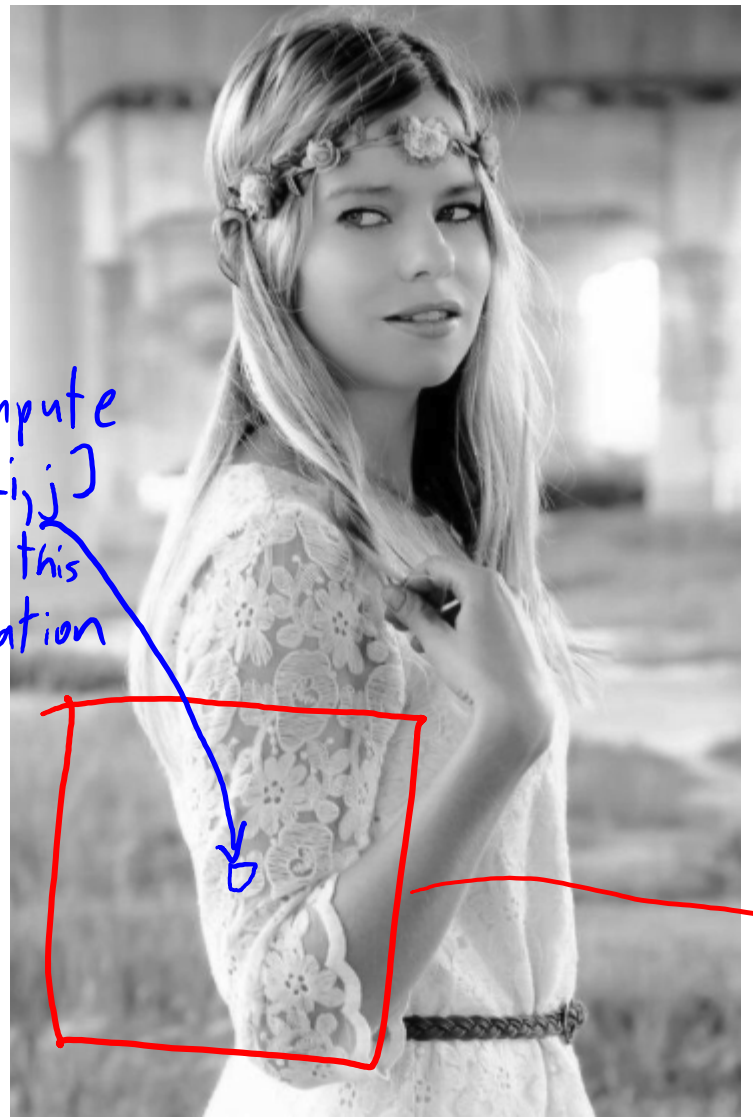
CPSC 340:
Machine Learning and Data Mining

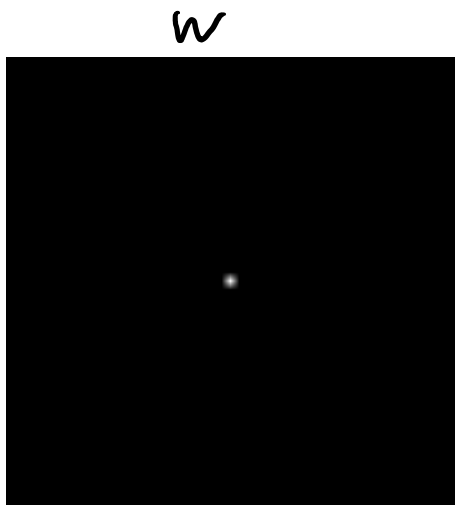
Convolutional Neural Networks

BONUS SLIDES

(convolutions)

Image Convolution Examples





multiply element-wise and add up result to get z[i,j]

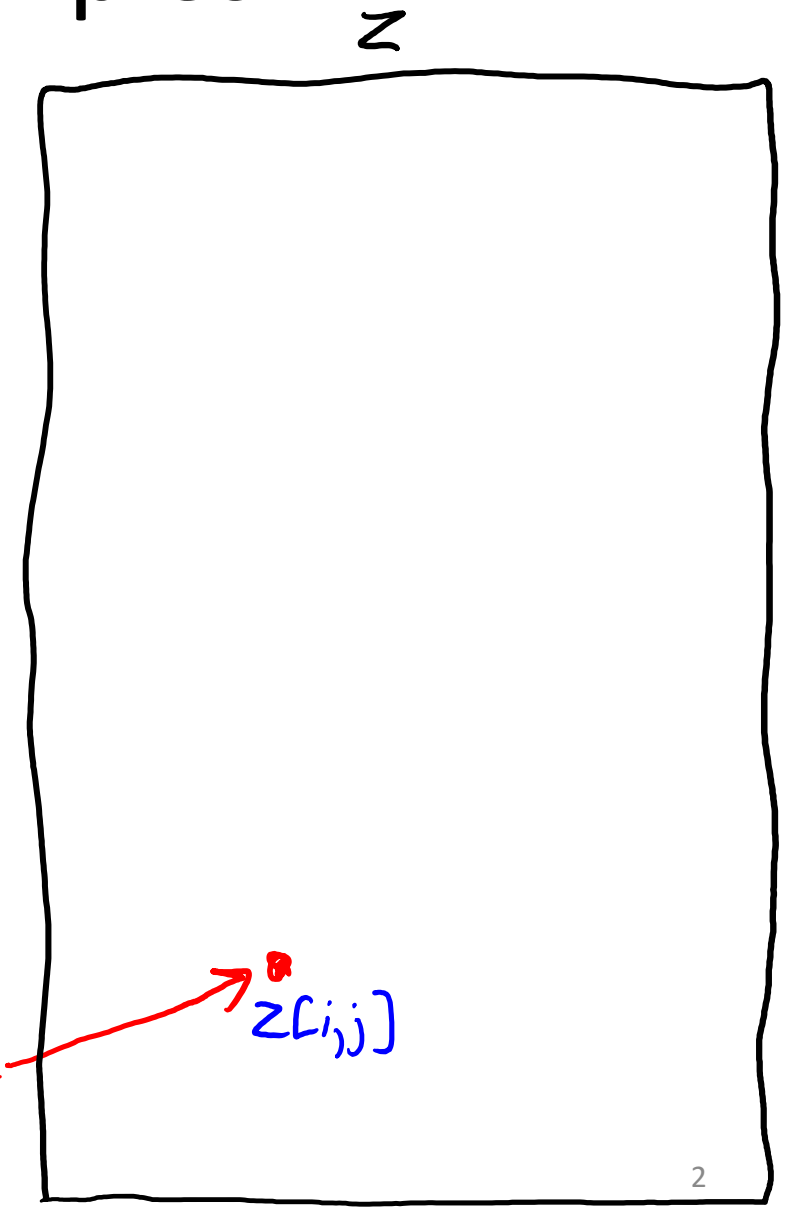


Image Convolution Examples

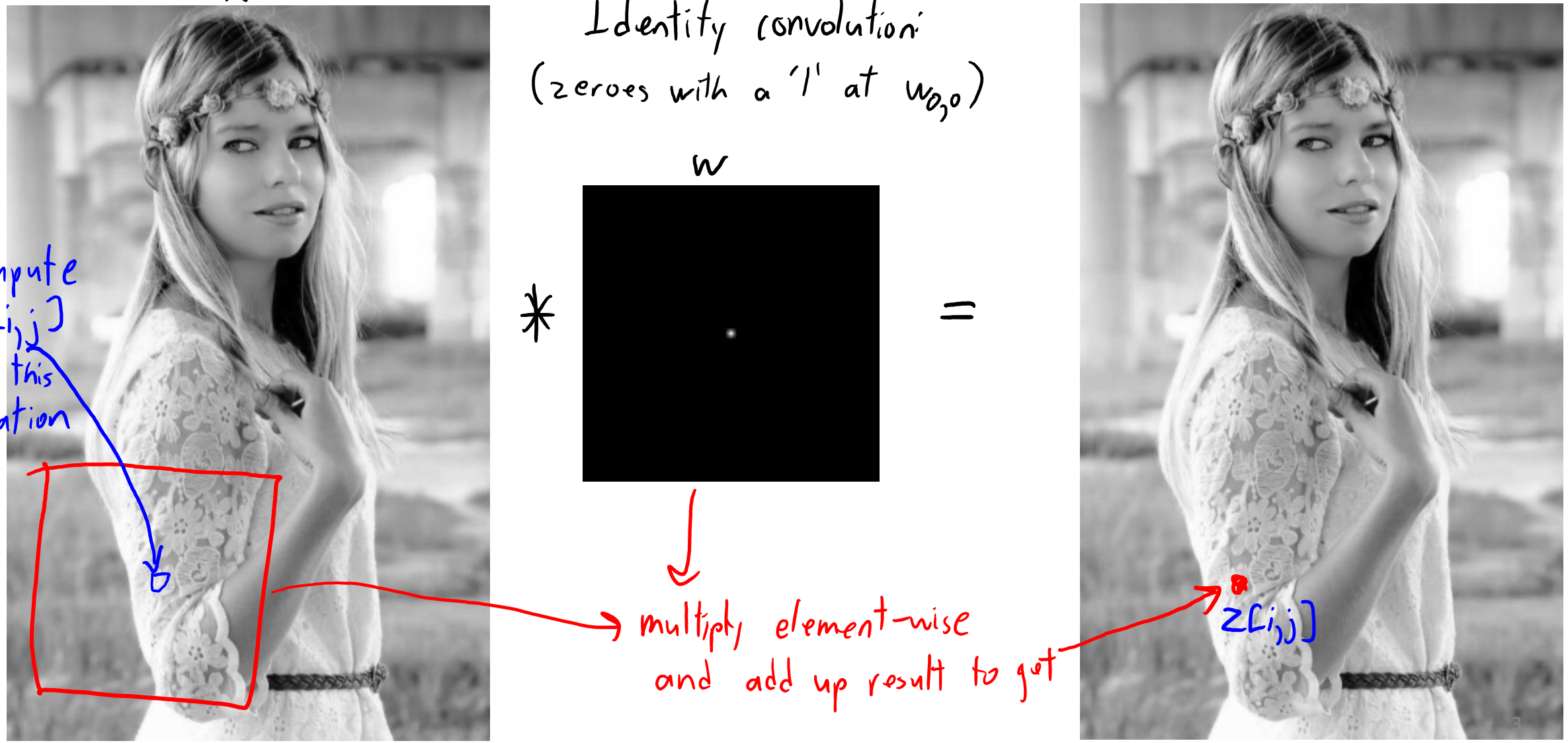


Image Convolution Examples

Translation Convolution:

*

=

Boundary: "zero"

Image Convolution Examples

Translation Convolution:

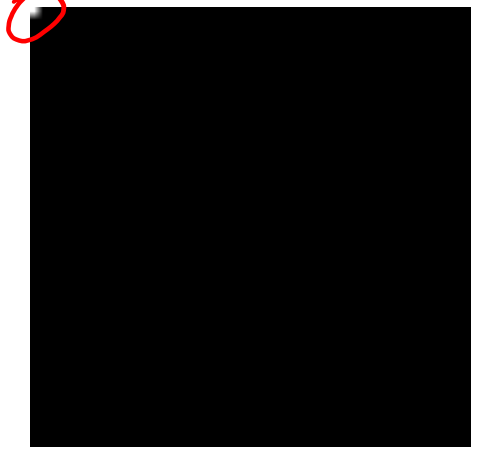
*

=

Boundary: "replicate"

Image Convolution Examples

Translation Convolution:

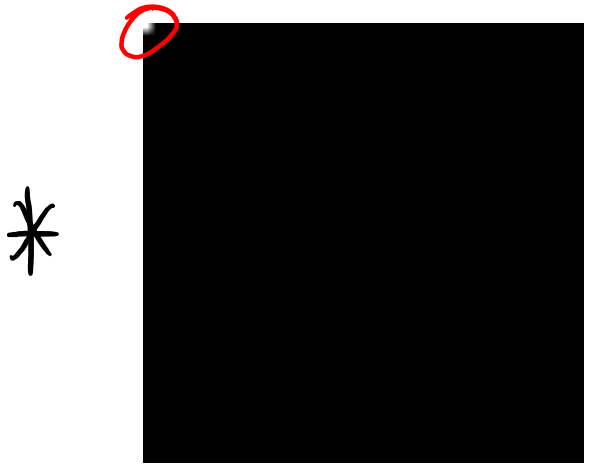


Boundary: "mirror"

flips

Image Convolution Examples

Translation Convolution:



Boundary: "ignore"

Image Convolution Examples

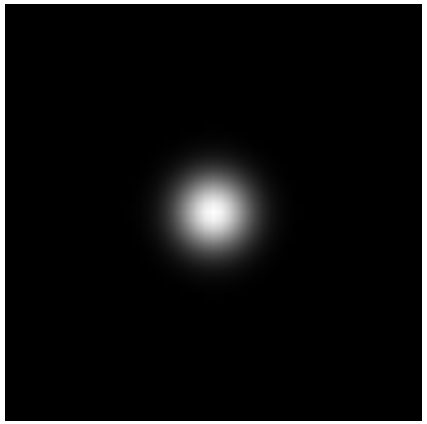
Average convolution:

$$* \frac{1}{51} \begin{bmatrix} 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & \cdots & 1 \end{bmatrix} =$$

Image Convolution Examples

Gaussian Convolution:

$*$



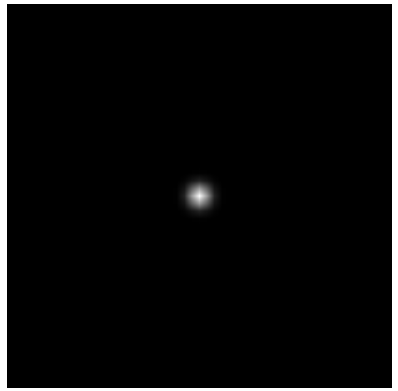
$=$

(smooths image)

Image Convolution Examples

Gaussian Convolution:

*



(smaller variance)

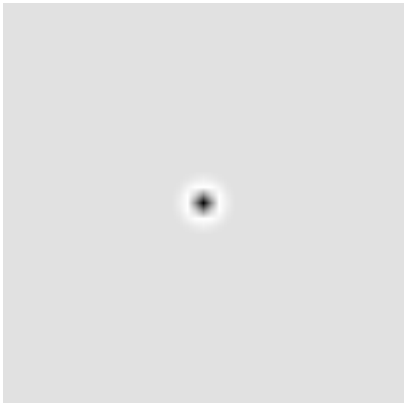
=

(smooths image)

Image Convolution Examples

Laplacian of Gaussian

$*$



$=$

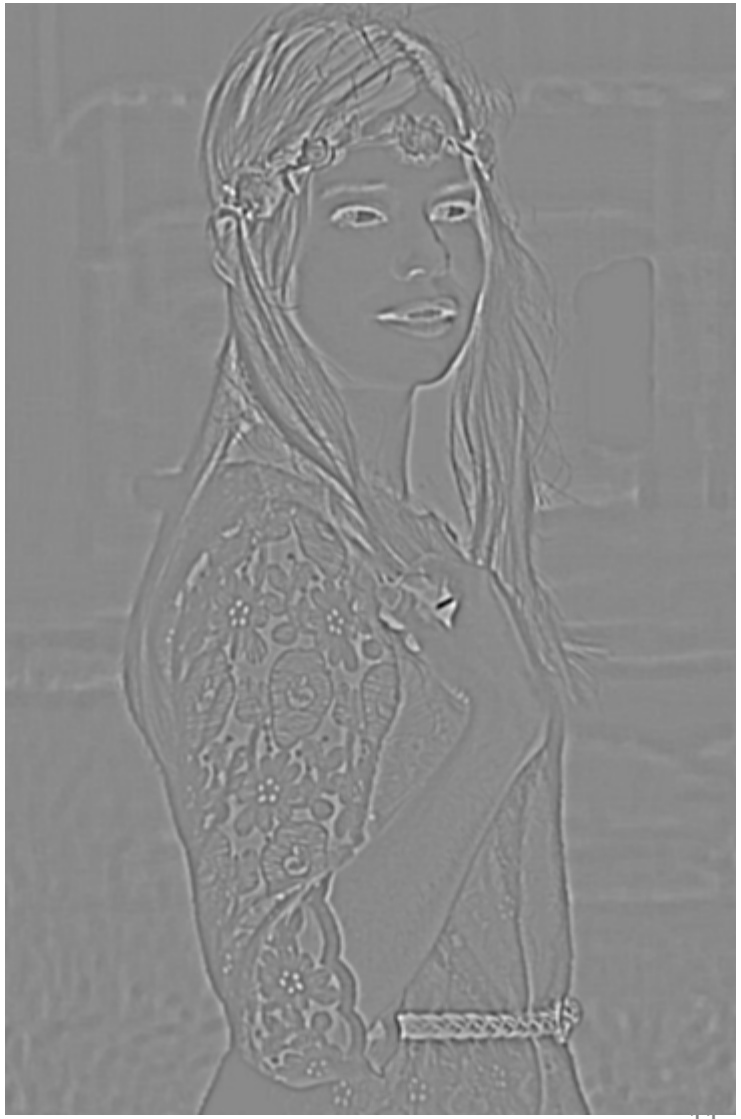
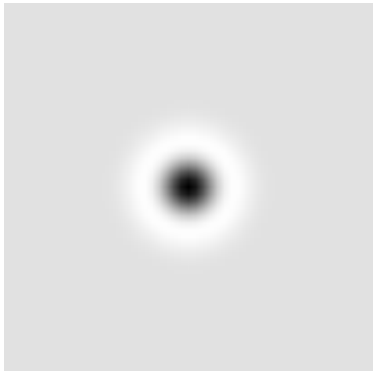


Image Convolution Examples

Laplacian of Gaussian

$*$



$=$

(larger variance)

Similar preprocessing may be done in basal ganglia and LGN.

Image Convolution Examples

"Emboss" filter:

$$* \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix} =$$

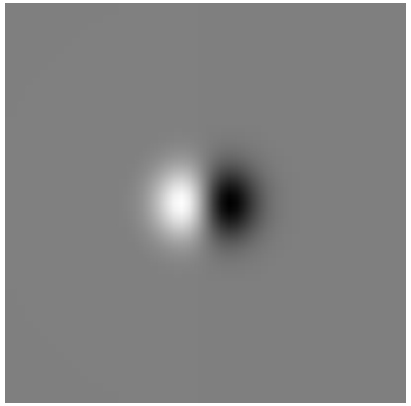
Many Photoshop effects are just convolutions.

http://setosa.io/ev/image-kernels

Image Convolution Examples

Gabor Filter
(Gaussian multiplied by sine or cosine)

*



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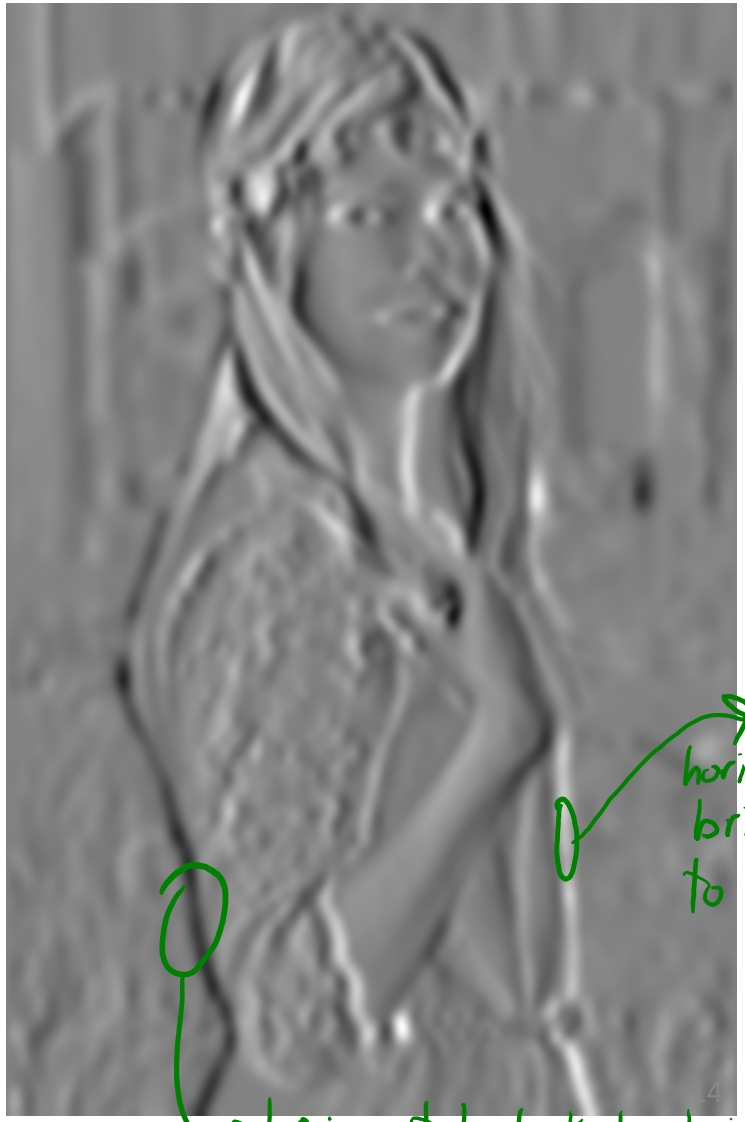

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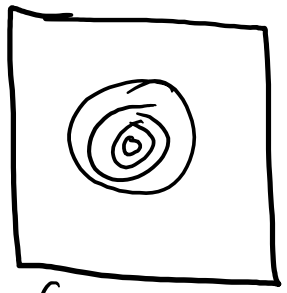
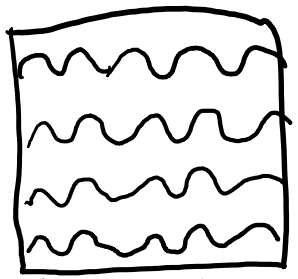


Gaussian

*



Parallel Sine functions

Image Convolution Examples

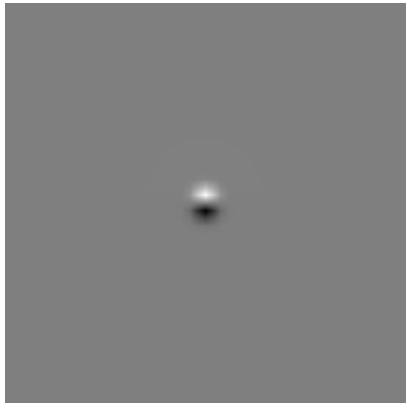
Gabor Filter
(Gaussian multiplied by sine or cosine)

Different orientations of the sine/cosine let us detect changes with different orientations.

Image Convolution Examples

Gabor Filter
(Gaussian multiplied by sine or cosine)

*



(smaller variance)

=

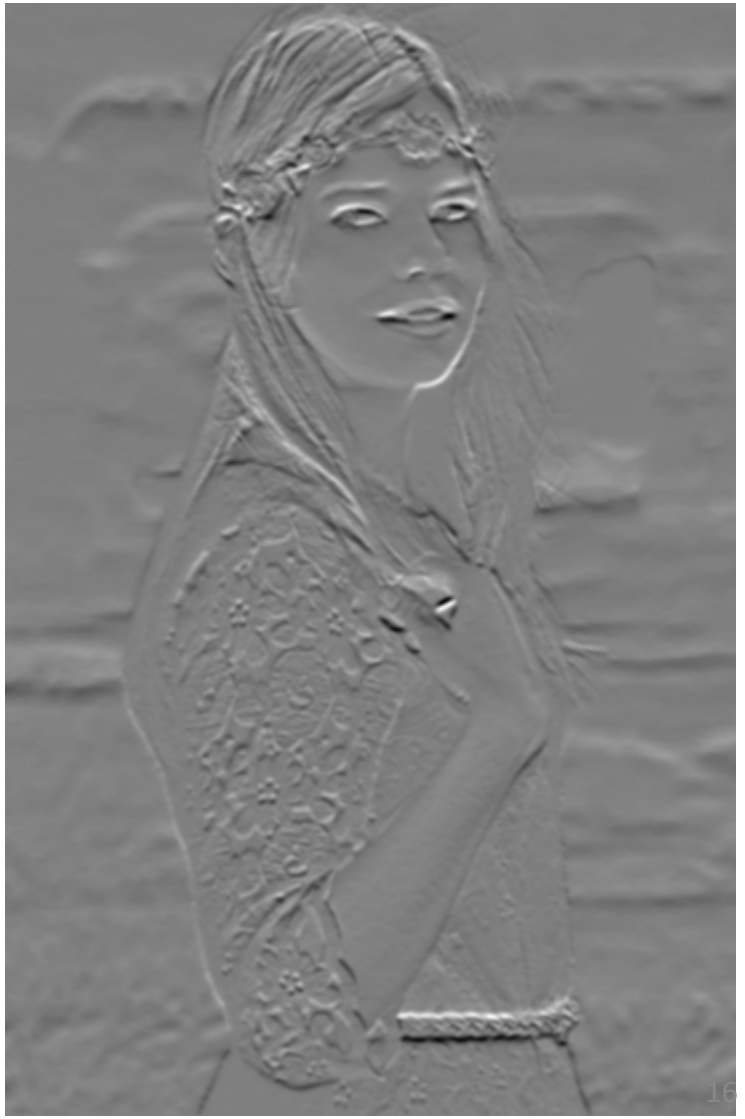
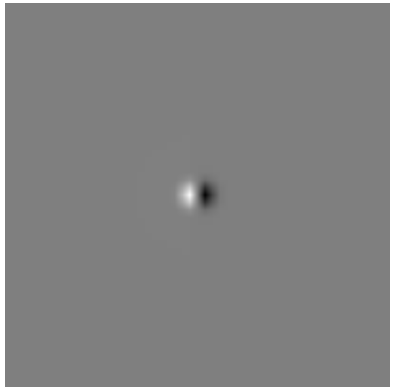


Image Convolution Examples

Gabor filter
(Gaussian multiplied by sine or cosine)

*



=

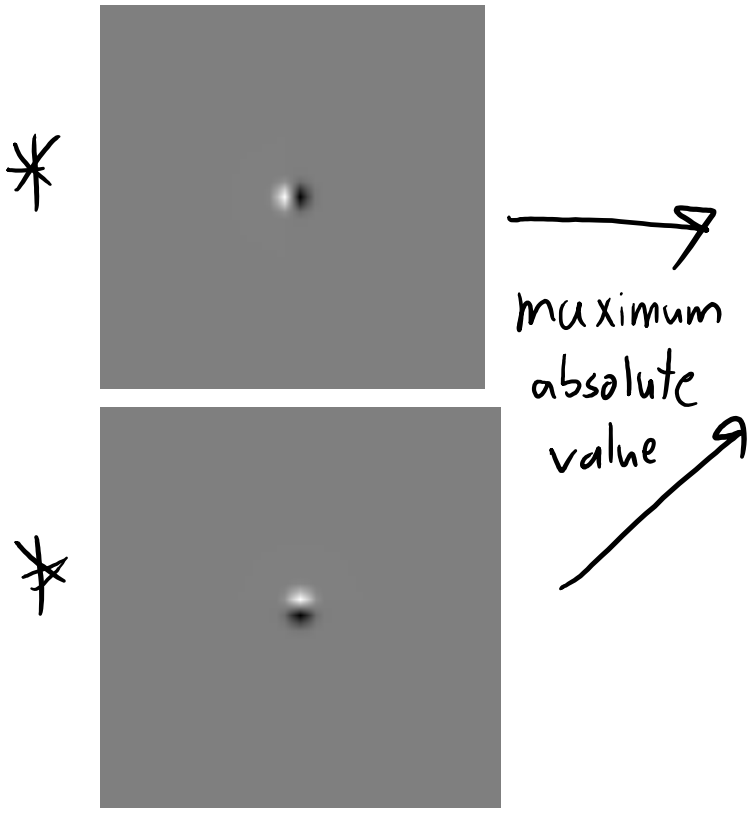
(smaller variance)

Vertical orientation

- Can obtain other orientations by rotating.
- May be similar to effect of V1 "simple cells."

Image Convolution Examples

Max absolute value between horizontal and vertical Gabor:



maximum absolute value

"Horizontal/vertical edge detector"

3D Convolution

Represent as RGB

Can apply 3D convolutions

3D Convolution

Gaussian filter

3D Convolution

Gaussian filter

(higher variance on green channel)

3D Convolution

Sharpen the blue channel.

3D Convolution

Gabor filter on each channel.