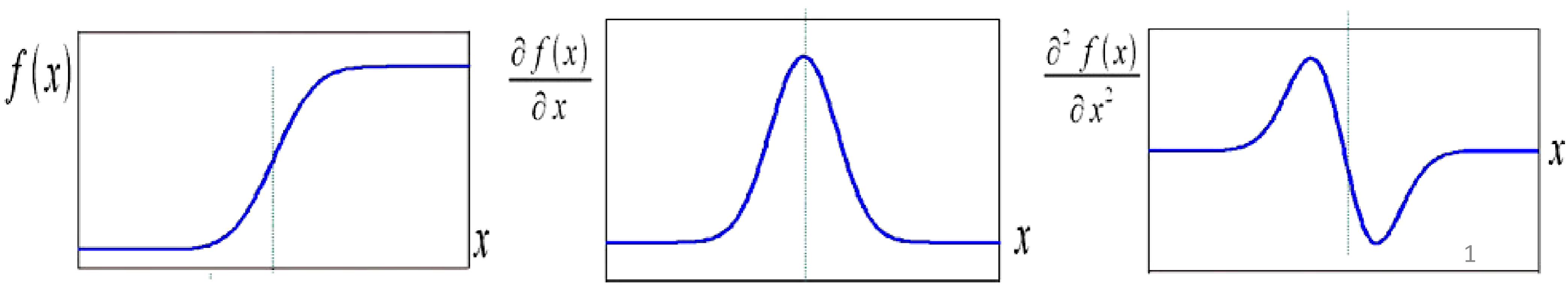
Edge detection

Edge detection is a technique for reducing information in images, which consists of transforming the image into a set of curves, not necessarily closed, forming the significant boundaries of the image. If the extracted structures are easy to handle (fine, regular, stable curves ...), they can be useful for image matching (robotics, indexing, ...).

Edges generally correspond to sudden changes in the physical or geometric properties of the perceived image and thus form very important attributes for analysis.

several local operators (directional or not) of first order and second order derivation are used. They are then followed respectively by a search for local maxima and zero crossing



Gradient operator

$$\frac{\partial f}{\partial x} \approx \Delta_x f(i,j) = f(i+1,j) - f(i,j) \qquad (V.5)$$

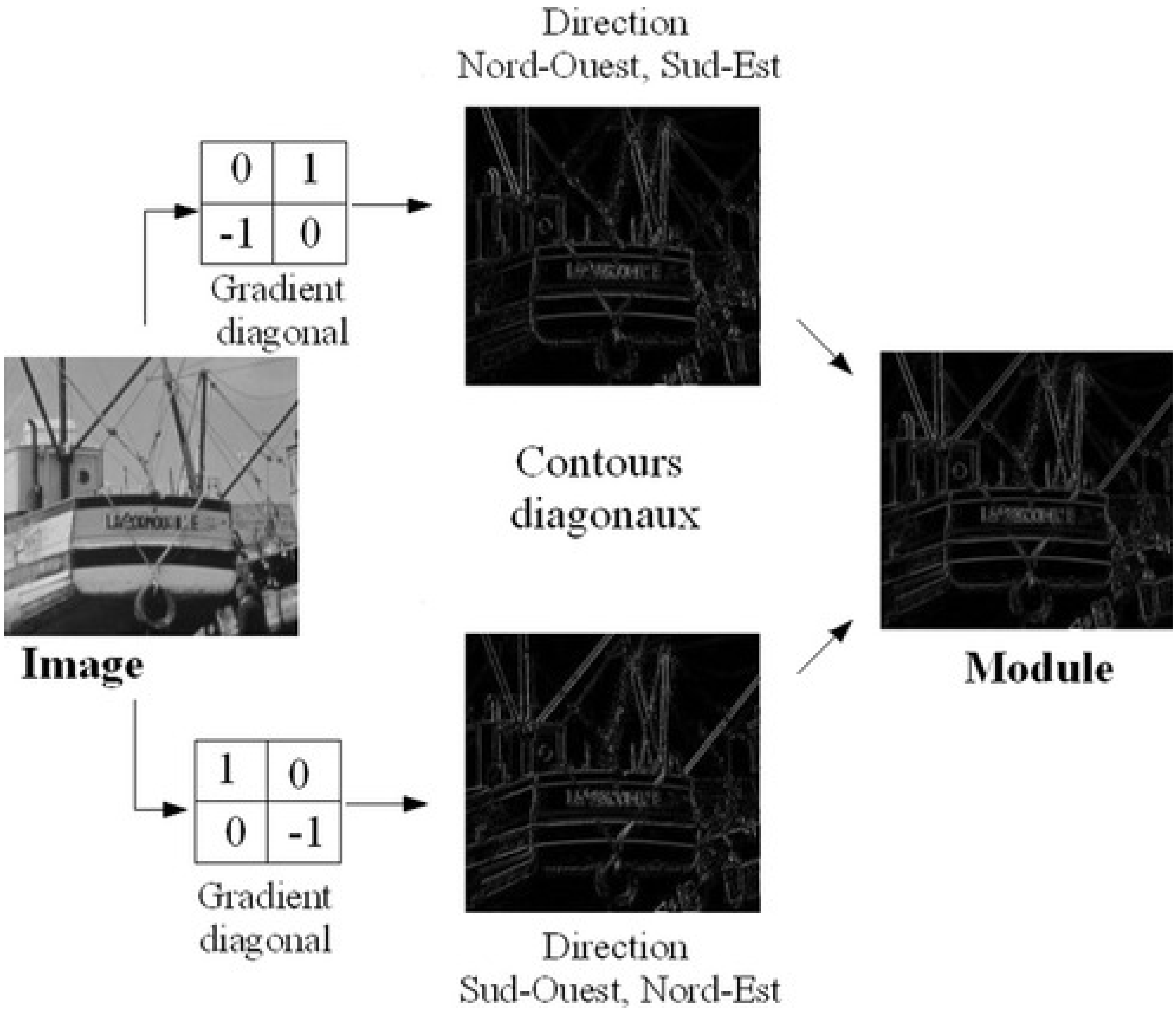
$$\frac{\partial f}{\partial y} \approx \Delta_y f(i,j) = f(i,j+1) - f(i,j) \qquad (V.6)$$

$$\left\| \underset{\nabla}{\rightarrow} f \right\| = \sqrt{\Delta_x f^2 + \Delta_y f^2} \qquad (V.6)$$

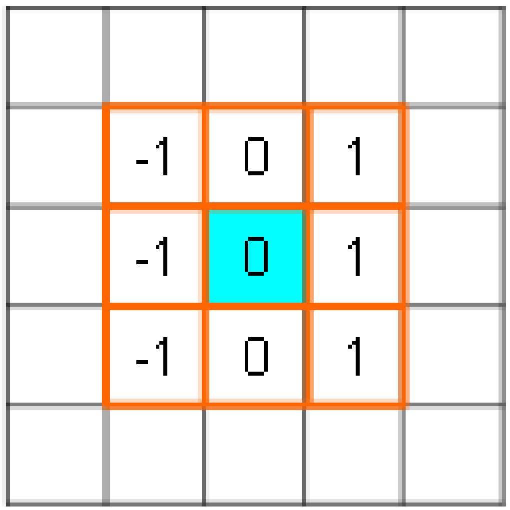
$$\left\| \underset{\nabla}{\rightarrow} f \right\| = \max\left(|\Delta_x f|, |\Delta_y f|\right) \qquad (V.7)$$

Some gradient operators :

Roberts Operator



Prewitt Operator



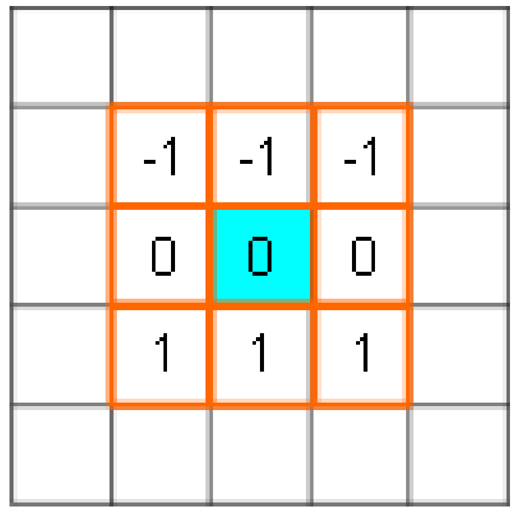
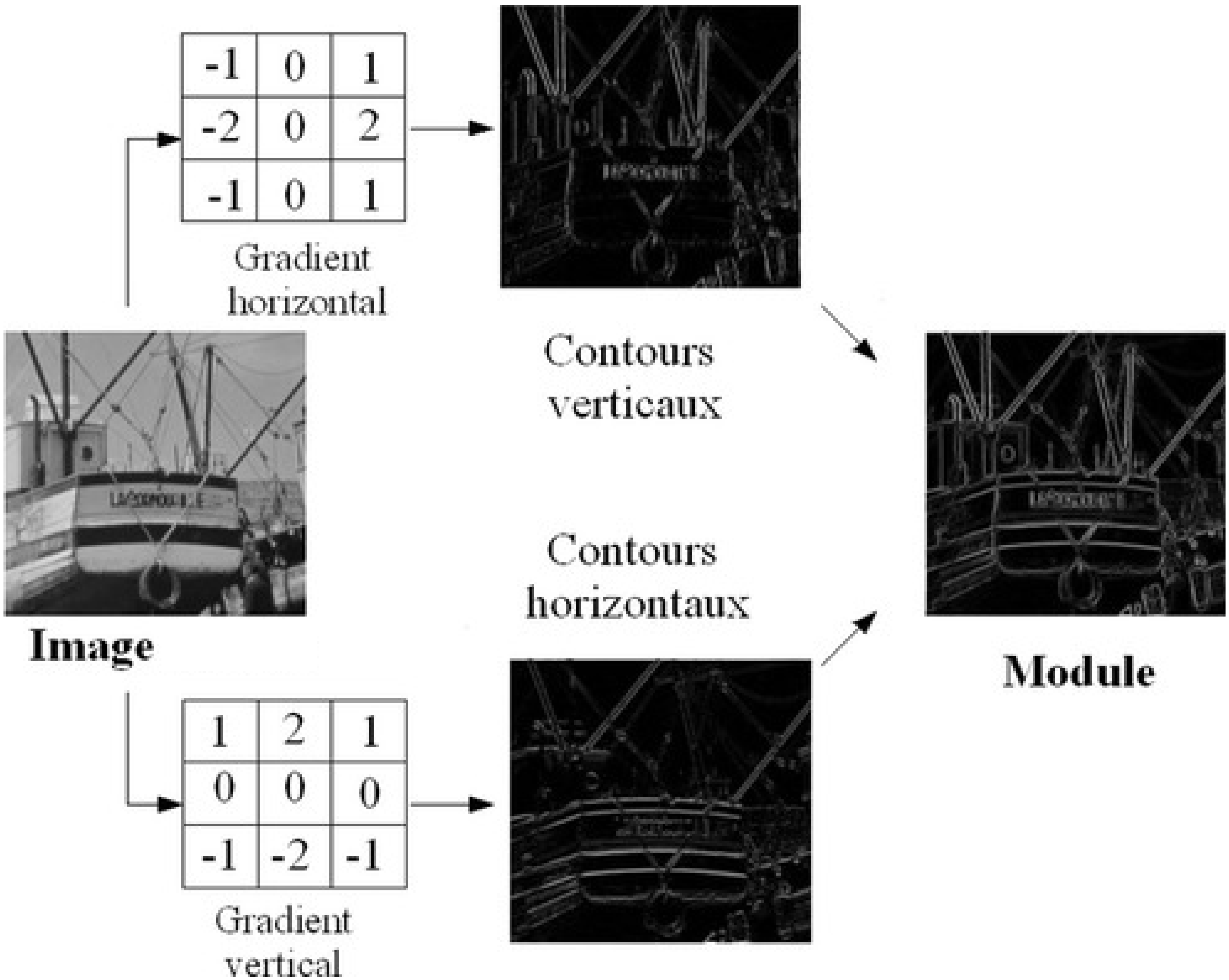


Figure : Horizontal and vertical Prewitt masks

Sobel Operator



Kirsch Operator

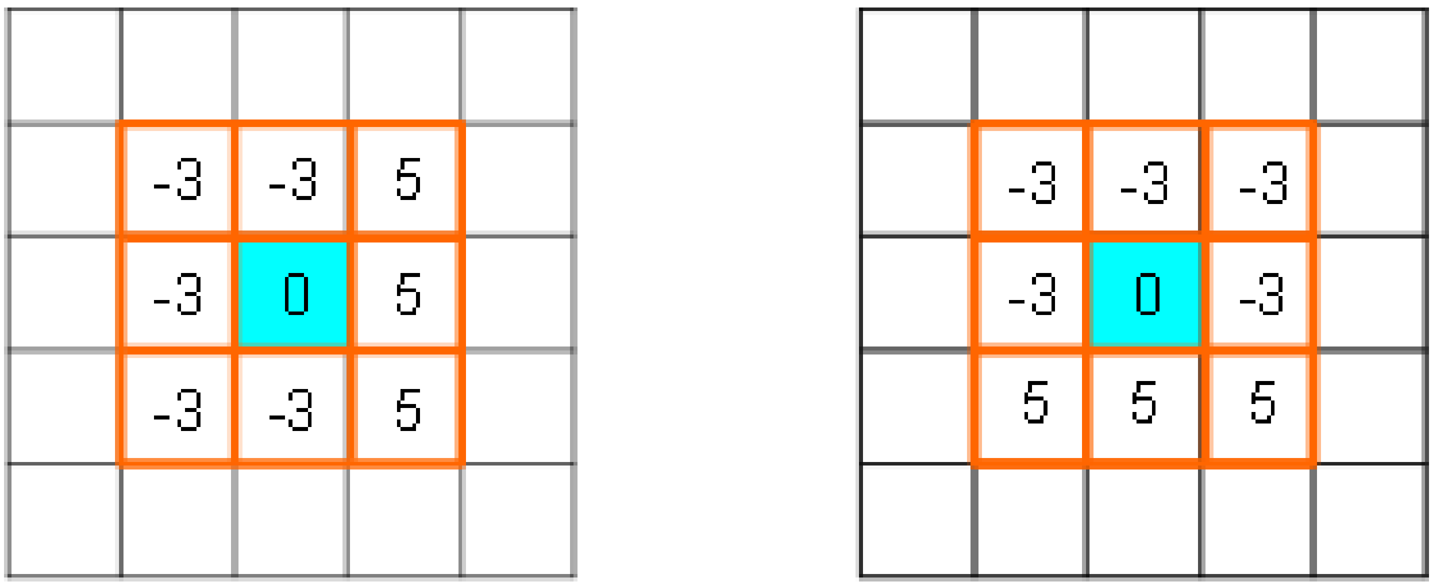


Figure : Horizontal (G) and vertical (D) Kirsch masks

Thresholding methods

Global Threshold :

$$\forall i, j \in N \times M \; I(i,j) = \begin{cases} 1 & \text{si} \quad f(i,j) > S \\ 0 & \text{sinon} \end{cases} \quad (\text{V}$$

Local threshold

$$S(i, j) = (\max(i, j) + \min(i, j))/2,$$

-S (i, j): threshold to be applied for point i, j;

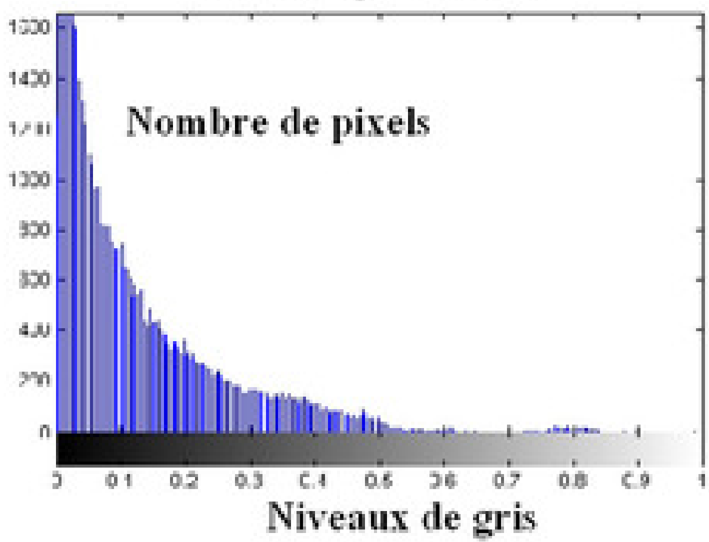
-Max (i, j): value of the maximum gray level in a centered window - in (i, j) of size N × M;

-Min (i, j): value of the minimum gray level in a window centered in (i, j) of size N × M;

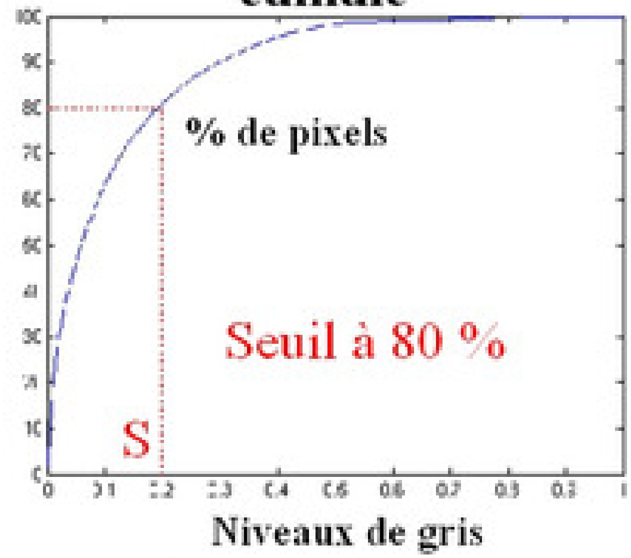
- N and M belonging to N

Global thresholding by histogram

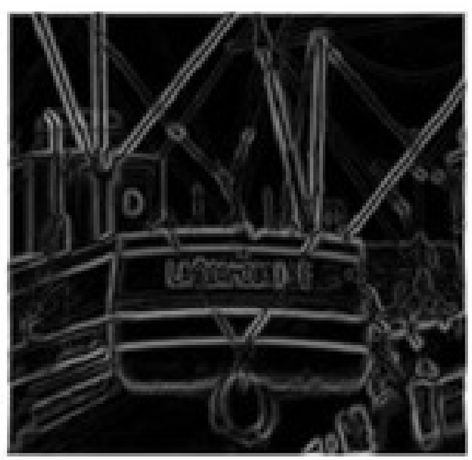
Histogramme



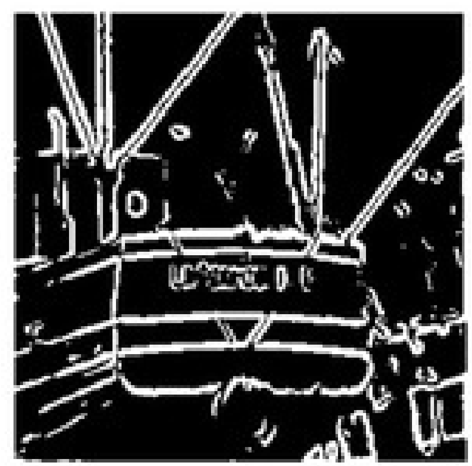
Histogramme cumulé



Module du gradient



Contours



The Laplacian operator

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = \frac{\partial}{\partial x}\left(\frac{df}{dx}\right) + \frac{\partial}{\partial y}\left(\frac{df}{dy}\right) \qquad (V.10)$$

$$\nabla^2 f = \nabla_x\big(f(x+1,y) - f(x,y)\big) + \nabla_y\big(f(x,y+1) - f(x,y)\big) \qquad (V.11)$$

$$\nabla_x\big(f(x+1,y) - f(x,y)\big) = f(x+1,y) - f(x,y) - (f(x,y) - f(x-1,y)) \qquad (V.12)$$

$$\nabla_x\big(f(x+1,y) - f(x,y)\big) = f(x+1,y) + f(x-1,y) - 2f(x,y) \qquad (V.13)$$

$$\nabla_y\big(f(x,y+1) - f(x,y)\big) = f(x,y+1) - f(x,y) - (f(x,y) - f(x,y-1)) \qquad (V.14)$$

$$\nabla_y\big(f(x,y+1) - f(x,y)\big) = f(x,y+1) + f(x,y-1) - 2f(x,y) \qquad (V.15)$$

$$\nabla^2 f = f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1) - 4f(x,y) \qquad (V.16)$$

Laplacian Mask

0	-1	0
-1	4	-1
0	-1	0

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

1	-2	1
-2	4	-2
1	-2	1

$$G = \sqrt{G_h^2 + G_v^2}$$

$$G_g = (G > \text{threshold})$$