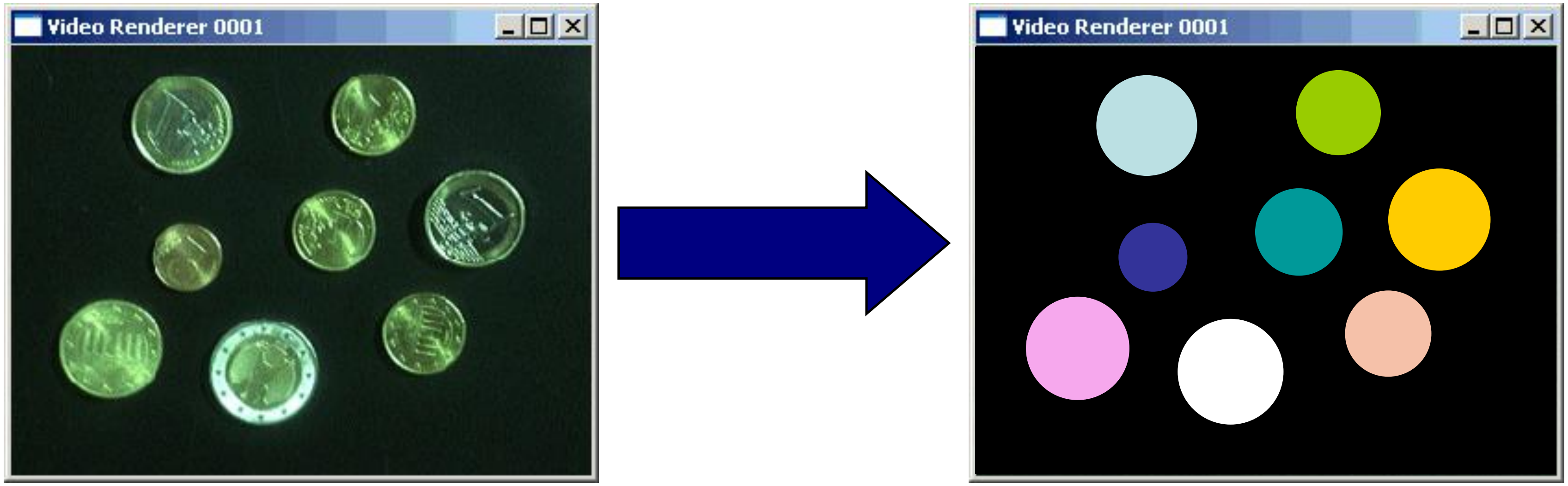
So far we have been considering image processing techniques used to transform images for human interpretation

Today we will begin looking at automated image analysis by examining the thorny issue of image segmentation:

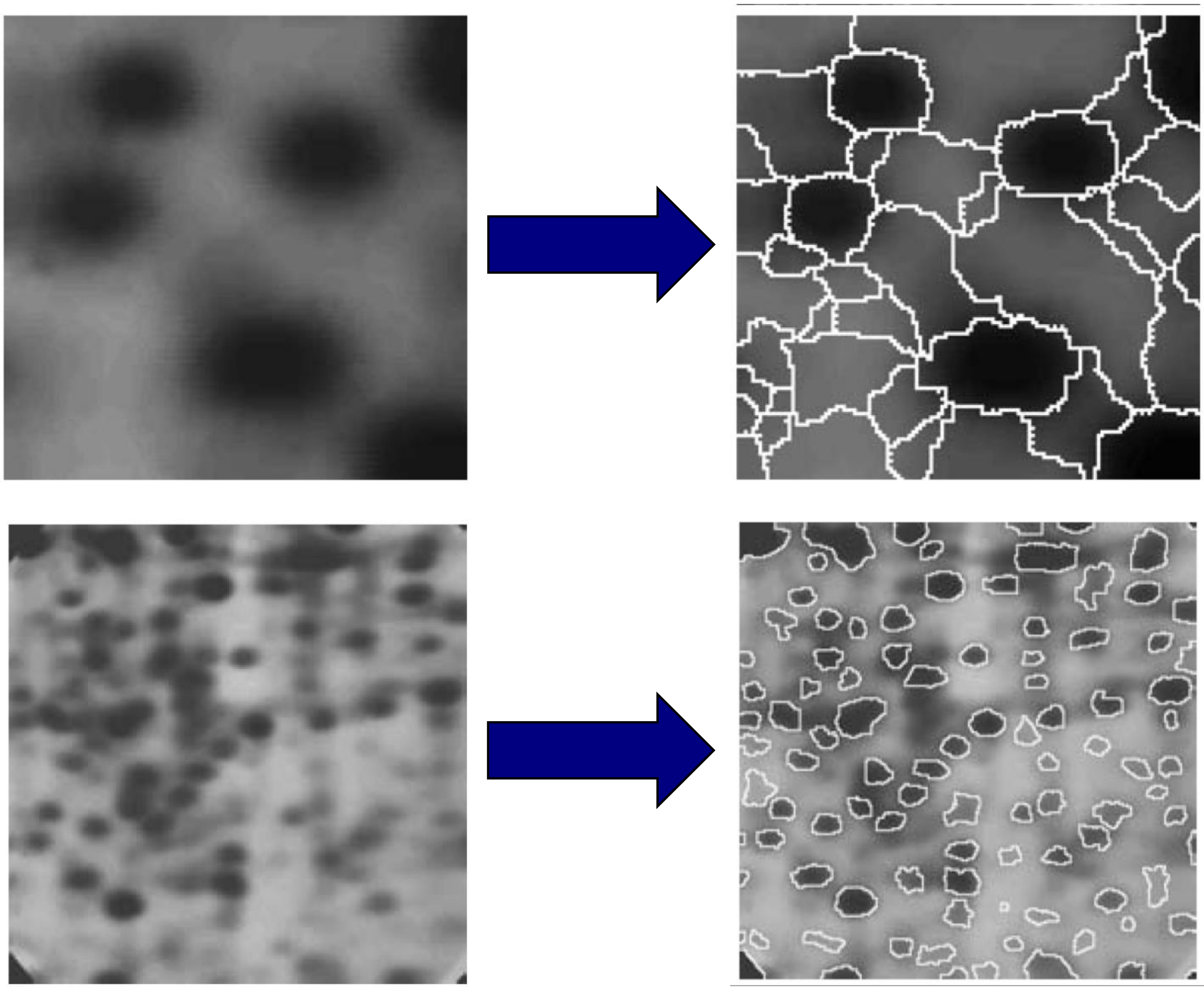
- The segmentation problem
- Finding points, lines and edges

The Segmentation Problem

- Segmentation attempts to partition the pixels of an image into groups that strongly correlate with the objects in an image
- Typically the first step in any automated computer vision application



Segmentation Examples



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Detection Of Discontinuities

There are three basic types of grey level discontinuities that we tend to look for in digital images:

- Points
- Lines
- Edges

We typically find discontinuities using masks and correlation

Point Detection

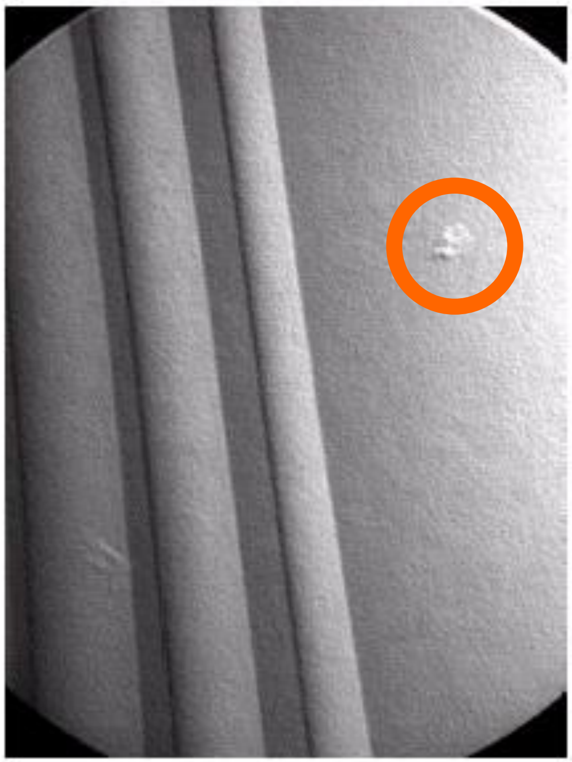
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Point detection can be achieved simply using the mask below:

–1	–1	–1
–1	8	–1
–1	–1	–1

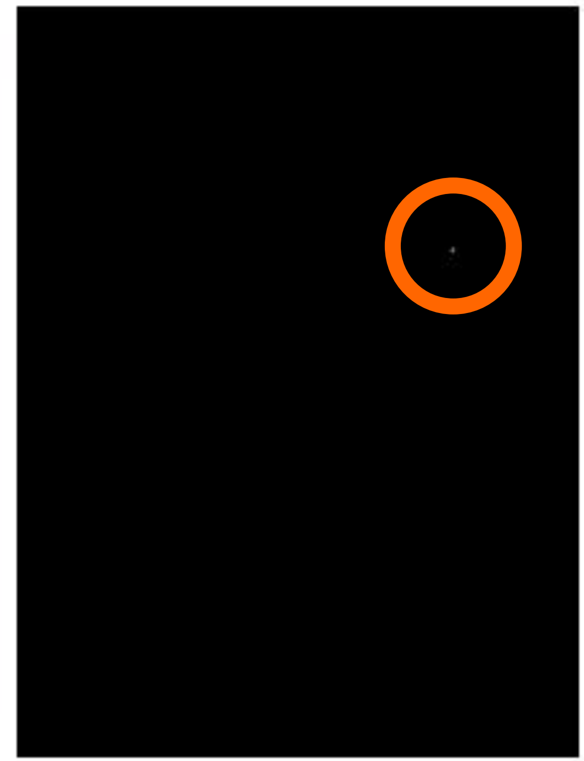
Points are detected at those pixels in the subsequent filtered image that are above a set threshold

Point Detection (cont…)



~~X-ray image~~ of
~~a turbine blade~~

Result of point
detection



Result of
thresholding

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Line Detection

- The next level of complexity is to try to detect lines
- The masks below will extract lines that are one pixel thick and running in a particular direction

−1	−1	−1
2	2	2
−1	−1	−1

Horizontal

−1	−1	2
−1	2	−1
2	−1	−1

+45°

−1	2	−1
−1	2	−1
−1	2	−1

Vertical

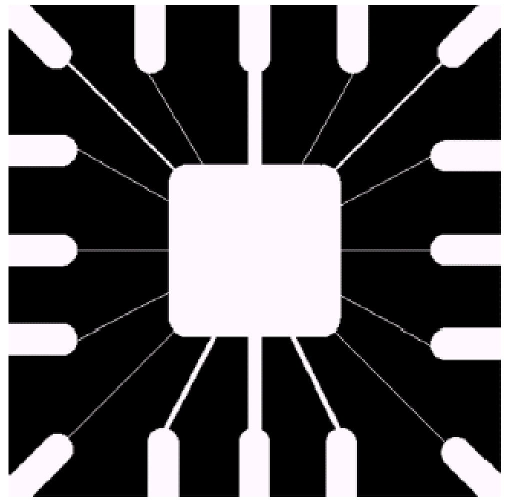
2	−1	−1
−1	2	−1
−1	−1	2

−45°

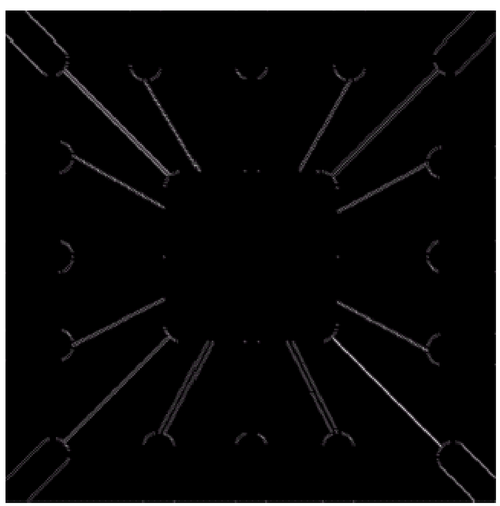
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

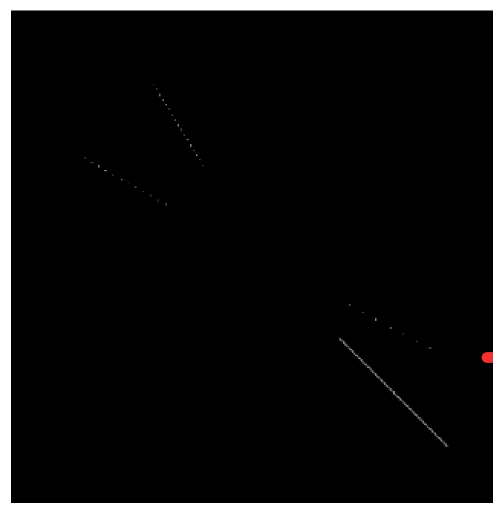
Line Detection (cont…)

Binary image of a wire bond mask



After processing with -45° line detector





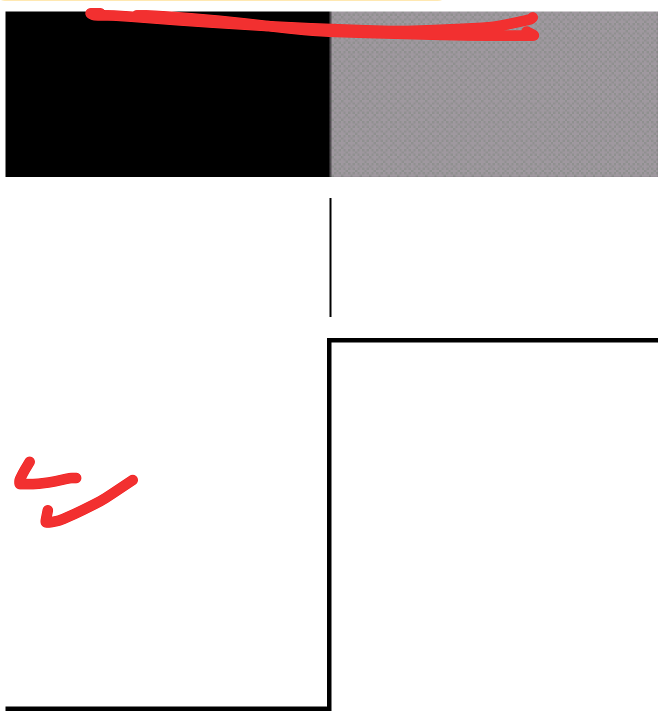
Result of thresholding filtering result

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection

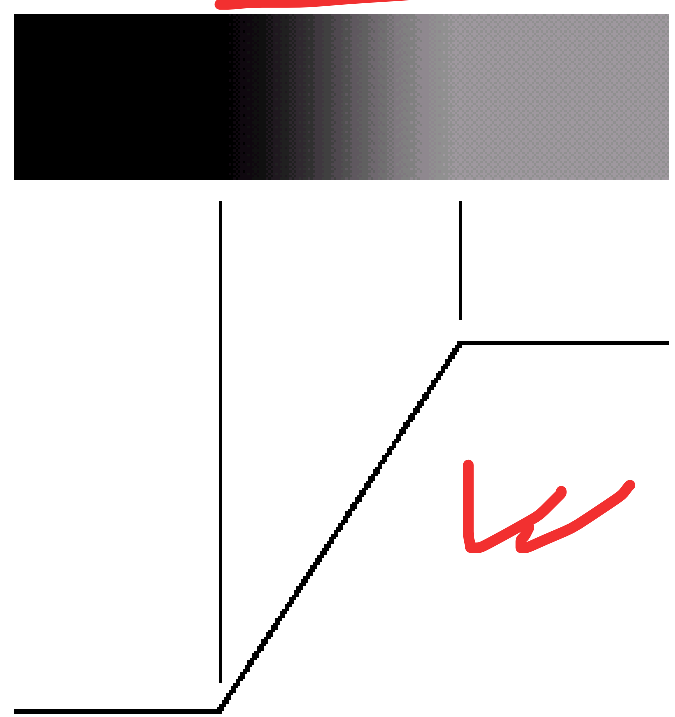
- An edge is a set of connected pixels that lie on the boundary between two regions

Model of an ideal digital edge



Gray-level profile
of a horizontal line
through the image

Model of a ramp digital edge

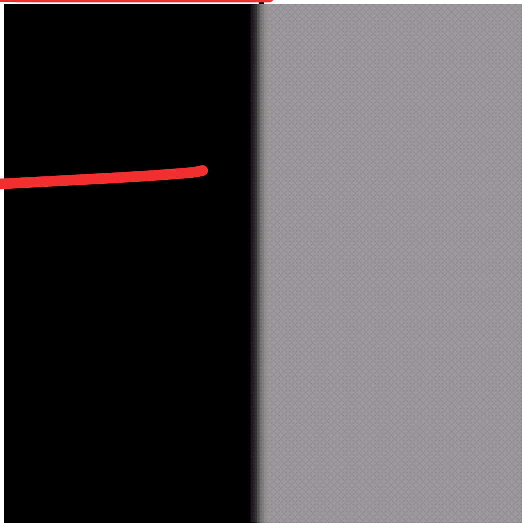


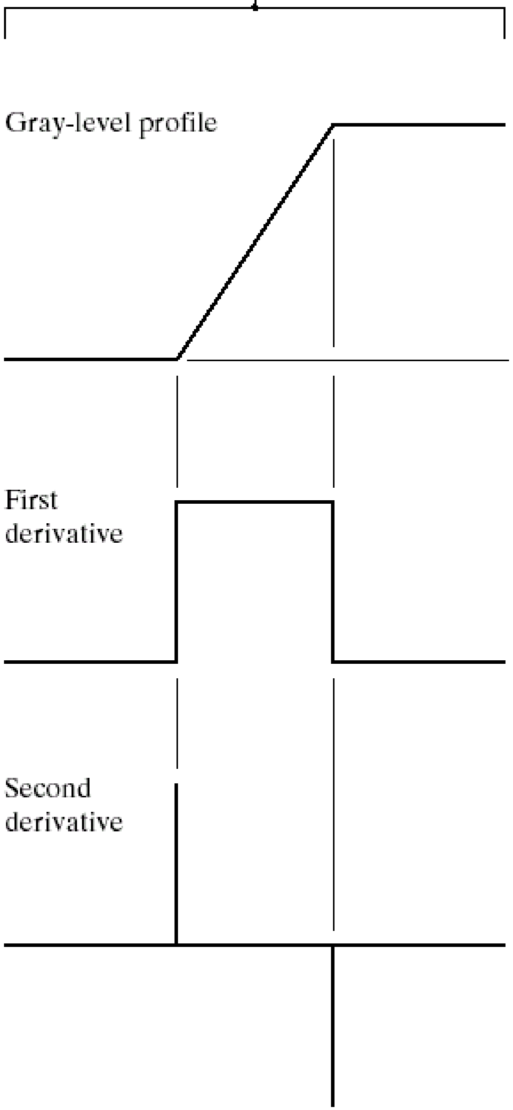
Gray-level profile
of a horizontal line
through the image

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edges & Derivatives

- We have already spoken about how derivatives are used to find discontinuities
- 1st derivative tells us where an edge is
- 2nd derivative can be used to show edge direction



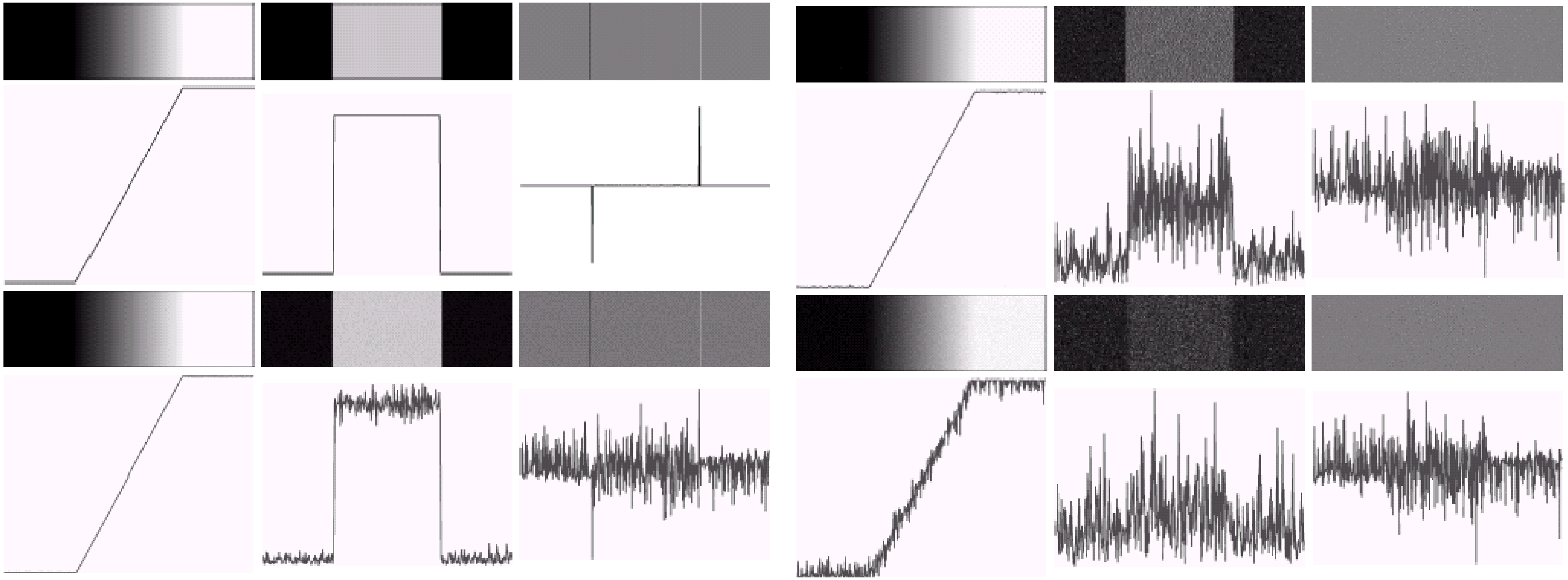


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Derivatives & Noise

Derivative based edge detectors are extremely sensitive to noise

We need to keep this in mind



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Common Edge Detectors

Given a 3*3 region of an image the following edge detection filters can be used

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

Prewitt

−1	0
0	1

0	−1
1	0

Roberts

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Sobel

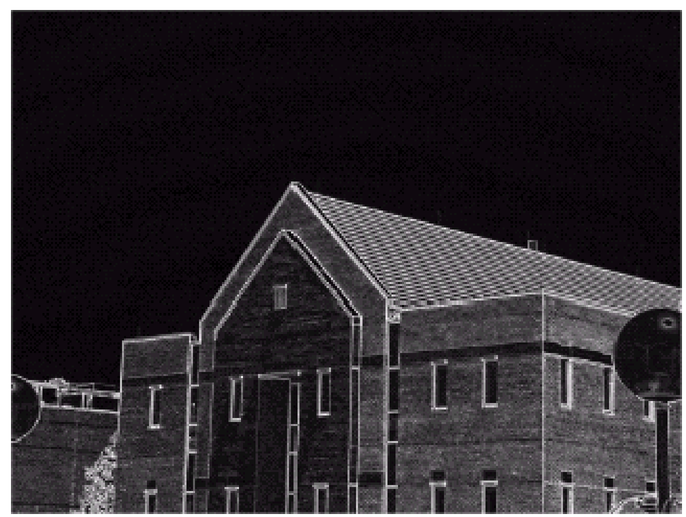
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection Example

Original Image

Horizontal Gradient Component

Vertical Gradient Component



Combined Edge Image

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection Example

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection Example

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection Example

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection Example

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Edge Detection Problems

Often, problems arise in edge detection in that there are is too much detail

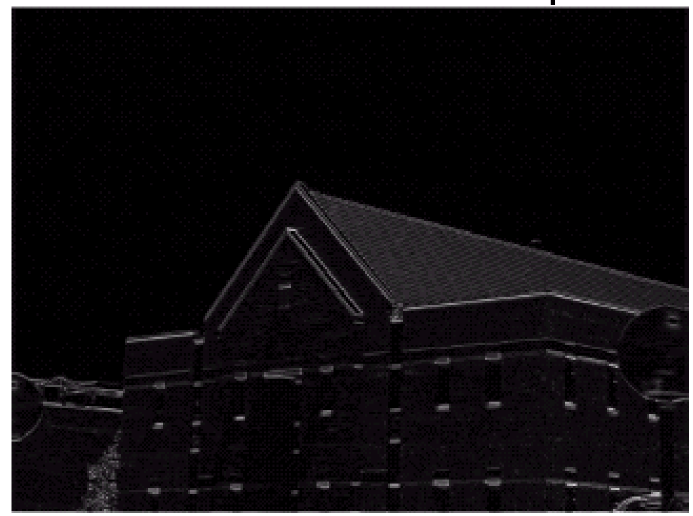
For example, the brickwork in the previous example

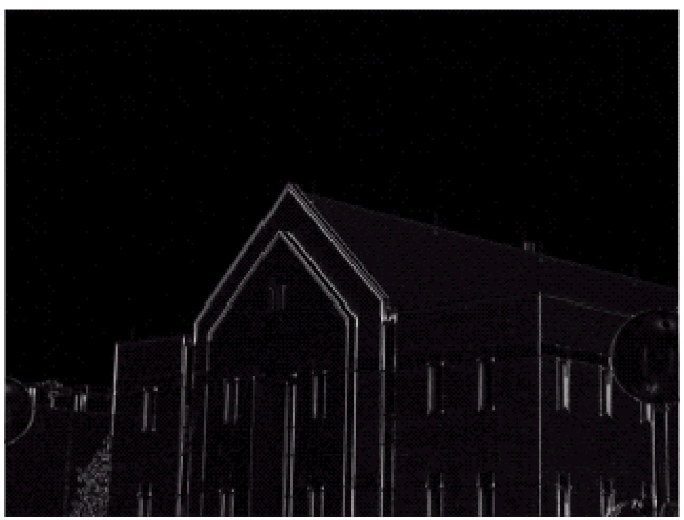
One way to overcome this is to smooth images prior to edge detection

Edge Detection Example With Smoothing

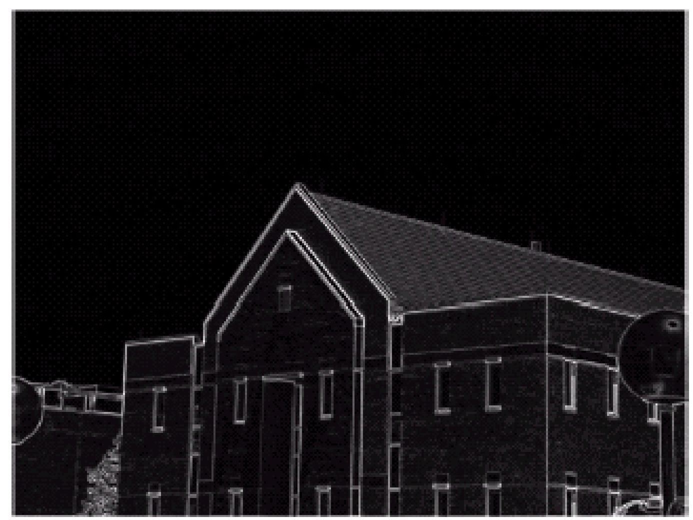
Original Image

Horizontal Gradient Component





Vertical Gradient Component



Combined Edge Image

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Laplacian Edge Detection

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

We encountered the 2nd-order derivative based Laplacian filter already

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

✓✓

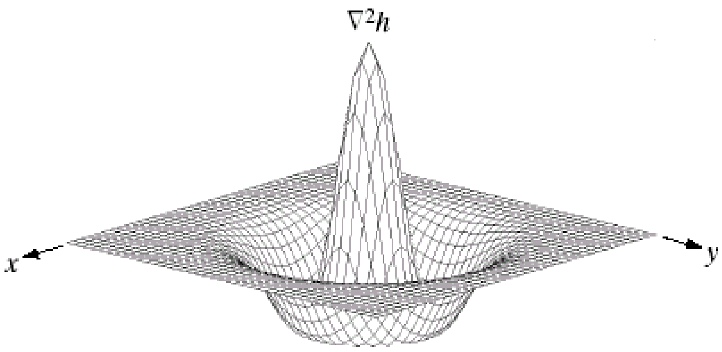
The Laplacian is typically not used by itself as it is too sensitive to noise

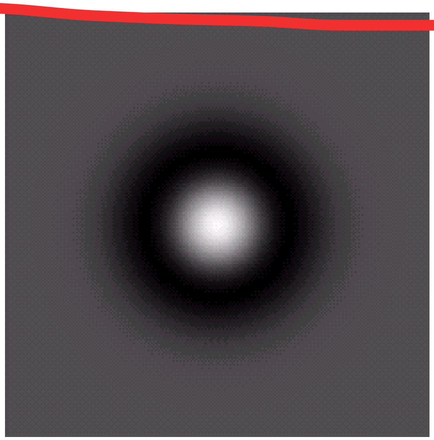
Usually hen used for edge detection the Laplacian is combined with a smoothing Gaussian filter

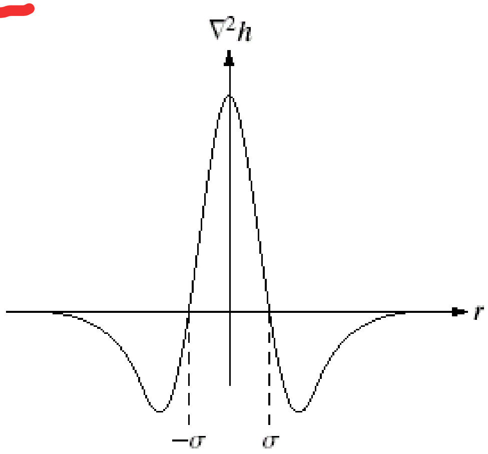
Laplacian Of Gaussian

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

The Laplacian of Gaussian (or Mexican hat) filter uses the Gaussian for noise removal and the Laplacian for edge detection

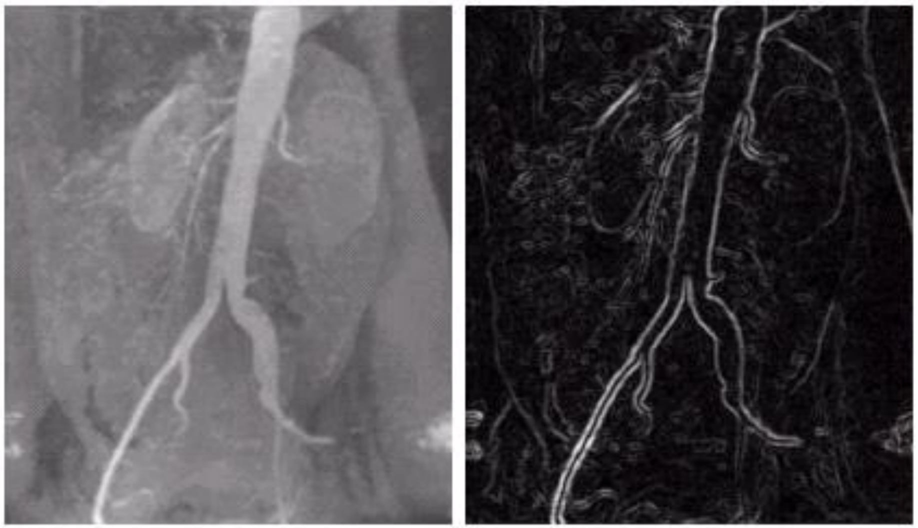


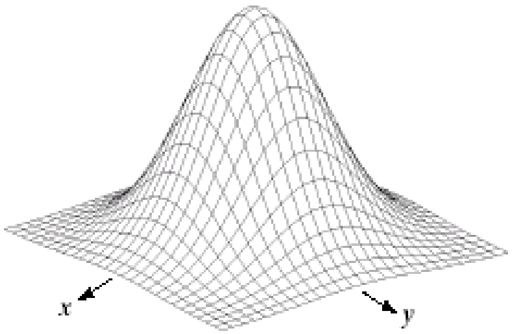




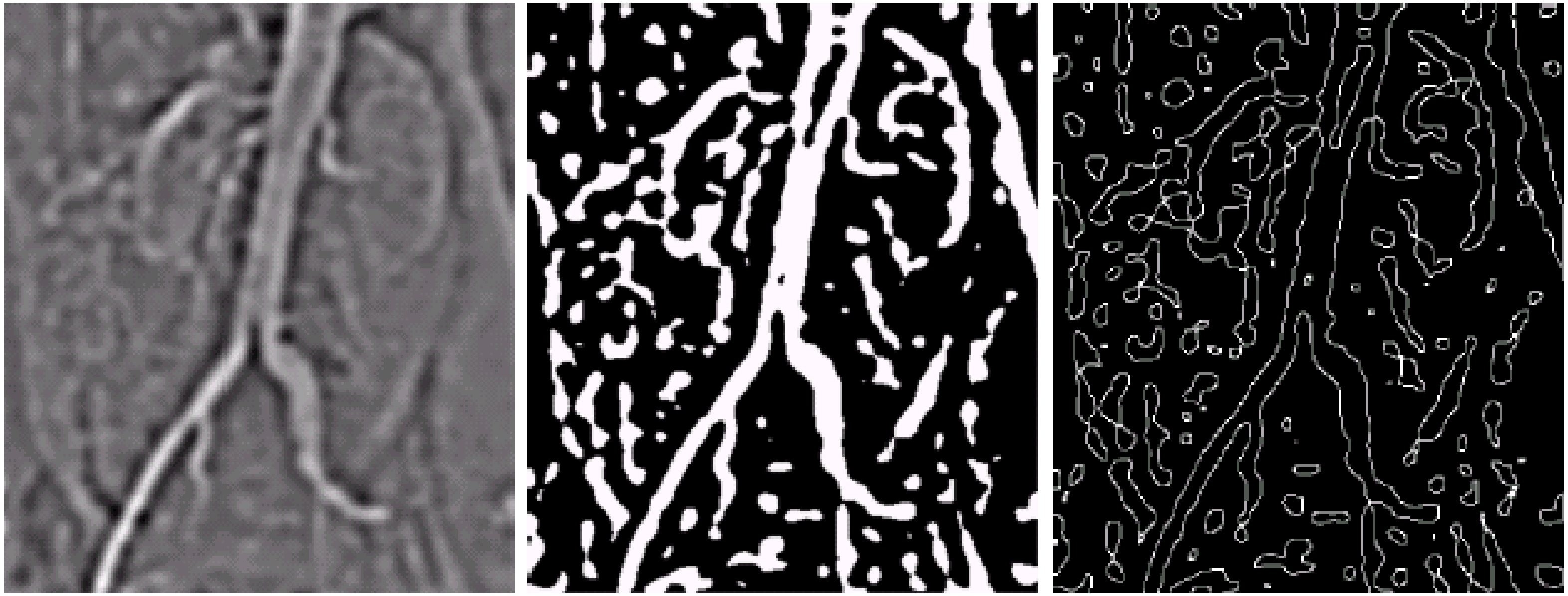
0	0	−1	0	0
0	−1	−2	−1	0
−1	−2	16	−2	−1
0	−1	−2	−1	0
0	0	−1	0	0

Laplacian Of Gaussian Example





−1	−1	−1
−1	8	−1
−1	−1	−1



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Summary

In this lecture we have begun looking at segmentation, and in particular edge detection

Edge detection is massively important as it is in many cases the first step to object recognition