

Local Enhancement

- Local Enhancement
- Median filtering

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Local Enhancement

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Local enhancement



Sometimes Local Enhancement is Preferred.

Malab: BlkProc operation for block processing.

Left: original "tire" image.

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Histogram equalized



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Local histogram equalized



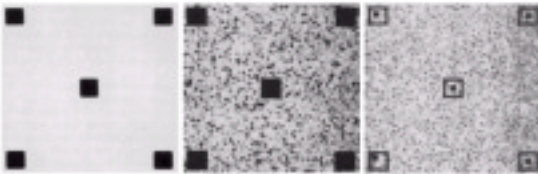
```
F=@ histeq;
I=imread('tire.tif');
J=blkproc(I,[20 20], F);
```

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Fig 3.23: Another example



3.23.23

FIGURE 3.23 (a) Original image; (b) Result of global histogram equalization; (c) Result of local histogram equalization using a 7×7 neighborhood about each pixel.

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Local Contrast Enhancement

- Enhancing local contrast

$$g(x,y) = A(x,y) [f(x,y) - m(x,y)] + m(x,y)$$

$$A(x,y) = k M / \sigma(x,y) \quad 0 < k < 1$$

M : Global mean

$m(x,y)$, $\sigma(x,y)$: Local mean and standard dev.

Areas with low contrast \rightarrow Larger gain $A(x,y)$ (fig 3.24-3.26)

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Fig 3.24

FIGURE 3.24 SEM image of a tungsten filament and support, magnified approximately 130x. Original image courtesy of Mr. Michael Stoffer, Department of Geological Sciences, University of Oregon, Eugene.



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Fig 3.25

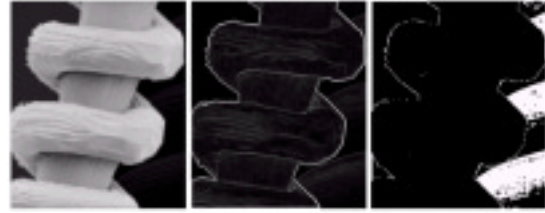


FIGURE 3.25 (a) Image formed from all local means obtained from Fig. 3.24 using Eq. (3.3-20). (b) Image formed from all local standard deviations obtained from Fig. 3.24 using Eq. (3.3-21). (c) Image formed from all multiplication constants used to produce the enhanced image shown in Fig. 3.26.

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Fig 3.26



FIGURE 3.26 Enhanced SEM image. Compare with Fig. 3.24. Note in particular the enhanced area on the right side of the image.

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Image Subtraction

$$g(x,y) = f(x,y) - h(x,y)$$

$h(x,y)$ —a low pass filtered version of $f(x,y)$.

- Application in medical imaging --“mask mode radiography”
- $H(x,y)$ is the mask, e.g., an X-ray image of part of a body; $f(x,y)$ —incoming image after injecting a contrast medium.

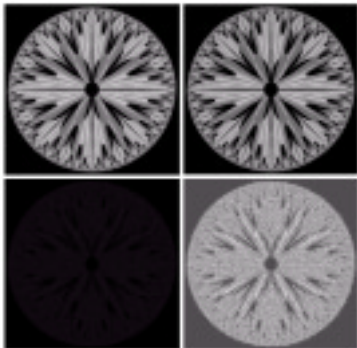
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Subtraction: an example

FIGURE 3.28 (a) Original mask image. (b) Mask of a tungsten filament and support. (c) Difference between (a) and (b). (d) Original image of a tungsten filament and support. (e) Original image of a tungsten filament and support. (f) Original image of a tungsten filament and support. (g) Original image of a tungsten filament and support. (h) Original image of a tungsten filament and support. (i) Original image of a tungsten filament and support. (j) Original image of a tungsten filament and support. (k) Original image of a tungsten filament and support. (l) Original image of a tungsten filament and support. (m) Original image of a tungsten filament and support. (n) Original image of a tungsten filament and support. (o) Original image of a tungsten filament and support. (p) Original image of a tungsten filament and support. (q) Original image of a tungsten filament and support. (r) Original image of a tungsten filament and support. (s) Original image of a tungsten filament and support. (t) Original image of a tungsten filament and support. (u) Original image of a tungsten filament and support. (v) Original image of a tungsten filament and support. (w) Original image of a tungsten filament and support. (x) Original image of a tungsten filament and support. (y) Original image of a tungsten filament and support. (z) Original image of a tungsten filament and support.



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Fig 3.28: mask mode radiography

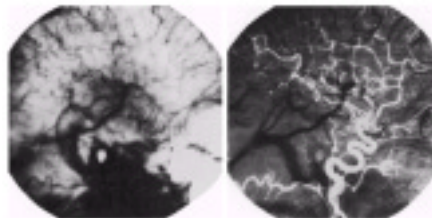


FIGURE 3.29 Enhanced image by image subtraction. (a) Mask image. (b) An image taken after injection of a contrast medium into the blood vessels with mask subtracted out.

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Averaging

$$g(x, y) = f(x, y) + \eta(x, y)$$

$$\bar{g}(x, y) = \frac{1}{M} \sum_{i=1}^M g_i(x, y)$$

$$E(\bar{g}(x, y)) = f(x, y) \text{ and } \sigma^2_{\bar{g}} = \frac{1}{M} \sigma^2_{\eta(x, y)}$$

$\eta(x, y) \rightarrow$ Uncorrelated zero mean

$\sigma^2_{\eta(x, y)} \rightarrow$ Reduces the noise variance

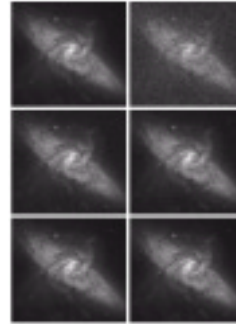
Fig 3.30

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Fig 3.30



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Another example



Images with additive
Gaussian Noise:
Independent
Samples.

`I=imnoise(J, 'Gaussian');`

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Averaged image



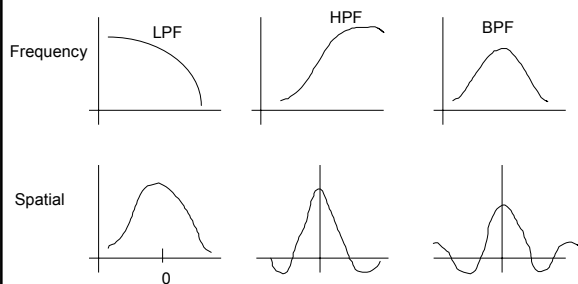
Left: averaged image (10 samples);
Right: original image

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Spatial filtering

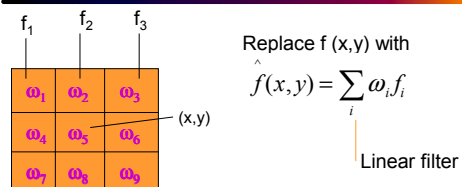


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Smoothing (Low Pass) Filtering



LPF: reduces additive noise \rightarrow blurs the image
 \rightarrow sharpness details are lost
(Example: Local averaging)

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Fig 3.35: smoothing



Fig 3.36: another example

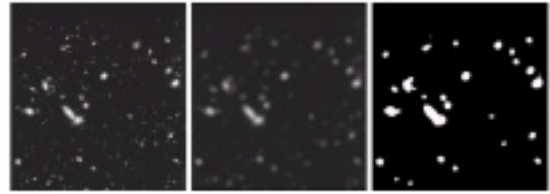


FIGURE 3.36 (a) Image from the Hubble Space Telescope. (b) Image processed by a 15×15 averaging mask. (c) Results of thresholding. (b, c) Original image courtesy of NASA.

Median filtering

Replace $f(x,y)$ with $\text{median}[f(x',y')]$
 $(x',y') \in \mathcal{N}$ neighbourhood

- Useful in eliminating intensity spikes. (salt & pepper noise)
- Better at preserving edges.

Example:

10	20	20
20	15	20
25	20	100

→ (10,15,20,20,20,20,20,25,100)
 Median=20
 So replace (15) with (20)

Median Filter: Root Signal

Repeated applications of median filter to a signal results in an invariant signal called the "root signal".

A root signal is invariant to further application of the mediana filter.

Example: 1-D signal: Median filter length = 3

```

0 0 0 1 2 1 2 1 2 1 0 0 0
0 0 0 1 1 2 1 2 1 1 0 0 0
0 0 0 1 1 1 2 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 0 0 0  root signal
    
```

Invariant Signals

Invariant signals to a median filter:

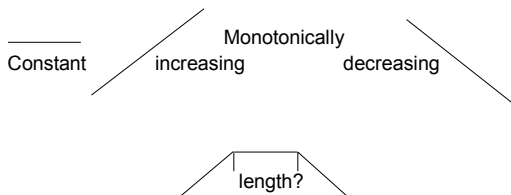


Fig 3.37: Median Filtering example

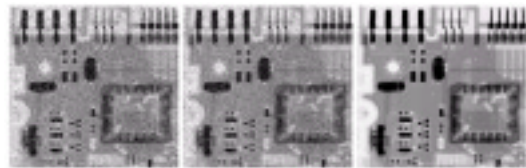


FIGURE 3.37 (a) X-ray image of circuit board contaminated by salt-and-pepper noise. (b) Noise reduction with a 3×3 averaging mask. (c) Noise reduction with a 3×3 median filter. (Original image courtesy of Mr Joseph E. Pavonetti, Ltd. Inc.)

Media Filter: another example



Original and with salt & pepper noise
`imnoise(image, 'salt & pepper');`

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Donoised images



Local averaging
`K=filter2('special('average',3),image)/255;`

Median filtered
`L=medfilt2(image, [3 3]);`

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Sharpening Filters

- Enhance finer image details (such as edges)
- Detect region /object boundaries.

Example:

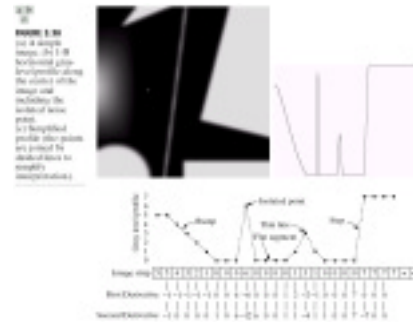
-1	-1	-1
-1	8	-1
-1	-1	-1

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Edges (Fig 3.38)



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Unsharp Masking

Subtract Low pass filtered version from the original
 emphasizes high frequency information

$$I' = A (\text{Original}) - \text{Low pass}$$

$$\text{HP} = O - \text{LP} \quad A > 1$$

$$I' = (A - 1) O + \text{HP}$$

$$A = 1 \Rightarrow I' = \text{HP}$$

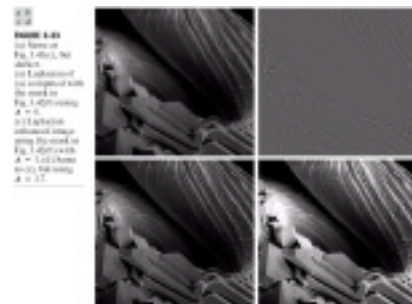
$$A > 1 \Rightarrow \text{LF components added back.}$$

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Fig 3.43 –example of unsharp masking



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Derivative Filters

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

Gradient

$$\nabla f = \begin{bmatrix} \frac{\partial f}{\partial x} & \frac{\partial f}{\partial y} \end{bmatrix}^T$$

$$\|\nabla f\| = \left[\left(\frac{\partial f}{\partial x} \right)^2 + \left(\frac{\partial f}{\partial y} \right)^2 \right]^{1/2}$$

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Edge Detection

Gradient based methods

$$\nabla f = \begin{pmatrix} \frac{\partial f}{\partial x} & \frac{\partial f}{\partial y} \end{pmatrix}^T$$

$f(x)$

$f'(x)$

$f''(x)$

Flowchart for edge detection:

```

    graph LR
      A[f(x)] --> B[d./dx]
      B --> C["|.|"]
      C --> D{Threshold}
      D --> E{Local max}
      E -- Yes --> F["X0 is an edge"]
      E -- No --> G["X0 not an edge"]
      D --> G
  
```

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Digital edge detectors

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

$$|\nabla f| \approx \left[(z_5 - z_8)^2 + (z_5 - z_6)^2 \right]^{1/2}$$

$$|\nabla f| \approx |z_5 - z_8| + |z_5 - z_6|$$

Robert's operator

1	0	0	1
0	-1	-1	0

$|z_5 - z_9|$ $|z_6 - z_8|$

prewitt

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

Sobel's

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

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Fig 3.45: Sobel edge detector

FIGURE 3.45
Original image of contact lens (left); edge detection on the boundary of 4 and 5 (middle); (b) Sobel gradient. (Original image courtesy of Jde. Pita-Salas, Perceptics Corporation.)

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Laplacian based edge detectors

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

	1	
1	-4	1
	1	

- Rotationally symmetric, linear operator
- Check for the zero crossings to detect edges
- Second derivatives => sensitive to noise.

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Fig 3.40: an example

FIGURE 3.40
Original image of the Moon (left); edge detection on the boundary of the Moon (middle); (b) Sobel gradient. (Original image courtesy of Jde. Pita-Salas, Perceptics Corporation.)

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