Matlab Tutorial
Derivatives, Filtering, Pyramids

Gonzalo Vaca-Castano

UCF

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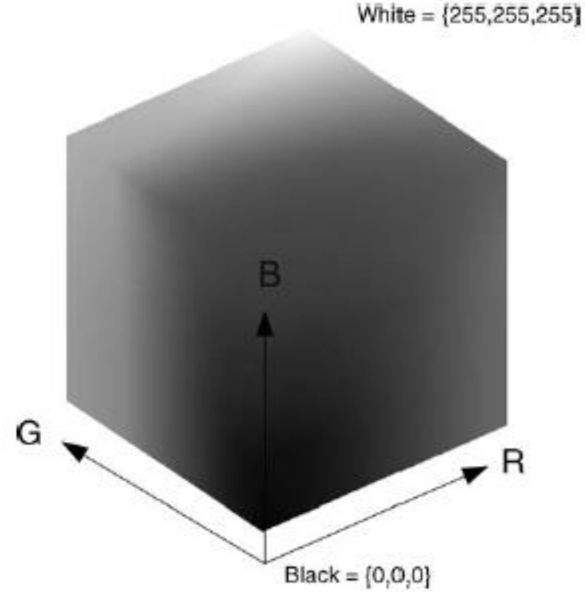
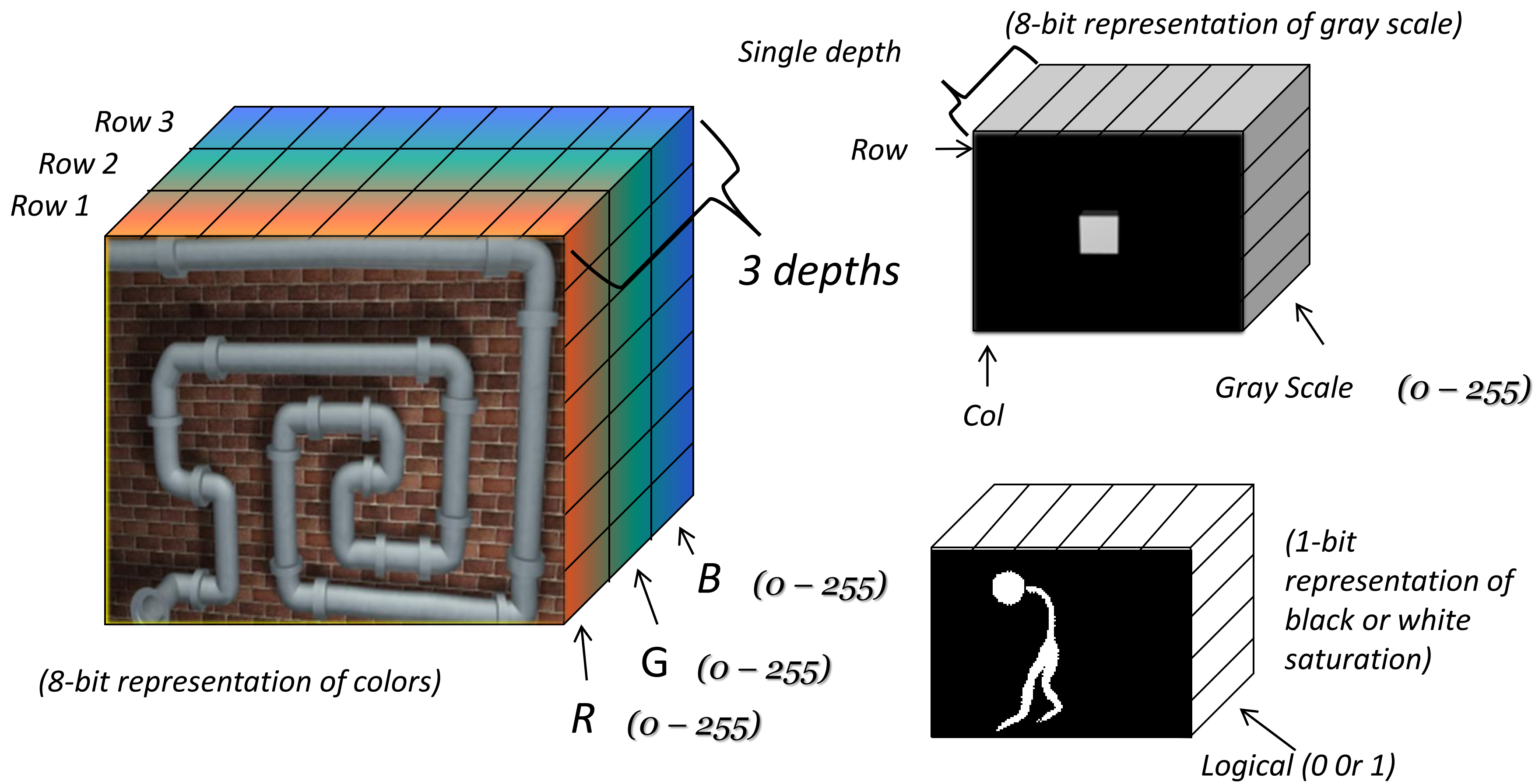


Matlab Tutorial. Session 1

COLOR SPACES: RGB,HSV, ETC

Image Architecture

- Raster Images (RGB, Gray Scale, Logical)



RGB space

- >> I = imread('board.tif')

- Displaying image:
  - >> imshow(I)

- Check image size
  - >> size(I)

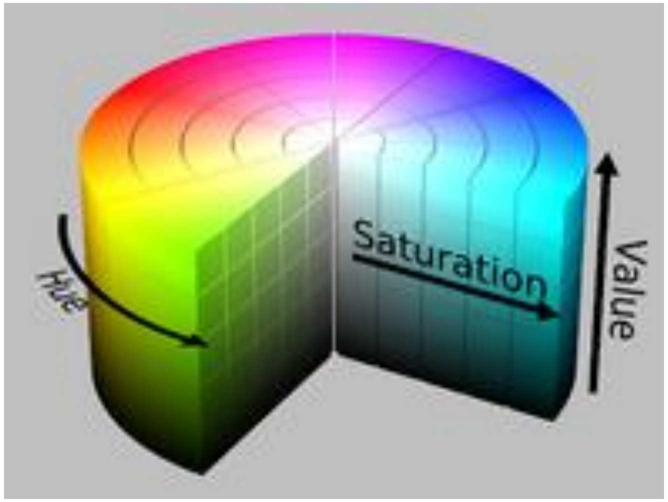
- Convert color image to black and white image:
  - >> rgb2gray(I)
  - % Gray= 0.2989 * R + 0.5870 * G + 0.1140 * B

Other Color spaces

http://en.wikipedia.org/wiki/HSL_and_HSV

- rgb2hsv(I)
- rgb2ycbcr(I)
- rgb2ntsc (I)

CIELAB or CIECAM02

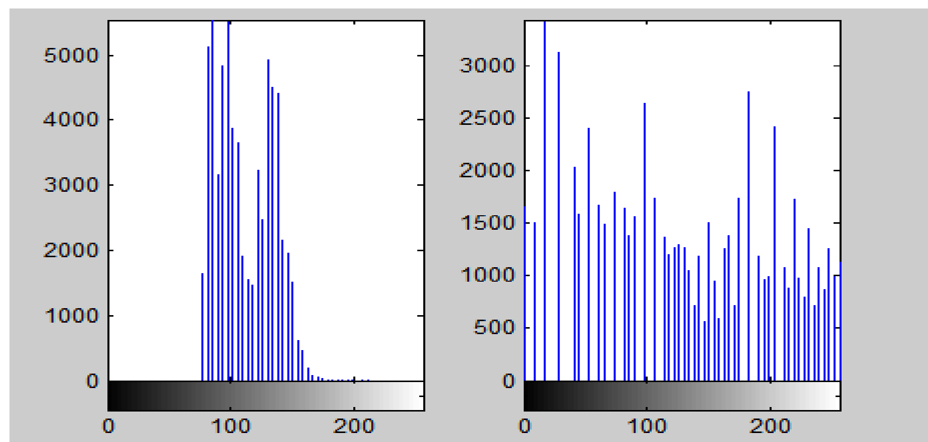


Color Space Conversions

applycform	Apply device-independent color space transformation
iccfind	Search for ICC profiles
iccread	Read ICC profile
iccroot	Find system default ICC profile repository
iccwrite	Write ICC color profile to disk file
isicc	True for valid ICC color profile
lab2double	Convert $L^*a^*b^*$ data to double
lab2uint16	Convert $L^*a^*b^*$ data to uint16
lab2uint8	Convert $L^*a^*b^*$ data to uint8
makecform	Create color transformation structure
ntsc2rgb	Convert NTSC values to RGB color space
rgb2ntsc	Convert RGB color values to NTSC color space
rgb2ycbcr	Convert RGB color values to YCbCr color space
whitepoint	*XYZ* color values of standard illuminants
xyz2double	Convert *XYZ* color values to double
xyz2uint16	Convert *XYZ* color values to uint16
ycbcr2rgb	Convert YCbCr color values to RGB color space

Histogram Equalization

```
%Histogram Equalizatio
I = imread('pout.tif')
J = histeq(I);
figure(1);
subplot(1,2,1);
imshow(I);
subplot(1,2,2);
imshow(J);
figure(2);
subplot(1,2,1);
imhist(I,64);
subplot(1,2,2);
imhist(J,64);
```



DERIVATIVES

Derivatives (Filters)

- In a continuos 1d Signal, derivative is:
  - lim dx->0   f(x+dx)-f(x)/dx
- In a discrete 1d signal, derivative is:
  - f(x+1)-f(x)
  - It is a convolution with the filter:

-1
1

  - Other popular filter is:

Sobel Filter

-1
0
1

Derivatives in 2D

Table 4.1 Derivative operators: their formal (continuous) definitions and corresponding discrete approximations

2 D derivative measure	Continuous case	Discrete case	KERNEL
$\frac{\partial f}{\partial x}$	$\lim_{\Delta x \to 0} \frac{f(x+\Delta x, y) - f(x,y)}{\Delta x}$	$f(x+1,y) - f(x,y)$	[1 -1]
$\frac{\partial f}{\partial y}$	$\lim_{\Delta y \to 0} \frac{f(x, y+\Delta y) - f(x,y)}{\Delta y}$	$f(x,y+1) - f(x,y)$	$\begin{bmatrix} -1 \\ 1 \end{bmatrix}$
$\nabla f(x,y)$	$\left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$	$[f(x+1,y) - f(x,y), f(x,y+1)$ $- f(x,y)]$	
$\frac{\partial^2 f}{\partial x^2}$	$\lim_{\Delta x \to 0} \frac{(\partial f/\partial x)(x+\Delta x, y) - (\partial f/\partial x) f(x,y)}{\Delta x}$	$f(x+1,y) - 2f(x,y) + f(x-1,y)$	[1 -2 1]
$\frac{\partial^2 f}{\partial y^2}$	$\lim_{\Delta y \to 0} \frac{(\partial f/\partial x)(x, y+\Delta y) - (\partial f/\partial x)(x,y)}{\Delta y}$	$f(x,y+1) - 2f(x,y) + f(x,y-1)$	[1 -2 1]’
$\nabla^2 f(x,y)$	$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$	$f(x+1,y) + f(x-1,y) - 4f(x,y)$ $+ f(x,y+1) + f(x,y-1)$	$\begin{matrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{matrix}$

Convolution

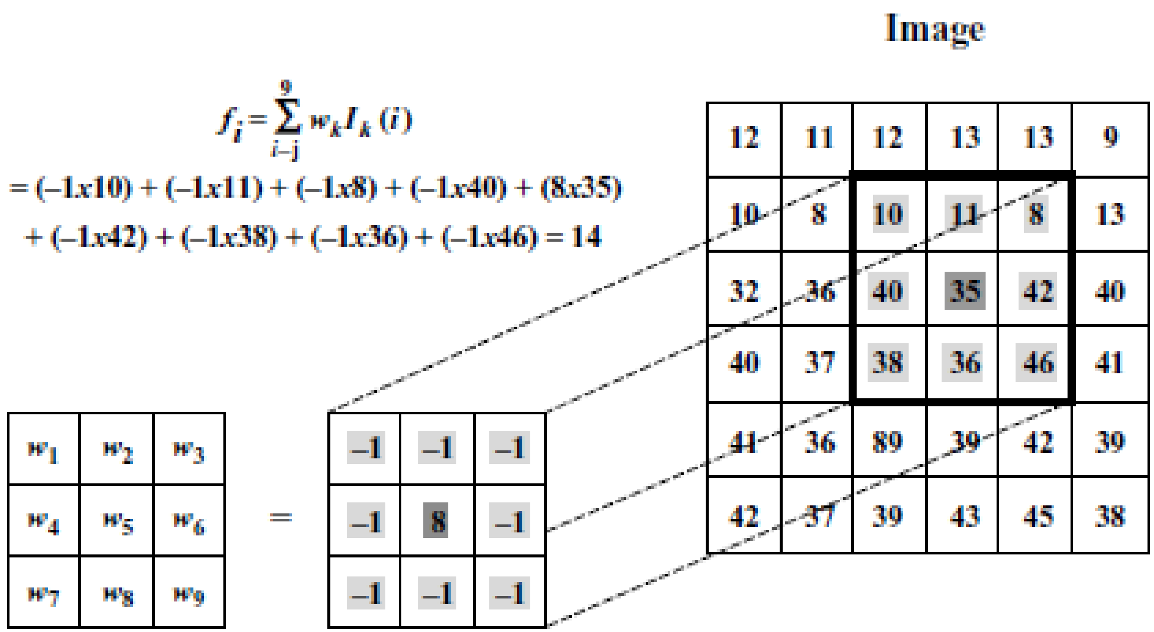
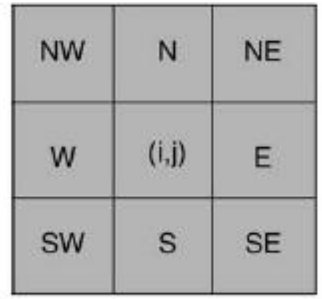
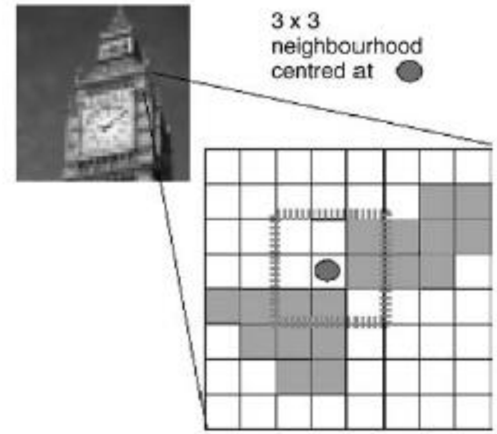


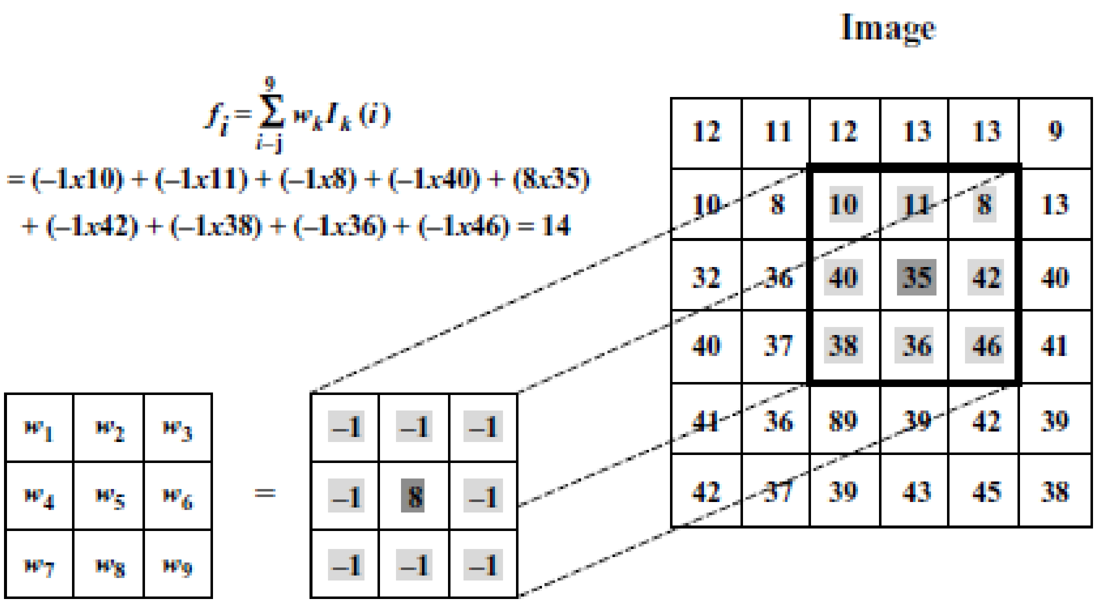
Figure 2.12 Discrete convolution. The centre pixel of the kernel and the target pixel in the image are indicated by the dark grey shading. The kernel is 'placed' on the image so that the centre and target pixels match. The filtered value of the target pixel is then given by a linear combination of the neighbourhood pixels, the specific weights being determined by the kernel values. In this specific case the target pixel of original value 35 has a filtered value of 14

Filtering in 2D Arrays (Convolution)





$$f_i = \sum_{i-j}^{9} w_k I_k(i)$$
$$= (-1x10) + (-1x11) + (-1x8) + (-1x40) + (8x35)$$
$$+ (-1x42) + (-1x38) + (-1x36) + (-1x46) = 14$$



Alternative derivatives in 2D

X derivative

Roberts

0	–1
1	0

Prewitt

1	0	–1
1	0	–1
1	0	–1

Sobel

1	0	–1
2	0	–2
1	0	–1

Y derivative

Roberts

–1	0
0	1

Prewitt

1	1	1
0	0	0
–1	–1	–1

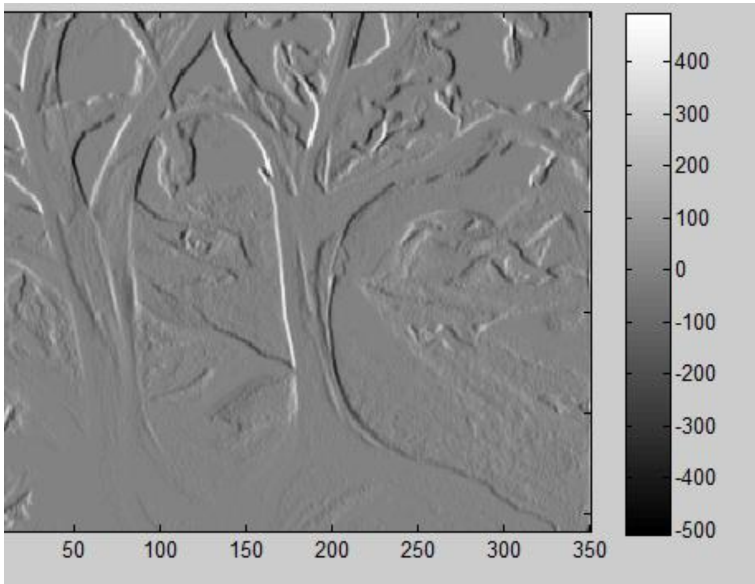
Sobel

1	2	1
0	0	0
–1	–2	–1

Figure 4.9 First-order edge-detection filters

Derivatives in Matlab

```
I = imread('trees.tif');
imshow(I)
k1=[ 1 0 -1;2 0 -2; 1 0 -1]
o=imfilter(double(I),k1,'same');
figure; imagesc(o)
colormap gray
```



QUESTION:Why imagesc instead of imshow ?

Gradient Magnitude and direction

```
% - Display derivative.
horgradI2=abs(conv2(double(I2),hcent,'same'));
figure;imshow(uint8(horgradI2));
vergradI2=abs(conv2(double(I2),hcent','same'));
figure;imshow(uint8(vergradI2));

% - Compute gradient magnitude and direction.
gradMag=sqrt(vergradI2.^2+horgradI2.^2);
figure;imshow(uint8(gradMag));
gradDir=atan2(vergradI2,horgradI2);
```

FILTERING

Mean filter

```
% - Box kernel for image smoothing
I1 = imread('groceries.jpg');
I2 = rgb2gray(I1);
h=ones(7)/49;
I6=uint8(conv2(I2,h,'same'));
figure;imshow(I6);
```

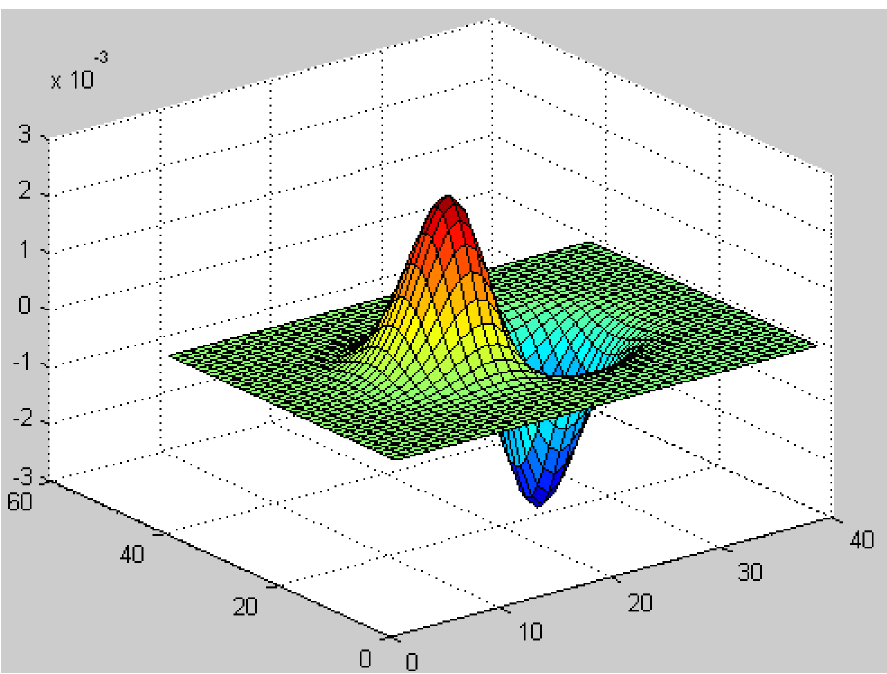
Special filters

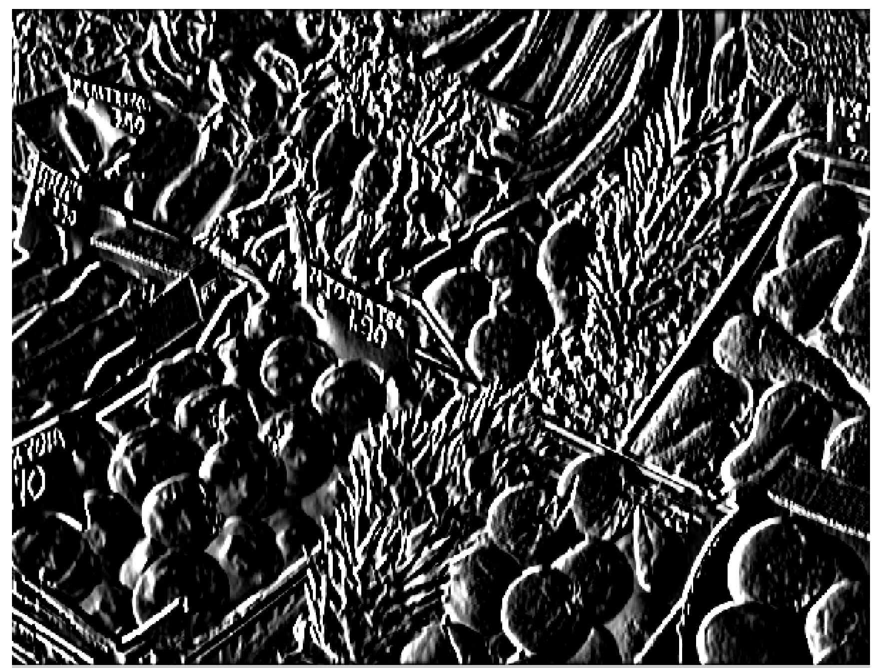
```
% - fspecial. Create arbitrary sized Gaussian kernel
% with different sizes and variances and their effects on smoothing (over/under smooth)
hg = fspecial('gaussian', [7 7], 1);

% - Use Gaussian kernel for smoothing
I3=conv2(double(I2),hg,'same');
imshow(uint8(I3));
```

Gaussian Derivative

```
% - Gaussian derivative. Wrote a one line code/formula for creating a Gaussian derivative kernel, for gradient computa
% - I emphasized Gaussian derivative and that, in general, this should be used for gradient computation of images.
gaussder = conv2(fspecial('gaussian',[7 7],4),[1 0 -1],'valid');
figure;surf(gaussder);
I4= conv2(double(I2),gaussder);
imshow(I4);
```





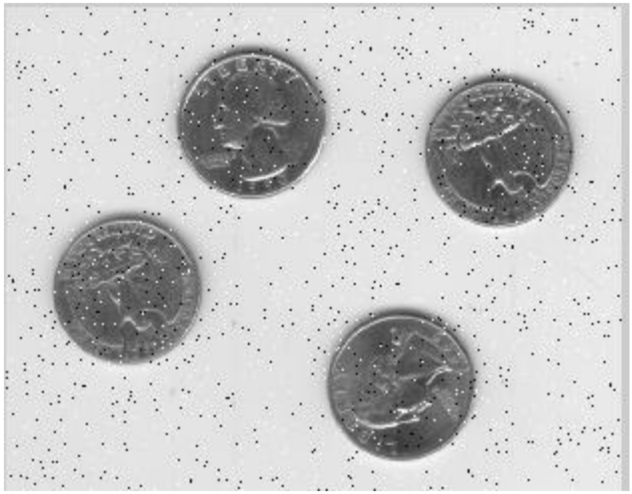
Separable Filters

```
% - Separable kernels
% - Computing derivatives
close all;
keyboard;
M=magic(7)
f1=[1;-1] % vertical gradient
f2=[-1 1] % horizontal gradient
a=conv2(double(M),f1,'same')
b=conv2(double(a),f2,'same')
f3=f1*f2
c=conv2(double(M),f3,'same')
sum(sum(abs(b-c)))
```

Ans = 0

Example: Removing noise

```
% Create a noisy image
I = imread('eight.tif');
imshow(I)
J = imnoise(I,'salt & pepper',0.02);
figure, imshow(J)
```



```
% Mean filter
K = filter2(fspecial('average',3),J)/255;
figure, imshow(K)

%Median filter
L = medfilt2(J,[3 3]);
figure, imshow(L)
```

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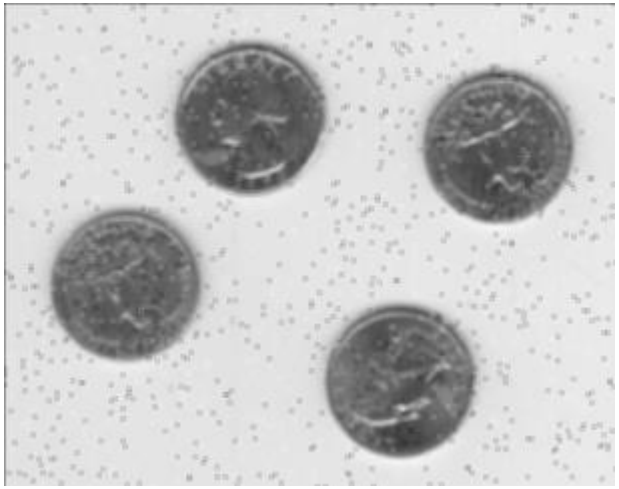

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```

```
%Median filter
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```

Smoothing

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

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

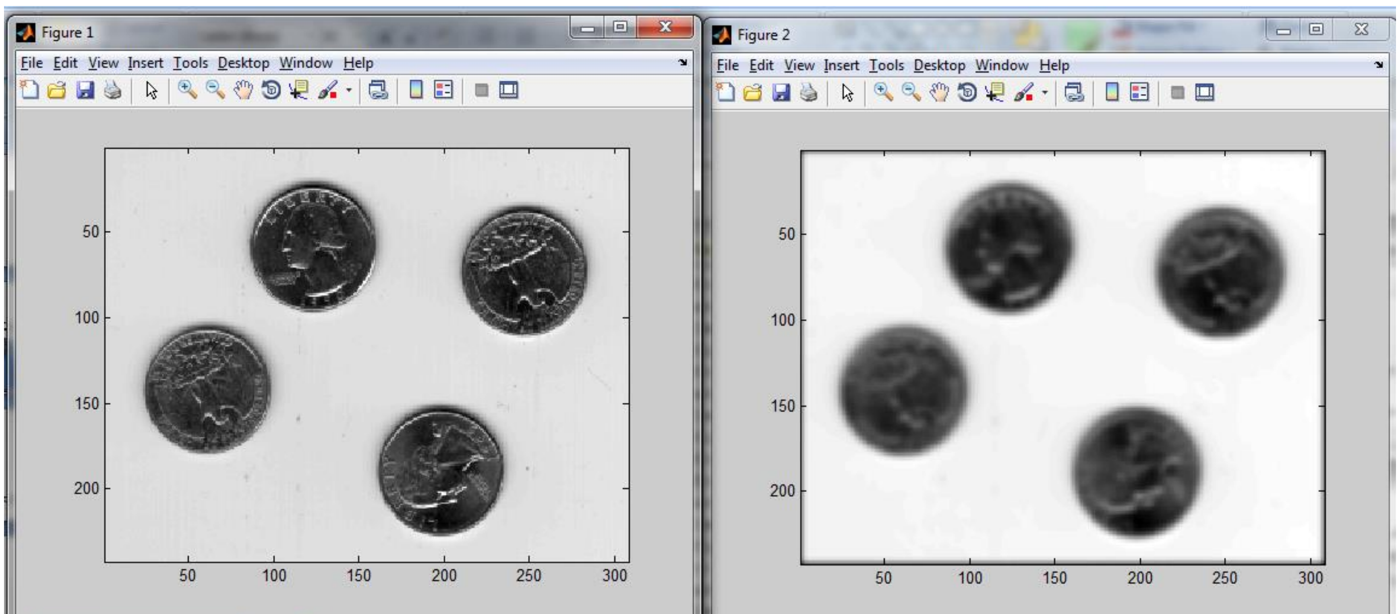
L is a blurred image
- G is the Gaussian Blur operator
- I is an image
- x,y are the location coordinates
- σ is the “scale” parameter. Think of it as the amount of blur. Greater the value, greater the blur.
- The * is the convolution operation in x and y. It “applies” gaussian blur G onto the image I

Smoothing function

```
% gauss_filter: Obtains a smoothed gaussian filter image
%    - Output:
%        smooth: image filter by a gaussian filter
%    - Input:
%        image:  Matrix containing single band image.
%        sigma:  Value of the sigma for the Gaussian filter
%        kernel_size: Size of the gaussian kernel (default: 6*sigma)
function [smooth]= gauss_filter(image,sigma,kernel_size)
if nargin < 2
    sigma=1;
end
if nargin < 3
    kernel_size=6*sigma;
end
gaussian_radio=floor(kernel_size/2);  %radio of the gaussian
x=[-gaussian_radio : gaussian_radio];   % x values (gaussian kernel size)
gaussiano= exp(-x.^2/(2*sigma^2))/(sigma*sqrt(2*pi) );   %calculate the unidimensional gaussian
temp=conv2(double(image),double(gaussiano),'same');
smooth=conv2(double(temp),double(gaussiano'),'same');
end
```

Example smoothing

```
I = imread('eight.tif'); imagesc(I); colormap gray;
antialiassigma=2;
Ismooth=gauss_filter(I,antialiassigma,11);
figure;  imagesc(Ismooth); colormap gray;
```



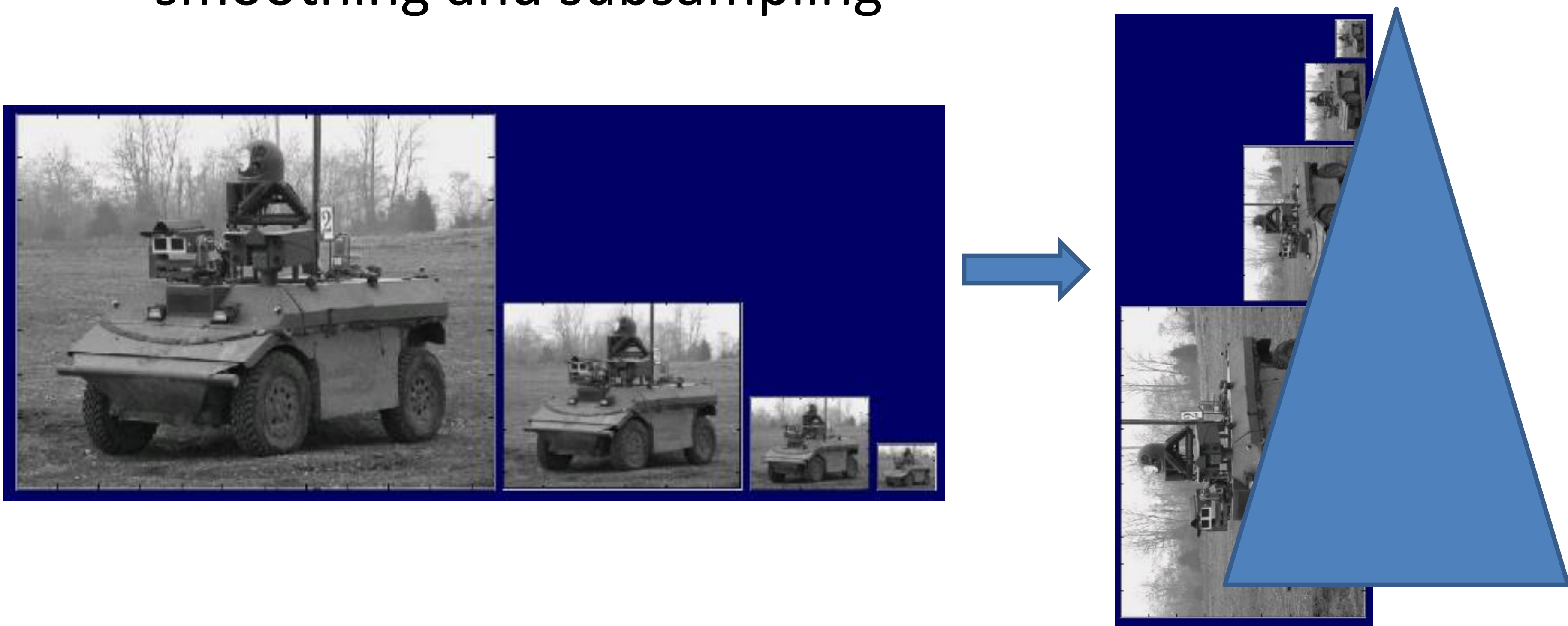
Resize

```
%Resizing an image
%Y=imresize(X,rows,cols,method);   %method -nearest bilinear, bicubic

[X,map]=imread ('groceries.jpg');
Y=imresize(X,[100,200],'bicubic');    %method -nearest bilinear, bicubic
imshow(Y);
```

Pyramid

- Definition:
  - is a type of multi-scale signal representation in which a signal or an image is subject to repeated smoothing and subsampling



Pyramid

```
I0 = imread('cameraman.tif');
I1 = impyramid(I0, 'reduce');
I2 = impyramid(I1, 'reduce');
I3 = impyramid(I2, 'reduce');

imshow(I0)
figure, imshow(I1)
figure, imshow(I2)
figure, imshow(I3)
```