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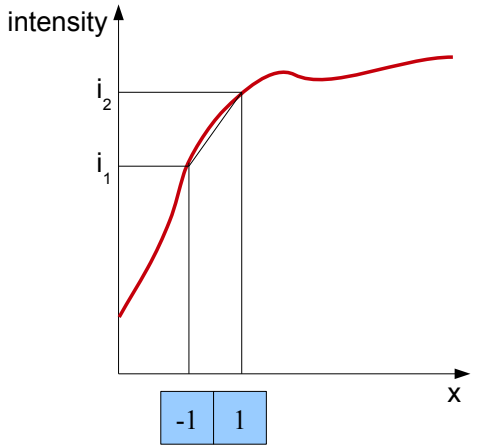
1st derivative mask

Estimate of gradient is $\frac{\Delta y}{\Delta x}$ i.e.: (i_2-i_1)



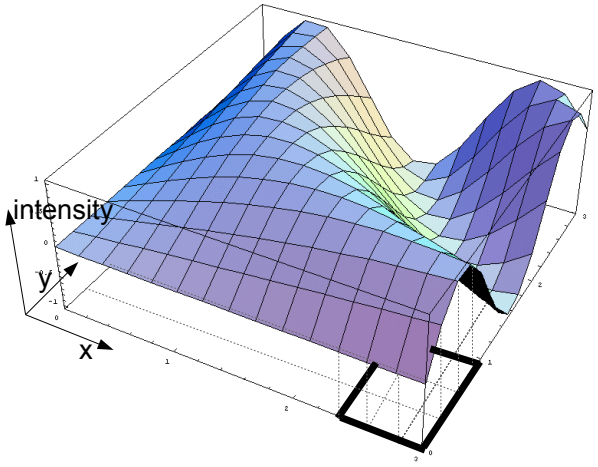
Difference Masks

As well as calculating averages (as with box and Gaussian masks), convolution can also be used to calculate differences.

The difference between pixel values measures the gradient of the intensity values.

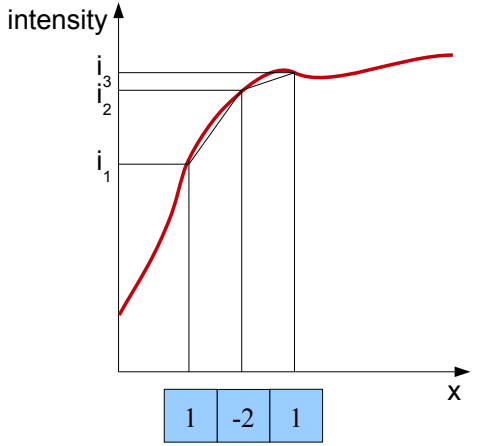
Hence:

- smoothing masks approximate integration
- difference masks approximate differentiation



2nd derivative mask

Estimate of change of gradient is $(i_3-i_2)-(i_2-i_1)$



Difference masks for different directions

vertical	horizontal	diagonals ← **Mask orientation**
horizontal	vertical	diagonals ← **Orientation of intensity change detected**

1st derivative masks:

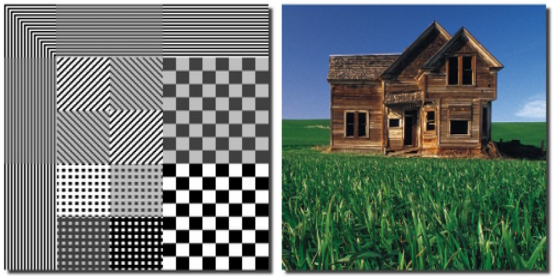
-1	$\approx -\delta/\delta y$	-1	1	-1	0	0	-1
1		$\approx -\delta/\delta x$		0	1	1	0

2nd derivative masks:

-1		-1	2	-1	-1	0	0	0	0	-1
2	$\approx -\delta^2/\delta y^2$				0	2	0	0	2	0
-1		$\approx -\delta^2/\delta x^2$			0	0	-1	-1	0	0

Difference mask example

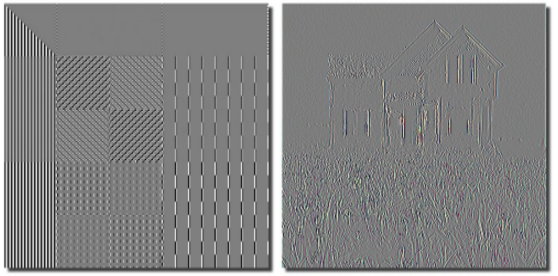
Original Images



Images convolved with horizontal difference mask

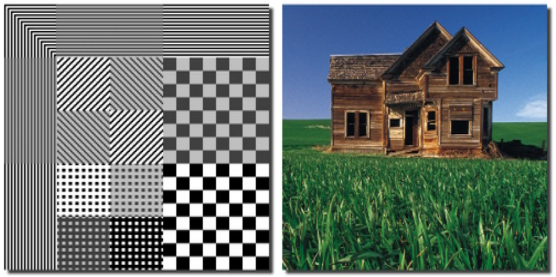
-1	2	-1

$(-\delta^2/\delta x^2)$



Difference mask example

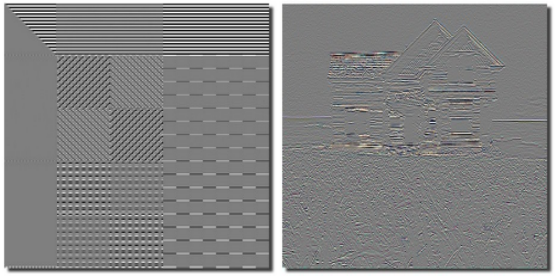
Original Images



Images convolved with vertical difference mask

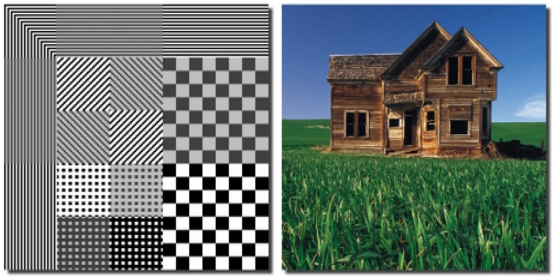
-1
2
-1

$(-\delta^2/\delta y^2)$



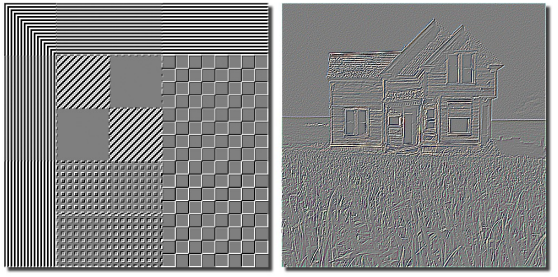
Difference mask example

Original Images



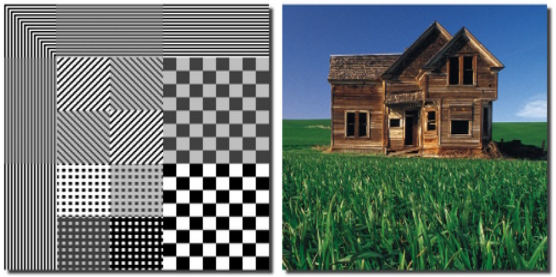
Images convolved with diagonal difference mask

-1	0	0
0	2	0
0	0	-1



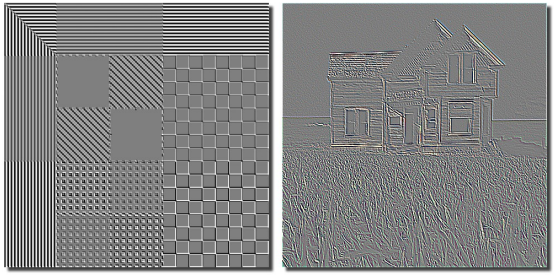
Difference mask example

Original Images



Images convolved with diagonal difference mask

0	0	-1
0	2	0
-1	0	0



The Laplacian mask

The final example be seen as a combination of 2nd derivative difference masks in each direction.

It therefore detects intensity discontinuities at all orientations.

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

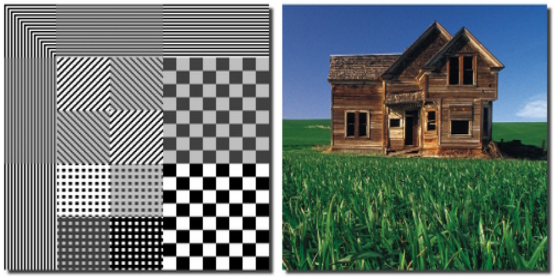
$$\approx -\delta^2/\delta x^2 - \delta^2/\delta y^2$$

Called the Laplacian mask.

However, note that strictly the Laplacian should be the additive inverse of this mask.

Difference mask example

Original Images



Images convolved with vertical + horizontal + both diagonal difference mask

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

$$\approx -\delta^2/\delta x^2 - \delta^2/\delta y^2$$