

Edge Detection

Sharpening Spatial Filters

- Remove blurring in images
- Highlight transition in intensity (edges)
- Uses spatial differentiation
- Differentiation measures the rate of change of a pixel intensities
- Image gradient is based on differentiation

Image Gradients

- Is fundamental building block of many computer vision and image processing techniques
- Use gradients to
 - detecting edges
 - find contours
 - outlines of objects
- Compute gradient magnitude and gradient orientation
- Image descriptors such as Histogram of Oriented Gradients and SIFT are built upon image gradient representations

Detection of Edges

Computation of Image gradients is a pre-processing step to detecting edges in images



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Gradient of image

Image matrix

	$f(r-1,c)$	
$f(r,c-1)$	$f(r,c)$	$f(r,c+1)$
	$f(r+1,c)$	

- Gradient along horizontal direction
 $g_x = f(r,c+1) - f(r,c-1)$

Mask/ filter for g_x

-1	0	1
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- Gradient along vertical direction
 $g_y = f(r+1,c) - f(r-1,c)$

Mask/ filter for $g_y =$

-1
0
1

Image Gradient/ Gradient Vector

$$M = \sqrt{g_x^2 + g_y^2} \qquad \alpha(x, y) = \tan^{-1}\left(\frac{g_y}{g_x}\right)$$

- M is magnitude and α is angle of gradient
- Size of matrix for magnitude and angle is same as image
- Magnitude is the value of rate of change in the direction of gradient vector
- Magnitude of gradient is used to measure how strong the change in image intensity is
- The gradient orientation is used to determine in which direction the change in intensity is pointing
- Angle between vertical axis and edge is α

Gradient of image

image

10	10	50	10	10
10	10	50	10	10
10	10	50	10	10
10	10	50	10	10

gx

-1	0	1
----	---	---

gy

-1
0
1

g_x

10	40	0	-40	10
10	40	0	-40	10
10	40	0	-40	10
10	40	0	-40	10

g_y

10	10	50	10	10
0	0	0	0	0
0	0	0	0	0
10	10	50	10	10

$$Mag = \sqrt{g_x^2 + g_y^2}$$

10	10	50	10	10
10	40	0	40	10
10	40	0	40	10
10	10	50	10	10

Sobel Filters for gradient

image

10	10	50	10	10
10	10	50	10	10
10	10	50	10	10
10	10	50	10	10

Filter for g_x

-1	0	1
-2	0	2
-1	0	1

Filter for g_y

-1	-2	-1
0	0	0
1	2	1

g_x

10	10	50	10	10
10	160	0	-160	10
10	160	0	-160	10
10	10	50	10	10

g_y

10	10	50	10	10
10	0	0	0	10
10	0	0	0	10
10	10	50	10	10

$$Mag = \sqrt{g_x^2 + g_y^2}$$

10	10	50	10	10
10	160	0	160	10
10	160	0	160	10
10	10	50	10	10

Gradient Magnitudes

image

10	10	50	10	10
10	10	50	10	10
10	10	50	10	10
10	10	50	10	10

Sobel Filter for g_x

-1	0	1
-2	0	2
-1	0	1

Sobel Filter for g_y

-1	-2	-1
0	0	0
1	2	1

Filter for g_x

-1	0	1
----	---	---

Filter for g_y

-1
0
1

Magnitude using Sobel

10	10	50	10	10
10	160	0	160	10
10	160	0	160	10
10	10	50	10	10

Magnitude

10	10	50	10	10
10	40	0	40	10
10	40	0	40	10
10	10	50	10	10

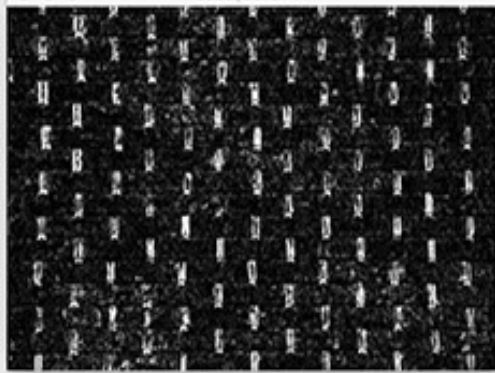
Image Gradients

Image



Image Gradients

Image



g_x

Image Gradients

Image



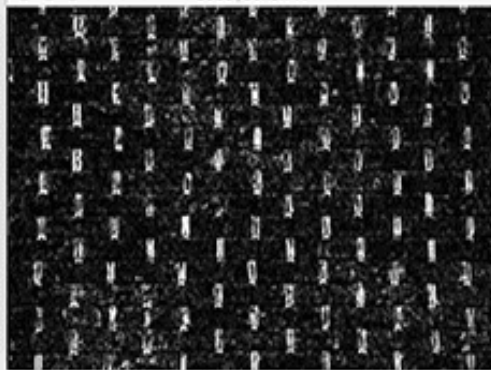
g_x



g_y

Image Gradients

Image



gx



gy

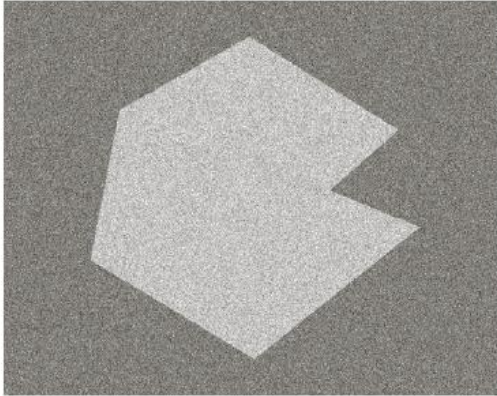


Magnitude, M

Image smoothing to improve edge detection

Image smoothing to improve edge detection

Image



Histogram of image

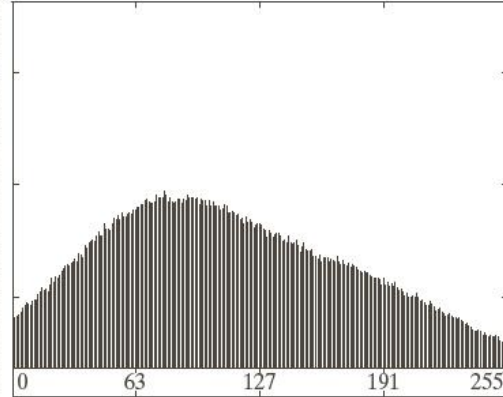


Image filtered by edge detection filter

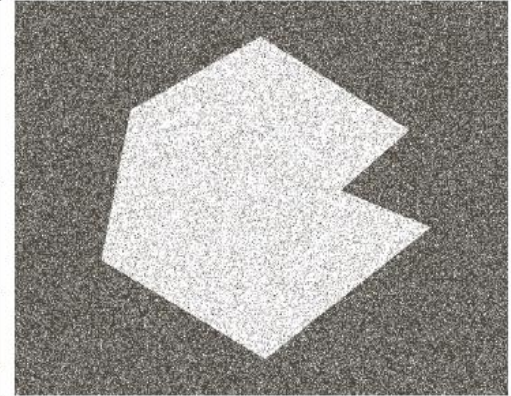
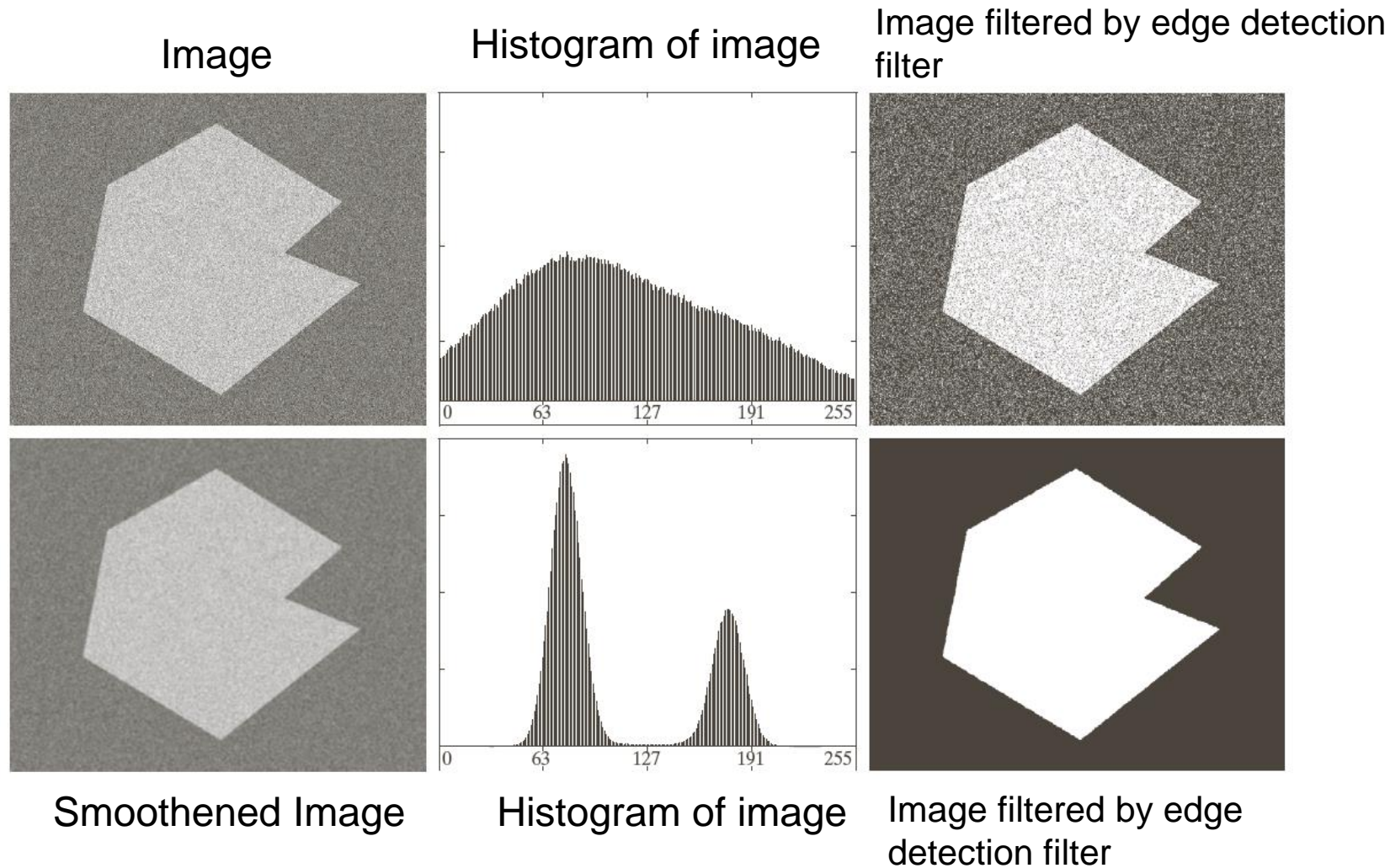


Image smoothing to improve edge detection



- Apply edge detection after image smoothing

Gaussian Filter (Smoothing filter)

- Gaussian filter with mean 0 and standard deviation, σ is

$$G_{\sigma} = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}}$$

3×3 filter with $\sigma = 1$

(1/16)

1	2	1
2	4	2
1	2	1

5×5 filter with $\sigma = 1$

(1/330)

1	4	7	4	1
4	20	33	20	4
7	33	54	33	7
4	20	33	20	4
1	4	7	4	1

5×5 filter with $\sigma = 2$

(1/34)

1	1	1	1	1
1	2	2	2	1
1	2	2	2	1
1	2	2	2	1
1	1	1	1	1

- Gaussian filter is averaging filter which blurs the image
- Blurring increases with the increase in σ

Gaussian Filter (Smoothing filter)

Image

100	100	100	100	100	100	100
100	100	100	100	100	100	100
100	100	100	100	100	100	100
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

5×5 filter with $\sigma = 1$

	1	4	7	4	1
	4	20	33	20	4
(1/330)	7	33	54	33	7
	4	20	33	20	4
	1	4	7	4	1

Gaussian Filter (Smoothing filter)

5×5 filter with $\sigma = 1$

(1/330)

1	4	7	4	1
4	20	33	20	4
7	33	54	33	7
4	20	33	20	4
1	4	7	4	1

5×5 filter with $\sigma = 2$

(1/34)

1	1	1	1	1
1	2	2	2	1
1	2	2	2	1
1	2	2	2	1
1	1	1	1	1

Filtered Image for $\sigma = 1$

100	100	100	100	100	100	100
100	100	100	100	100	100	100
100	100	70	70	70	100	100
0	0	30	30	30	0	0
0	0	10	10	10	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Filtered Image for $\sigma = 2$

100	100	100	100	100	100	100
100	100	100	100	100	100	100
100	100	60	60	60	100	100
0	0	40	40	40	0	0
0	0	10	10	10	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Laplacian Filter

0	1	0
1	-4	1
0	1	0

 or

0	-1	0
-1	4	-1
0	-1	0

Detects horizontal and vertical edges

1	1	1
1	-8	1
1	1	1

 or

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

Detects horizontal, vertical and diagonal edges

Laplacian Filter for Edge Enhancement

Image

10	10	10	100	10	10	10
10	10	10	100	10	10	10
10	10	10	100	10	10	10
100	100	100	100	100	100	100
10	10	10	100	10	10	10
10	10	10	100	10	10	10
10	10	10	100	10	10	10

Laplacian filter

0	-1	0
-1	4	-1
0	-1	0

=

10	10	10	100	10	10	10
10	0	-90	180	-90	0	10
10	-90	-180	180	-180	-90	10
100	180	180	0	180	180	100
10	-90	-180	180	-180	-90	10
10	0	-90	180	-90	0	10
10	10	10	100	10	10	10

Filtered image

Laplacian Filter for Edge Enhancement

10	10	10	100	10	10	10
10	0	-90	180	-90	0	10
10	-90	-180	180	-180	-90	10
100	180	180	0	180	180	100
10	-90	-180	180	-180	-90	10
10	0	-90	180	-90	0	10
10	10	10	100	10	10	10

Filtered image

Edge points have values for which zero crossings exceeds threshold

10	10	10	100	10	10	10
10	0	-90	180	-90	0	10
10	-90	-180	180	-180	-90	10
100	180	180	0	180	180	100
10	-90	-180	180	-180	-90	10
10	0	-90	180	-90	0	10
10	10	10	100	10	10	10

Filtered image with edges highlighted