

Edge Detection (Turunan ke dua)

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Using Second Derivatives for Image Enhancement

- The 2nd derivative is more useful for image enhancement than the 1st derivative
 - Stronger response to fine detail
 - Simpler implementation

- The first sharpening filter we will look at is the *Laplacian*
 - Isotropic
 - One of the simplest sharpening filters
 - We will look at a digital implementation

The Laplacian

- The Laplacian is defined as follows:

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

- where the partial 1st order derivative in the x direction is defined as follows:

$$\frac{\partial^2 f}{\partial^2 x} = f(x+1, y) + f(x-1, y) - 2f(x, y)$$

- and in the y direction as follows:

$$\frac{\partial^2 f}{\partial^2 y} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

The Laplacian (cont...)

- So, the Laplacian can be given as follows:

$$\begin{aligned}\nabla^2 f = & [f(x+1, y) + f(x-1, y) \\ & + f(x, y+1) + f(x, y-1)] \\ & - 4f(x, y)\end{aligned}$$

- We can easily build a filter based on this

0	1	0
1	-4	1
0	1	0

The Laplacian (cont...)

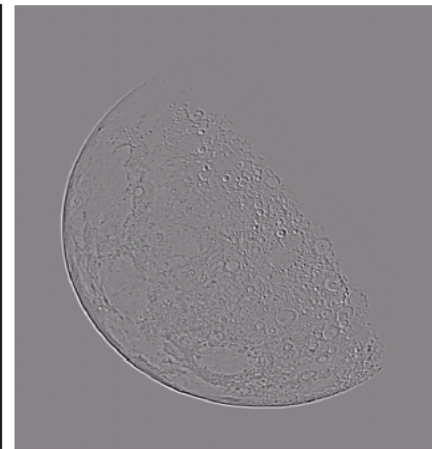
- Applying the Laplacian to an image we get a new image that highlights edges and other discontinuities



Original
Image



Laplacian
Filtered Image



Laplacian
Filtered Image
Scaled for Display

But That Is Not Very Enhanced!

- The result of a Laplacian filtering is not an enhanced image
- We have to do more work in order to get our final image
- Subtract the Laplacian result from the original image to generate our final sharpened enhanced image

$$g(x, y) = f(x, y) - \nabla^2 f$$



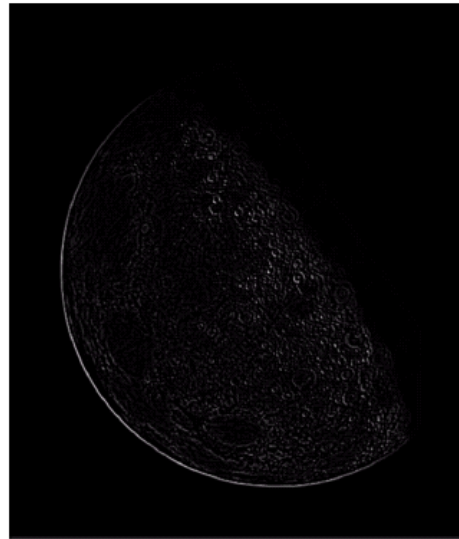
Laplacian
Filtered Image
Scaled for Display

Laplacian Image Enhancement



Original
Image

-



Laplacian
Filtered Image

=



Sharpened
Image

- In the final sharpened image edges and fine detail are much more obvious

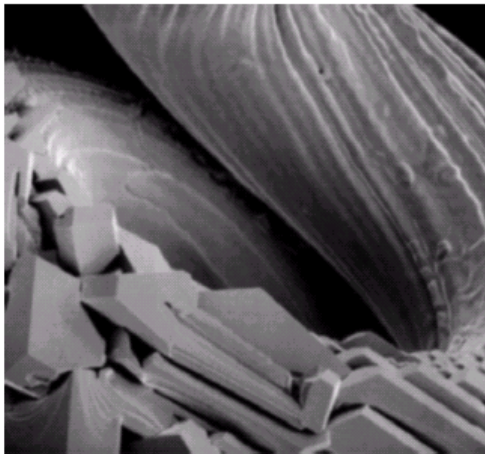
Simplified Image Enhancement

- The entire enhancement can be combined into a single filtering operation

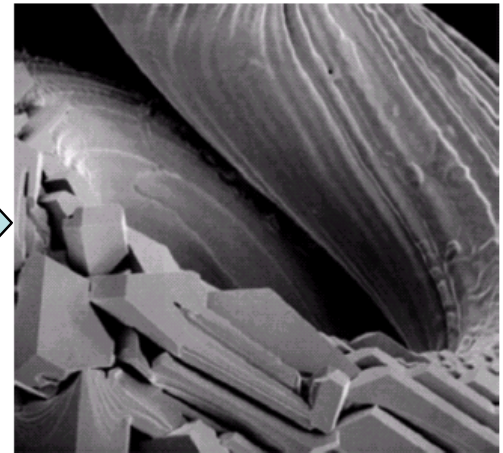
$$\begin{aligned}g(x, y) &= f(x, y) - \nabla^2 f \\ &= f(x, y) - [f(x+1, y)f(x-1, y) \\ &\quad + f(x, y+1) + f(x, y-1)] \\ &\quad + 4f(x, y) \\ &= 5f(x, y) - [f(x+1, y)f(x-1, y) \\ &\quad + f(x, y+1) + f(x, y-1)]\end{aligned}$$

Simplified Image Enhancement (cont...)

- This gives us a new filter which does the whole job for us in one step



0	1	0
1	5	1
0	1	0



Variants on the Simple Laplacian

- There are lots of slightly different versions of the Laplacian that can be used:

0	1	0
1	-4	1
0	1	0

Simple
Laplacian

1	1	1
1	-8	1
1	1	1

Variant of
Laplacian

