

KERATECH

INTRODUCCIÓN AL PROCESAMIENTO DE IMÁGENES

EDWIN MENDOZA

AGENDA

1



1

Convolucion

2

Filtros espaciales lineales

3

Filtros espaciales no lineales

The background is a blurred photograph of a classroom or meeting room. A man in a white shirt stands at the front, gesturing with his hand. Several people are seated in the foreground, seen from behind. The image has a teal overlay.

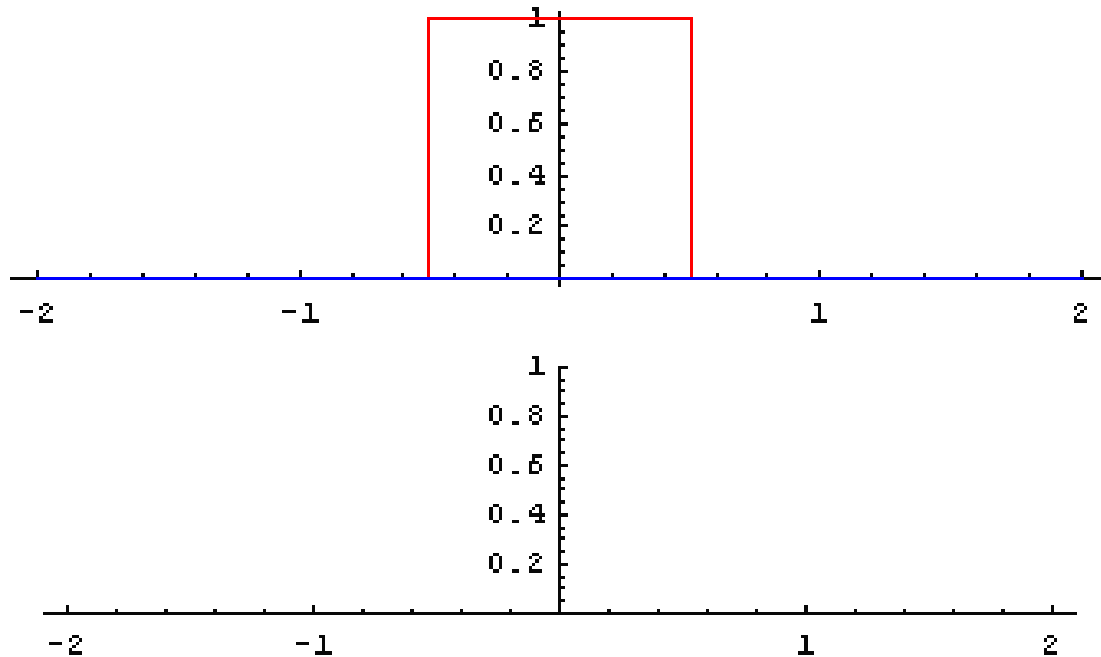
01

Convolucion



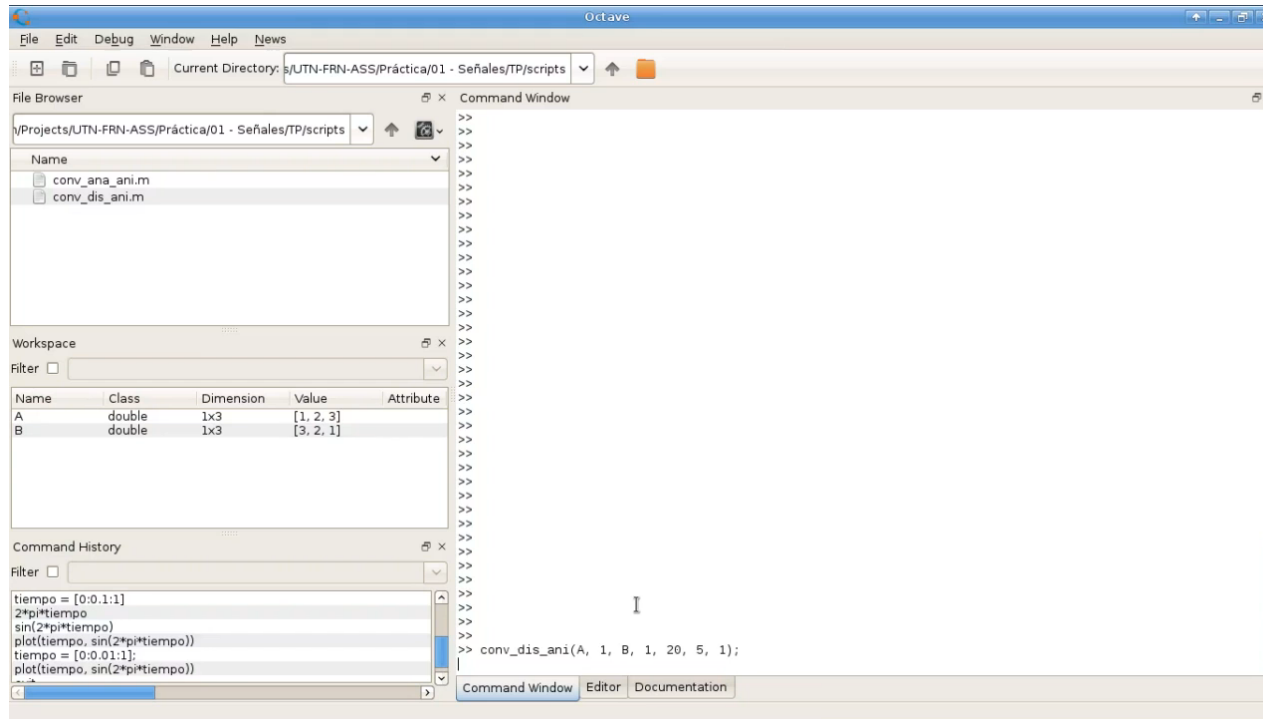
¿Qué es la
convolucion?

Convolution – 1D



$$(f * g)(t) = \int_{-\infty}^{+\infty} f(n)g(t - n) dn$$

Convolution - 1D



$$f[m] * g[m] = \sum_n f[n]g[m - n]$$



¿Y en 2D?

Convolution - 2D

35	40	41	45	50
40	40	42	46	52
42	46	50	55	55
48	52	56	58	60
56	60	65	70	75

*

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

=

35	40	41	45	50
40	78	87	94	52
42	98	283	108	55
48	120	125	127	60
560	60	65	70	75

$$g(x, y) = h(x, y) * f(x, y) = \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} f(i, j) h(x - i, y - j)$$

Convolution - 2D

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*

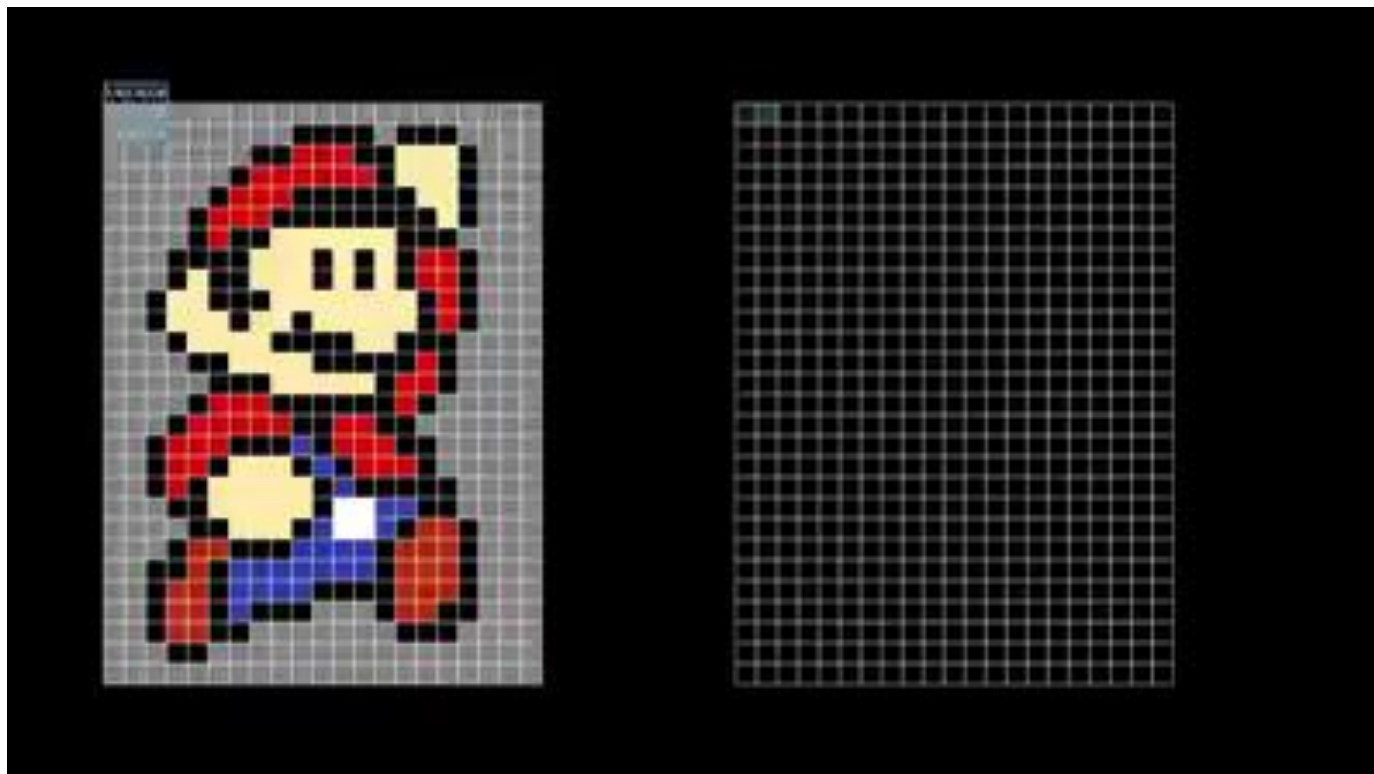
-2	-1	0
-1	1	1
0	1	2

=

35	40	41	45	50
40	78	87	94	52
42	98	109	108	55
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$$g(x, y) = h(x, y) * f(x, y) = \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} f(i, j) h(x - i, y - j)$$

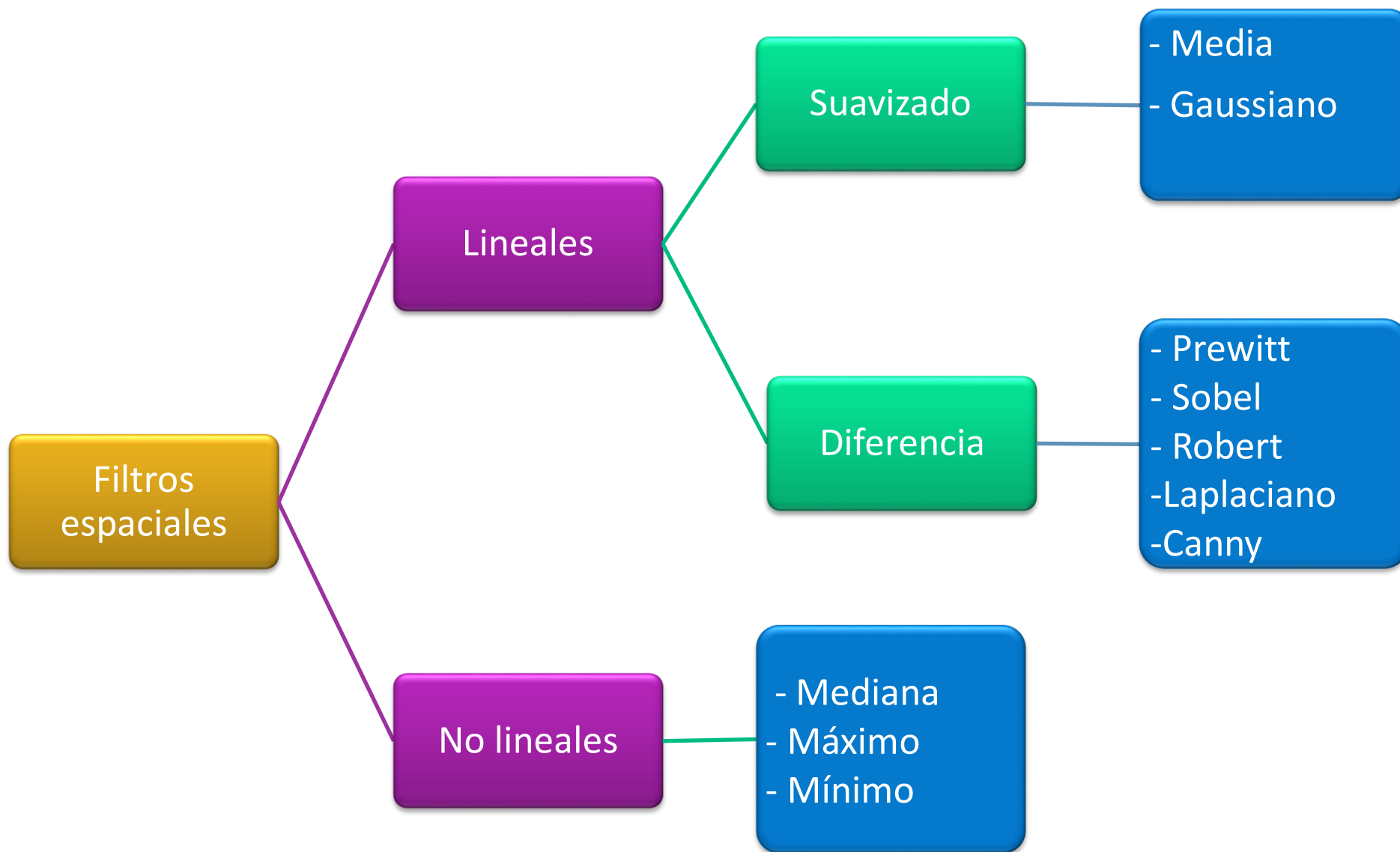
Convolution - 2D





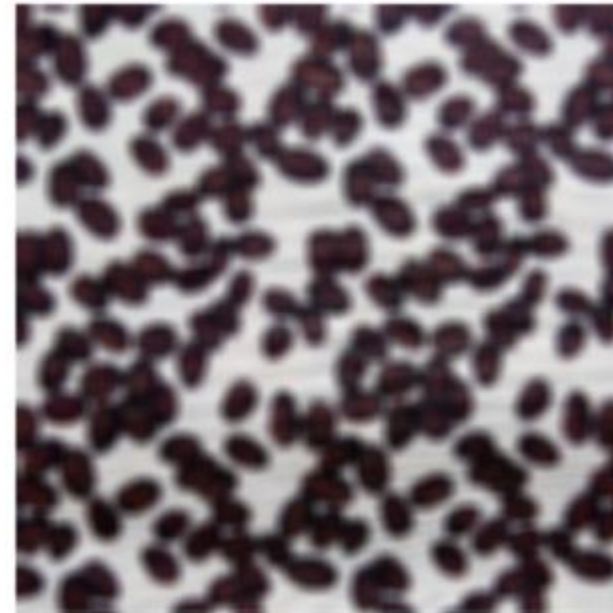
02

Filtros espaciales lineales



Filtro Lineal-Suavizado-Media

$$\text{Kernel} = \frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$



Filtro Lineal-Suavizado-Gaussiano

$$\text{Kernel} = \frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Original



Gaussiano 3x3



Gaussiano 5x5



Filtro Lineal-Suavizado-Gaussiano

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

$$\sigma = 1.0$$

$$\frac{1}{273} *$$

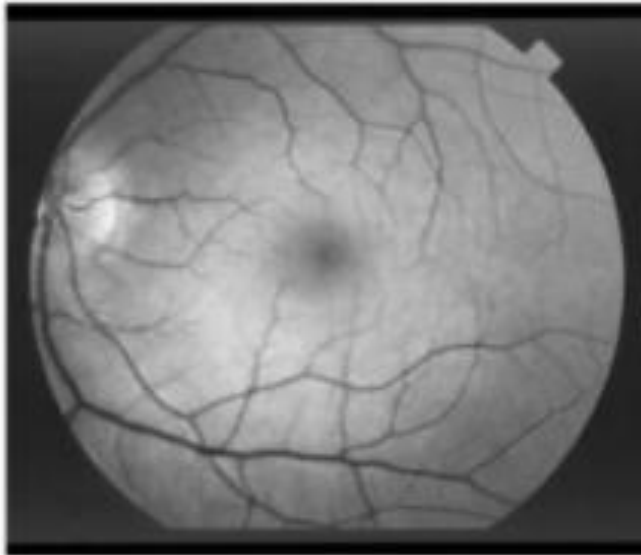
1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

Filtro Lineal-Diferencia-Prewit

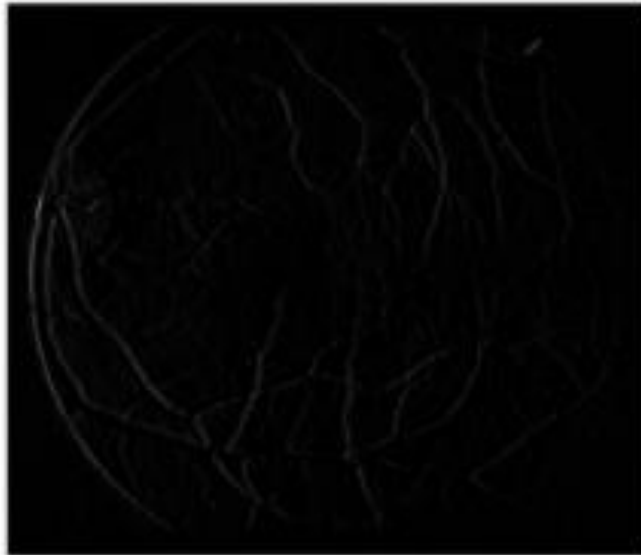
$$\text{Kernel_x} = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$\text{Kernel_Y} = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

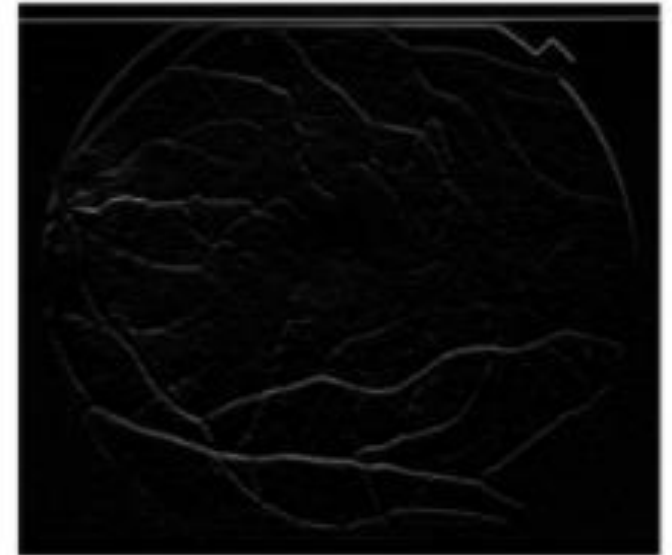
Original



filtro de Prewitt X



filtro de Prewitt Y



Filtro Lineal-Diferencia-Prewit

$$\frac{\partial f}{\partial x} = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \approx \frac{2 * \Delta f}{2 * \Delta h}$$

$$\frac{\partial I_{(x,y)}}{\partial x} \approx \frac{I_{(x+1,y)} - I_{(x,y)} + I_{(x,y)} - I_{(x-1,y)}}{2} = \frac{I_{(x+1,y)} + 0 * I_{(x,y)} - I_{(x-1,y)}}{2}$$

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

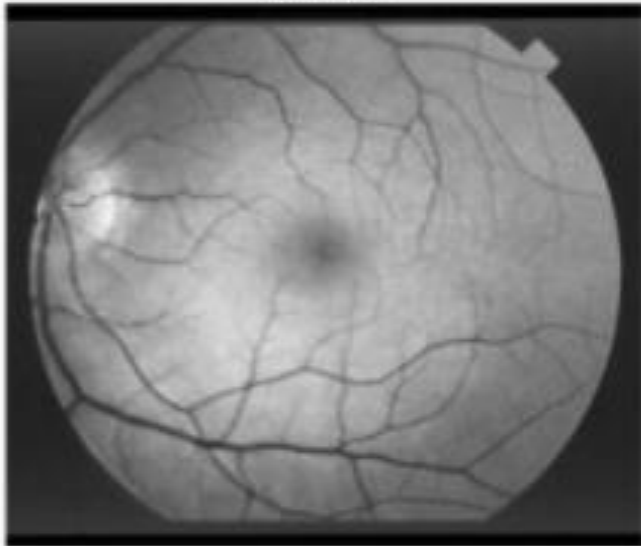
$I_{(x-1,y+1)}$	$I_{(x,y+1)}$	$I_{(x+1,y+1)}$
$I_{(x-1,y)}$	$I_{(x,y)}$	$I_{(x+1,y)}$
$I_{(x-1,y-1)}$	$I_{(x,y-1)}$	$I_{(x+1,y-1)}$

Filtro Lineal-Diferencia-Sobel

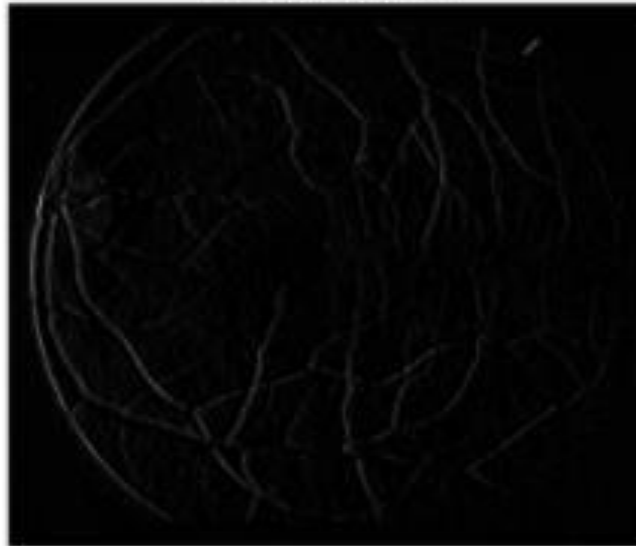
$$\text{Kernel_x} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

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

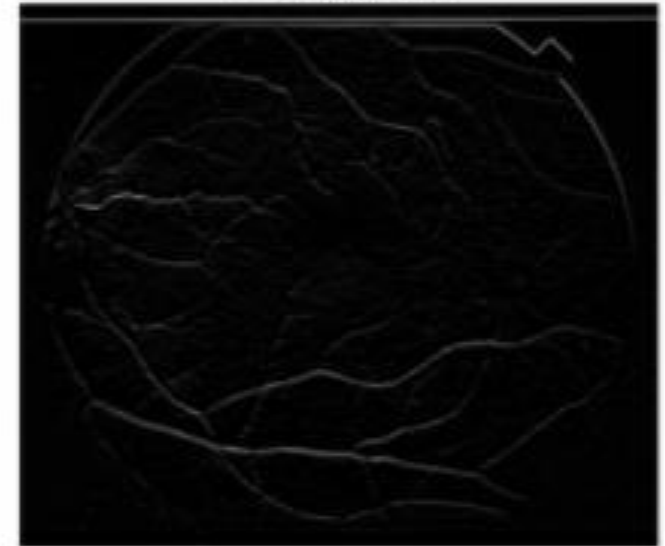
Original



filtro de Sobel X



filtro de Sobel Y

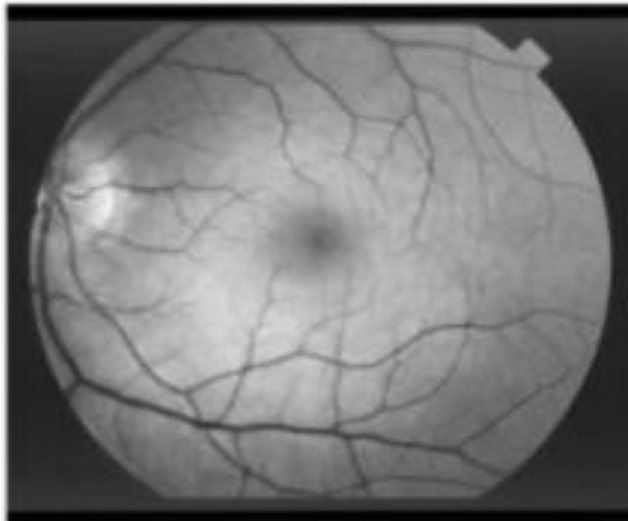


Filtro Lineal-Diferencia-Robert

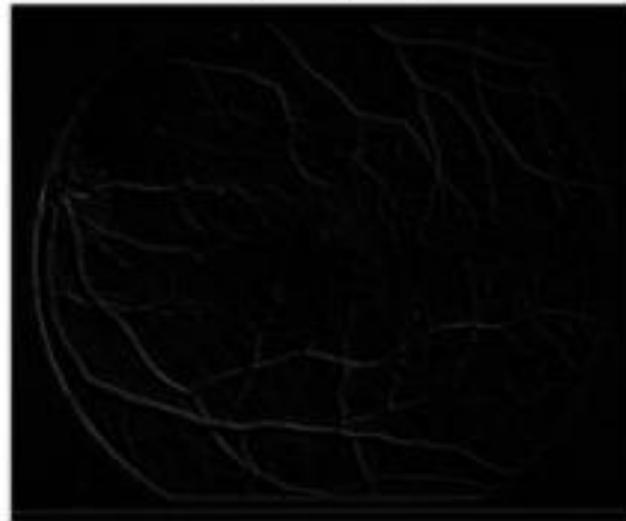
$$\text{Kernel_2} = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

$$\text{Kernel_1} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

Original



filtro de Robert 1



filtro de Robert 2

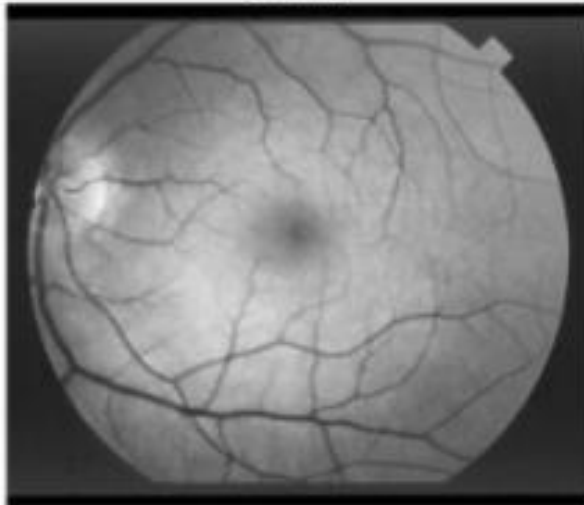


Filtro Lineal-Diferencia-Laplaciano

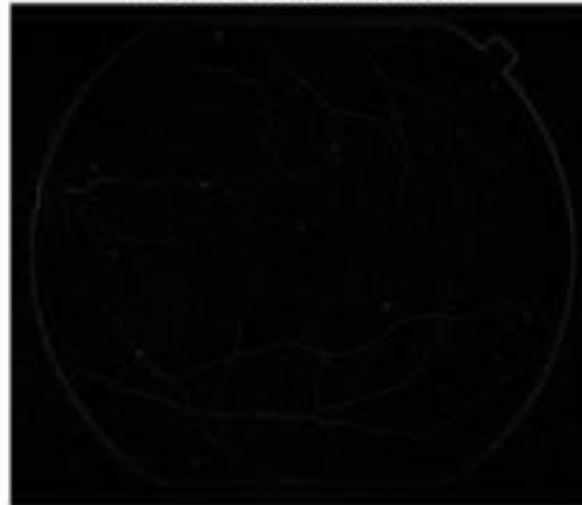
$$\text{Kernel_1} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

$$\text{Kernel_Y} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

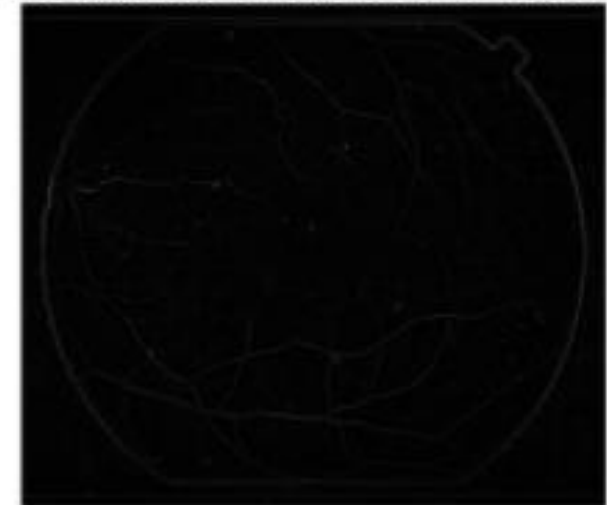
Original



filtro de Laplaciano basico



filtro de Laplaciano con contribucion de las esquinas



Filtro Lineal-Diferencia-Laplaciano

$$\frac{\partial f}{\partial x} = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

$$\frac{\partial f}{\partial y} = \lim_{h \rightarrow 0} \frac{f(y+h) - f(y)}{h}$$

$$\frac{\partial I_{(x,y)}}{\partial x} \approx \frac{I_{(x+1,y)} - I_{(x,y)}}{1}$$

$$\frac{\partial I_{(x,y)}}{\partial y} \approx \frac{I_{(x,y+1)} - I_{(x,y)}}{1}$$

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

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

$$\nabla^2 I_{(x,y)} = \frac{\partial^2 I_{(x,y)}}{\partial^2 x} + \frac{\partial^2 I_{(x,y)}}{\partial^2 y}$$

$$\nabla^2 I_{(x,y)} = I_{(x+1,y)} + I_{(x-1,y)} + I_{(x,y+1)} + I_{(x,y-1)} - 4 * I_{(x,y)}$$

Filtro Lineal-Diferencia-Canny



¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	20	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	20	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

$$\text{Kernel_1} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

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20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	0	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	0	55	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	0	55	0	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	0	55	0	101
110	0	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	0	55	0	101
110	0	255	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

¿Que son los bordes ?

20	100	110	90	98	100	100	110	104	100
100	20	105	95	100	98	150	102	103	101
110	100	20	102	99	102	101	100	100	100
101	100	101	20	25	110	102	101	102	100
110	100	100	101	100	20	105	108	100	105
100	98	99	101	100	101	19	20	102	103
110	90	98	100	100	110	104	100	20	20
100	101	110	90	98	100	100	110	104	20

20	100	110	90	98	100	100	110	104	100
100	255	0	17	0	60	0	55	0	101
110	0	255	0	0	0	50	4	5	100
101	2	164	249	229	0	9	8	0	100
110	8	1	0	0	255	0	0	17	105
100	0	1	0	2	0	254	249	0	103
110	47	7	0	8	0	0	0	246	20
100	101	110	90	98	100	100	110	104	20

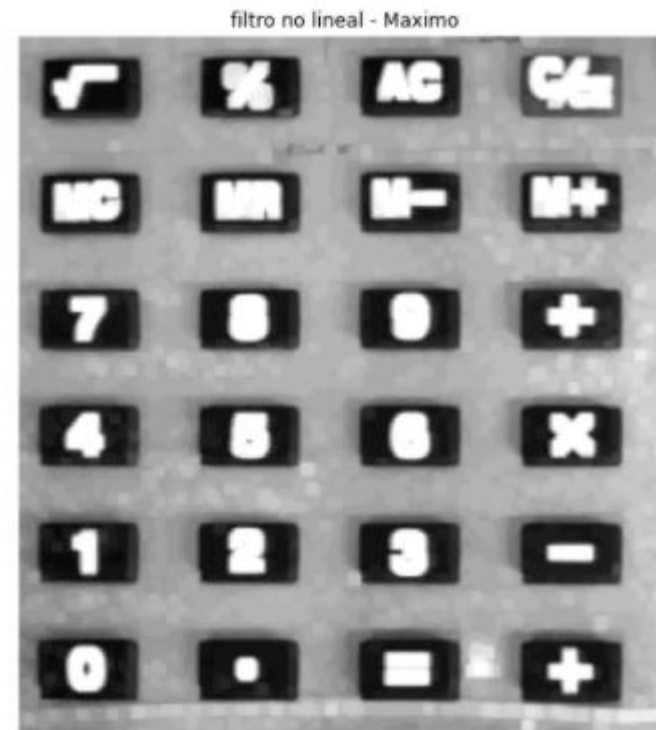


03

Filtros espaciales no lineales

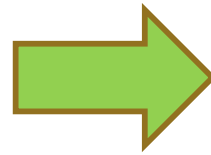
Filtro no lineal - Maximo

$$R(x, y) = \max\{I_{(x-k, y-k)}, \dots, I_{(x, y)}, \dots, I_{(x+k, y+k)}\}$$



Filtro no lineal - Maximo

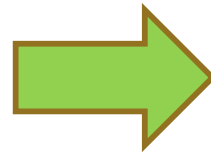
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70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

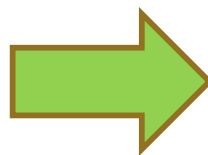
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

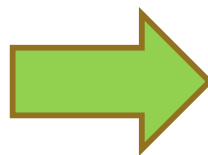
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200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

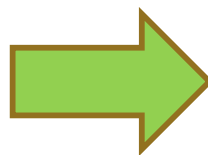
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

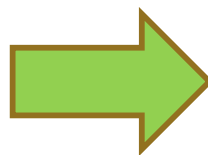
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	250	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

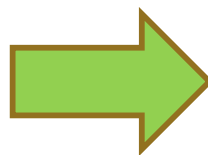
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	250	201	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

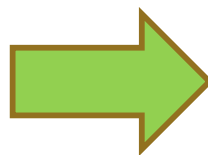
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	250	201	75
40	250	31	160	90
100	250	40	80	100

Filtro no lineal - Maximo

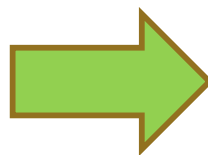
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200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	250	201	75
40	250	250	160	90
100	250	40	80	100

Filtro no lineal - Maximo

100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	250	250	201	100
70	250	250	201	75
40	250	250	160	90
100	250	40	80	100

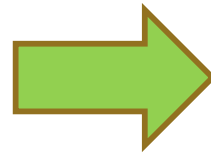
Filtro no lineal - Minimo

$$R(x, y) = \min\{I_{(x-k, y-k)}, \dots, I_{(x, y)}, \dots, I_{(x+k, y+k)}\}$$



Filtro no lineal - Minimo

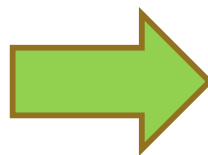
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

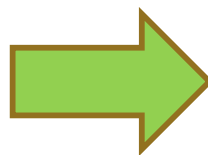
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

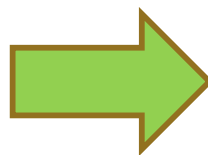
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200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

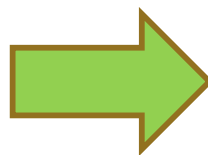
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	31	100	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

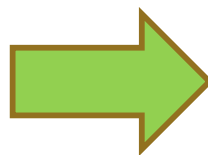
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200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	31	31	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

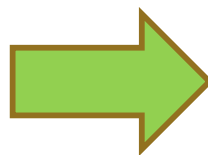
100	105	110	45	50
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100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	31	31	30	75
40	160	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

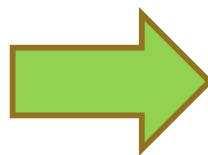
100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	31	31	30	75
40	31	31	160	90
100	250	40	80	100

Filtro no lineal - Minimo

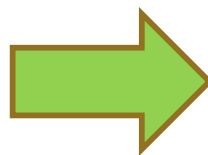
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40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	31	31	30	75
40	31	30	160	90
100	250	40	80	100

Filtro no lineal - Minimo

100	105	110	45	50
200	160	201	60	100
70	250	100	30	75
40	160	31	160	90
100	250	40	80	100



100	105	110	45	50
200	70	30	30	100
70	31	31	30	75
40	31	30	30	90
100	250	40	80	100

Filtro no lineal - Mediana

$$R(x, y) = \text{mediana}\{I_{(x-k, y-k)}, \dots, I_{(x, y)}, \dots, I_{(x+k, y+k)}\}$$





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Muchas gracias

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