计算机辅助手术讲座（9）

Image Guided Surgery (9)

灰度的数学形态学(1)

Mathematical morphology in gray scale(1)

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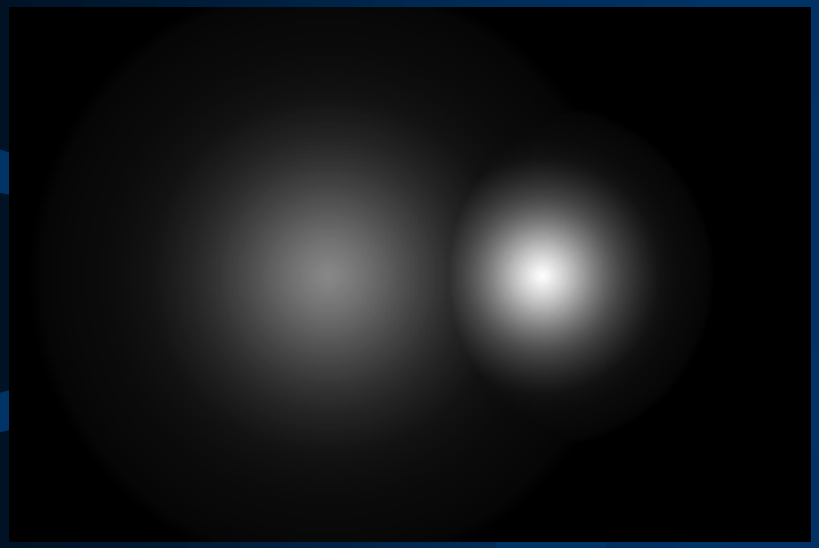
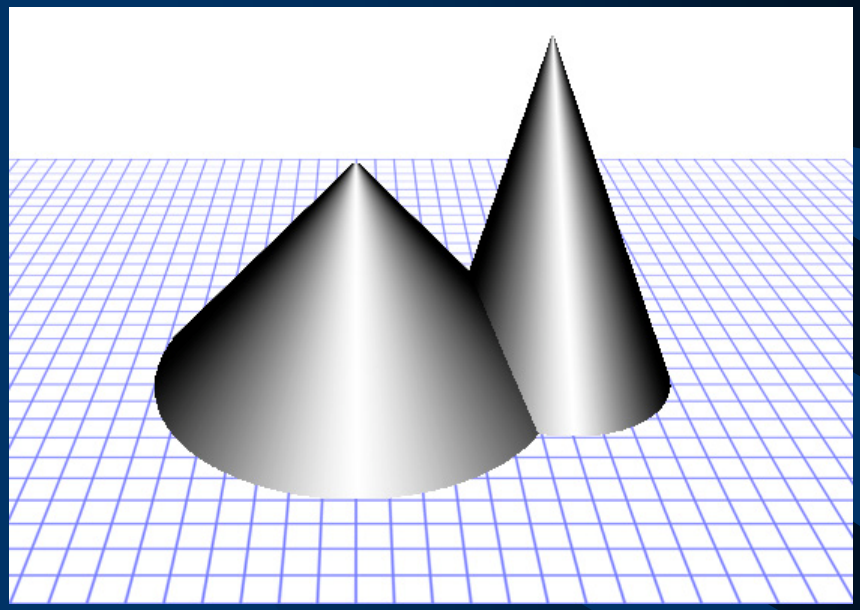
Grayscale Morphology: image



image



landscape

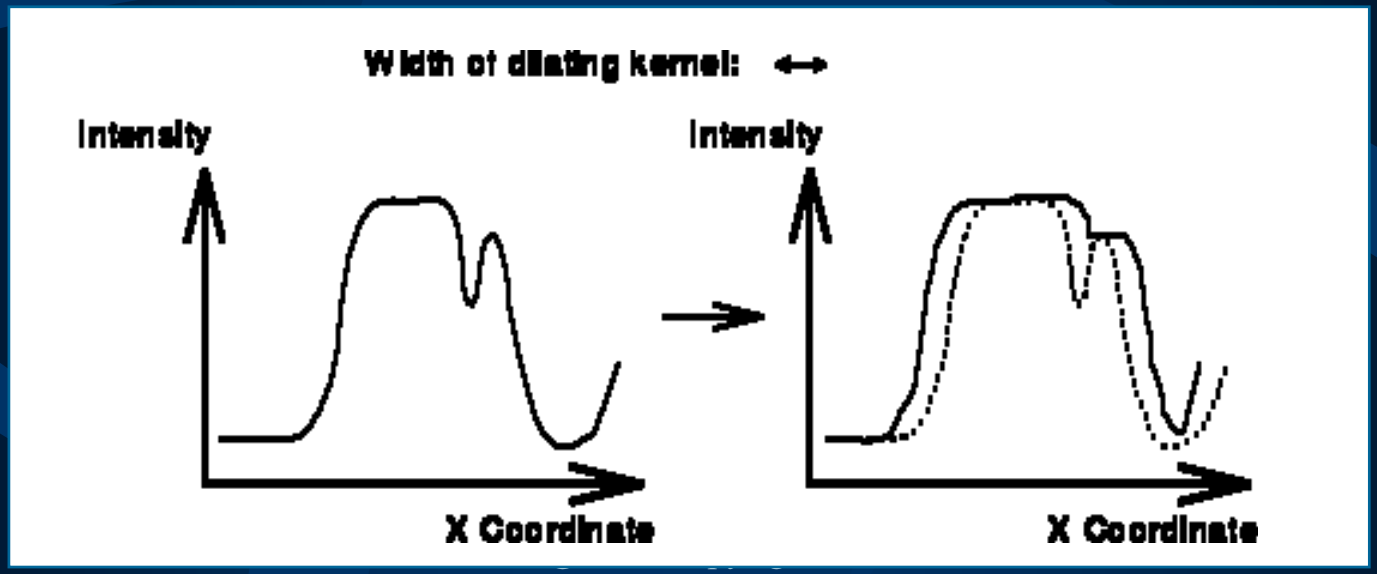
Grayscale image and 3D solid representation

Grayscale Dilation

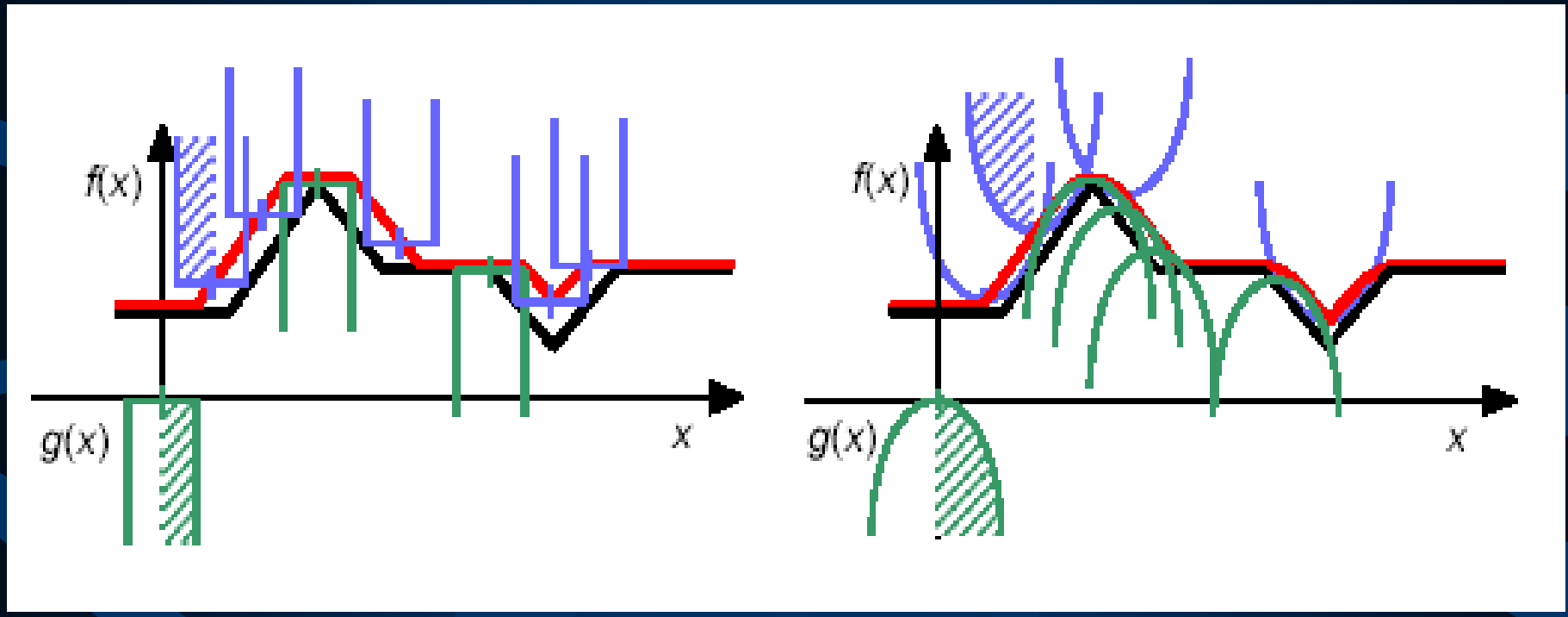
- Grayscale Dilation: A grayscale image F dilated by a grayscale SE K is defined as:

$$D_G(F,K) = F \oplus_g K = \max_{[a,b]\in K} \{F(m-a,n-b) + K(a,b)\}$$

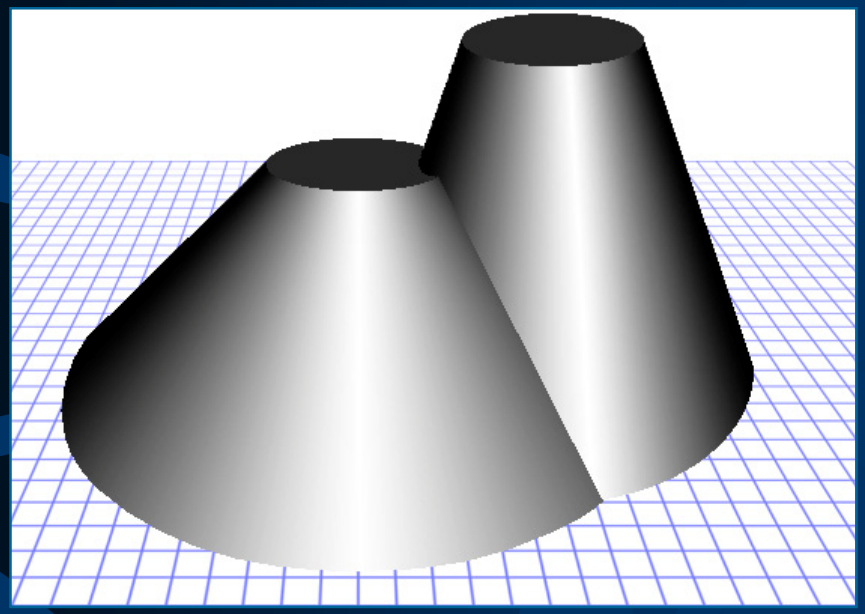
- It generally brighten the source image.



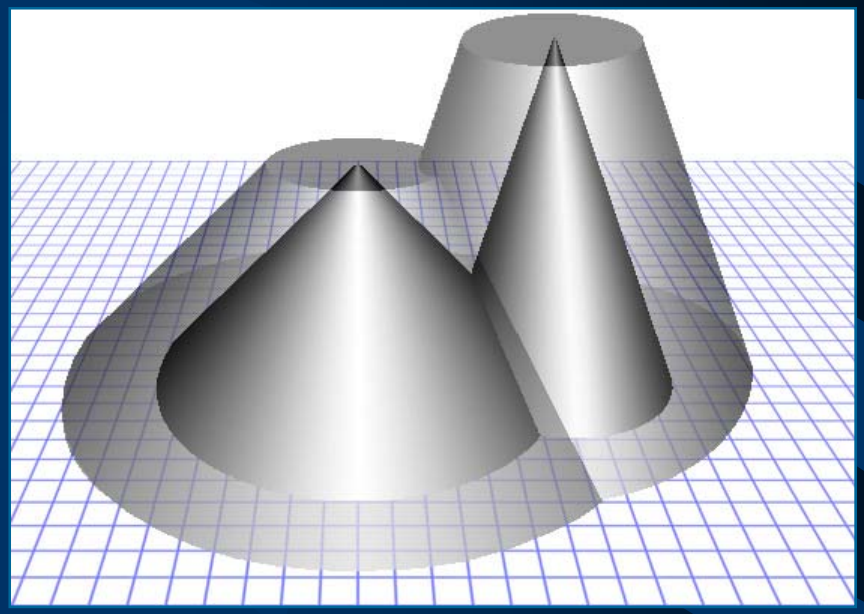
Grayscale Dilation



Grayscale Dilation



dilation



dilation over original

Grayscale Dilation

$F = (7\ \ 9\ \ 8\ \ 3\ \ 8\ \ 9\ \ 9);$ $\qquad$ $k = (-3\ \ 0_{\#}\ \ -3)$

$F_{-1}-3 = (4$	6	5	0	5	6	6	*	*)
$F_{0}+0 = (*$	7	9	8	3	8	9	9	*)
$F_{+1}-3 = (*$	*	4	6	5	0	5	6	6)
$F \oplus_g k = (4$	7	9	8	5	8	9	9	6） max

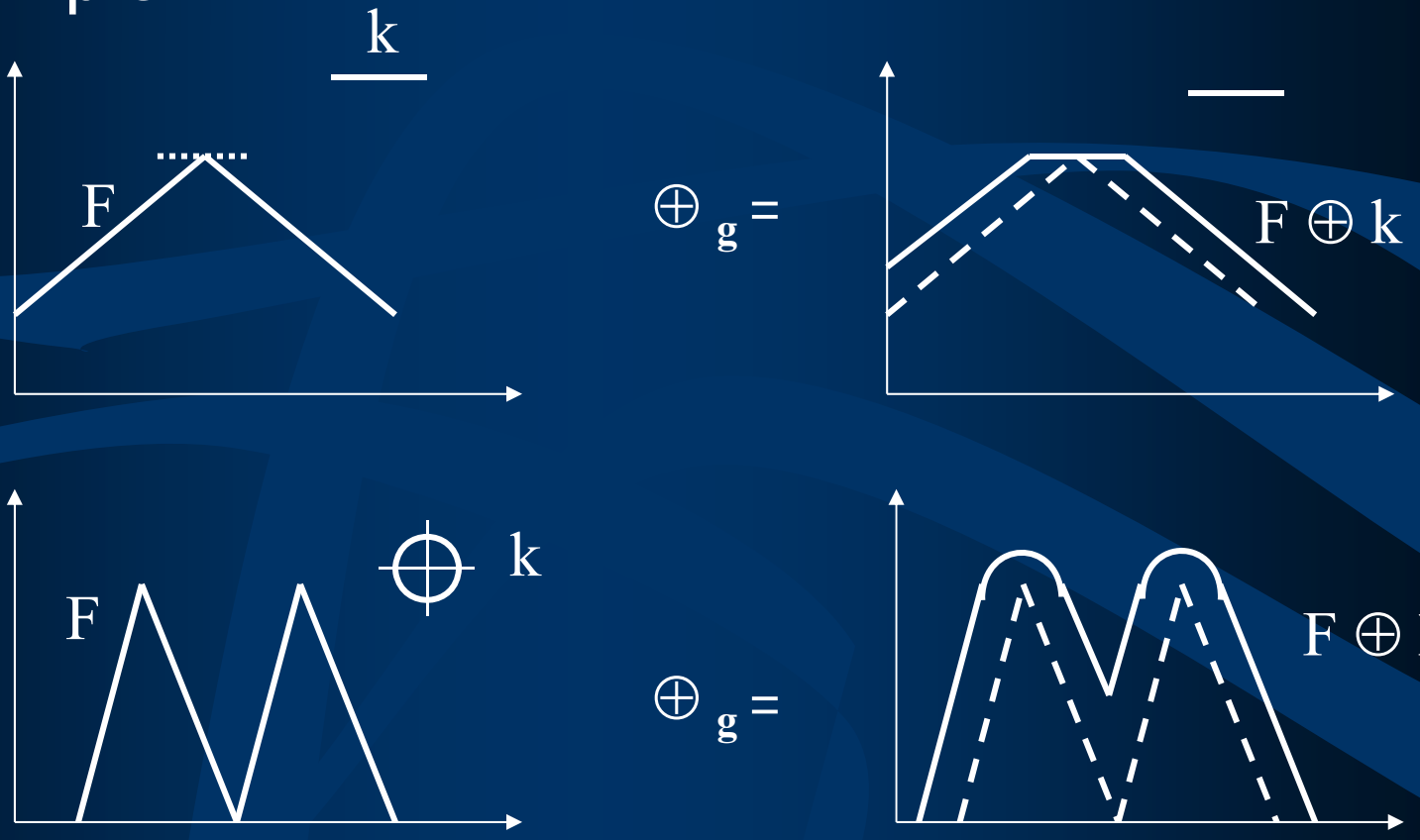
Grayscale Dilation

$F = (0\ \ 2\ \ 1\ \ 5\ \ 9\ \ 6\ \ 1\ \ 0);$ $\qquad k = (5_{\#}\ \ 5\ \ \ 4)$

$F_0 + 5$ = (5	7	6	10	14	11	6	5	*	*)
$F_{+1} + 5$ = (*	5	7	6	10	14	11	6	5	*)
$F_{+2} + 4$ = (*	*	4	6	5	9	13	10	5	4)
$F \oplus_g k$ = (5	7	7	10	14	14	13	10	5	4) max

Grayscale Dilation

- Example:



Grayscale Dilation

Source image

Dilated image

Grayscale Dilation

Source image S

$S \oplus_g r_5 K_{square}$

$S \oplus_g r_{11} K_{square}$

Grayscale Dilation

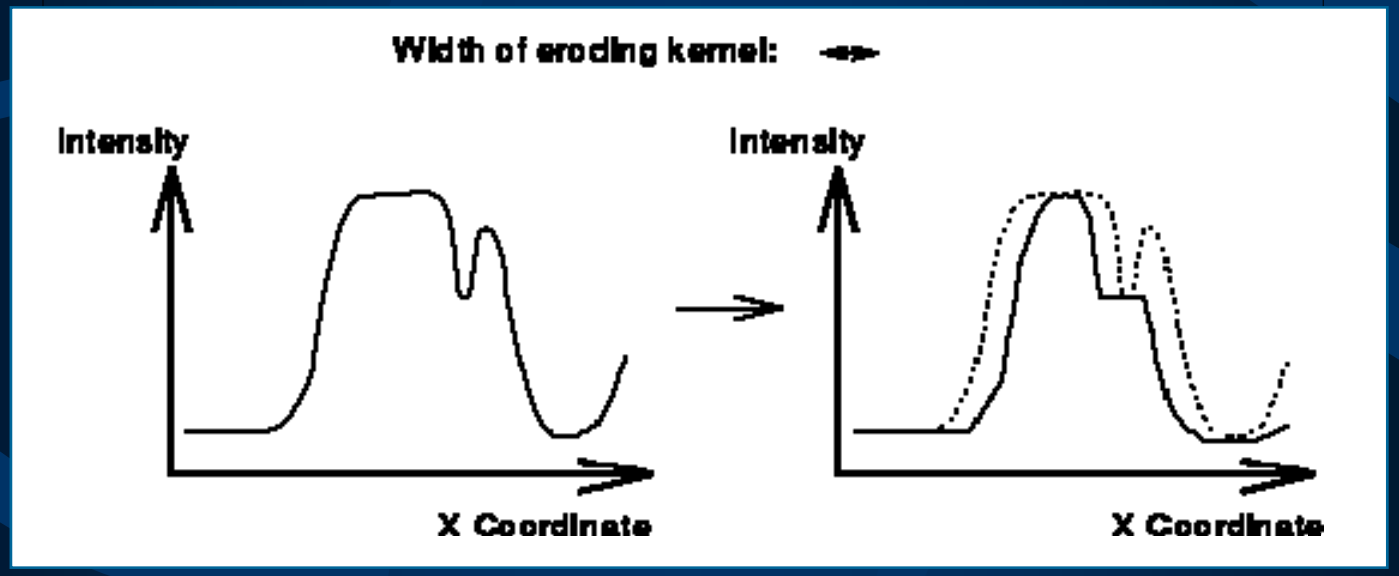
- Bright regions surrounded by dark regions grow in size, and dark regions surrounded by bright regions shrink in size.
- Small dark spots in images will disappear as they get `filled in' to the surrounding intensity value.
- Small bright spots will become larger spots.
- The effect is most marked at places in the image where the intensity changes rapidly and regions of fairly uniform intensity will be largely unchanged except at their edges.

Grayscale Erosion

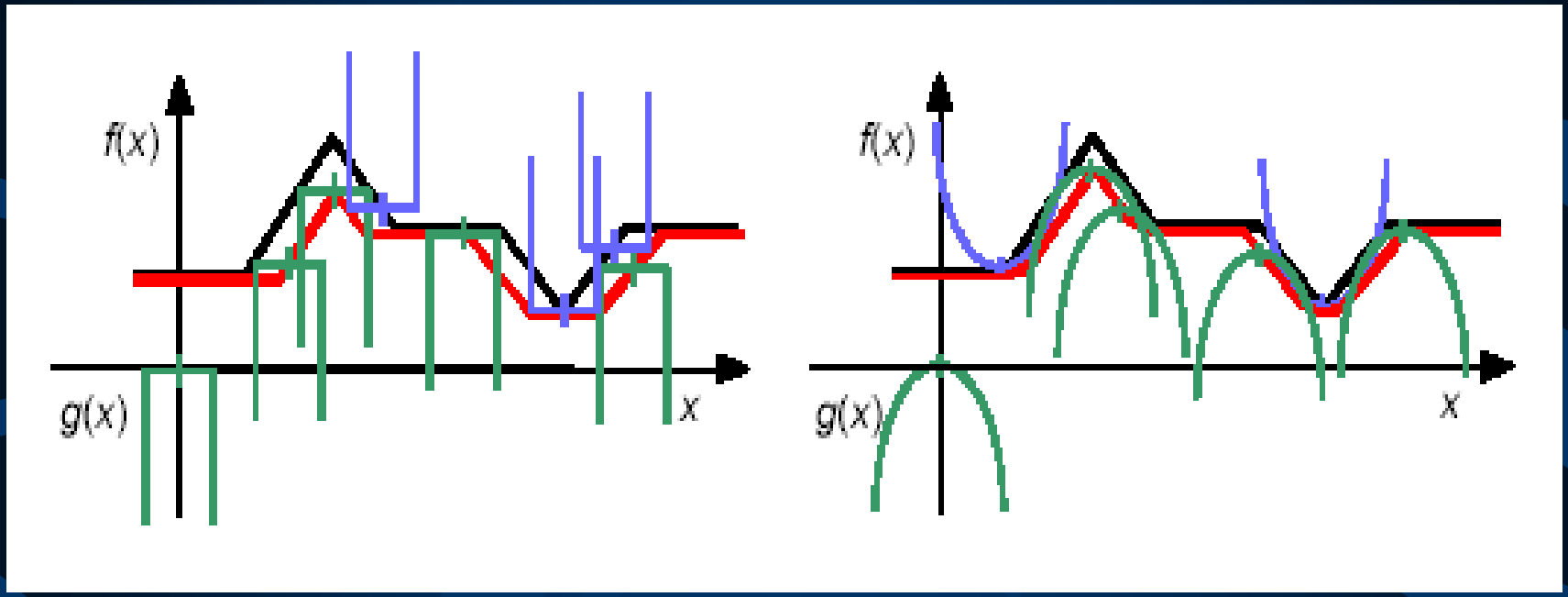
- Grayscale Erosion: A grayscale image F eroded by a grayscale SE K is defined as:

$$E_G(F,K) = F \,\$_g\, K = \min_{[a,b]\in K} \{F(m-a,n-b) - K(a,b)\}$$

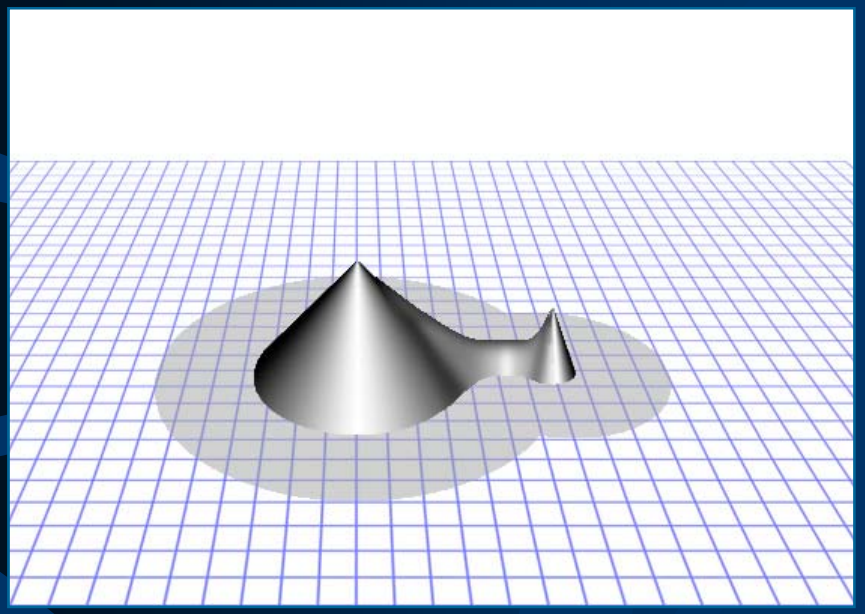
- It generally darken the image.



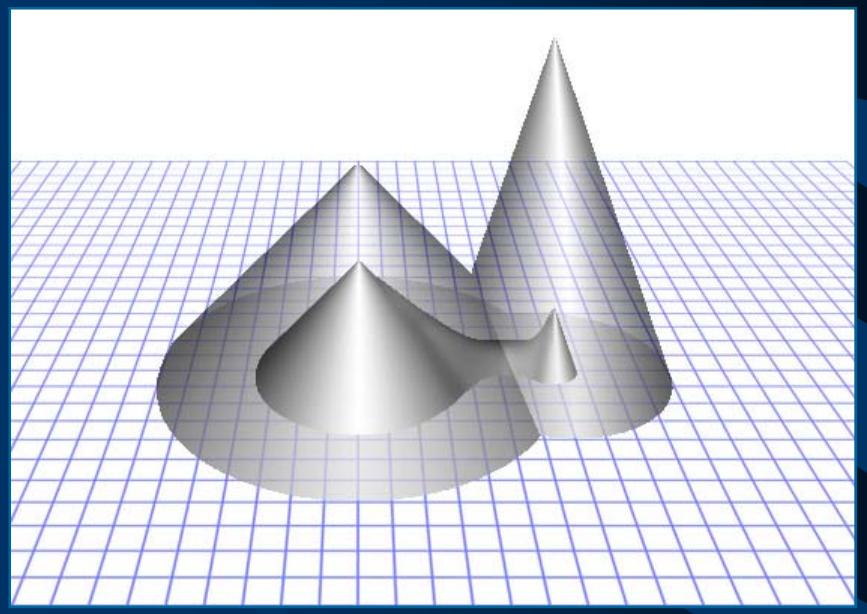
Grayscale Erosion



Grayscale Erosion



erosion



erosion under original

Grayscale Erosion

$F = (7\ \ 9\ \ 8\ \ 3\ \ 8\ \ 9\ \ 9);$ $k = (-3\ \ 0_{\#}\ \ -3)$

$F_{-(-1)}$-(-3) = (*	*	10	12	11	6	11	12	12)
F_0-0 = (*	7	9	8	3	8	9	9	*)
F_{-1}-(-3) = (10	12	11	6	11	12	12	*	*)
$F \$_g k$ = (*	*	9	6	3	6	9	*	*）	min

Grayscale Erosion

$F = (0\ \ 2\ \ 1\ \ 5\ \ 9\ \ 6\ \ 1\ \ 0);$ $k = (5_{\#}\ \ 5\ \ \ 4)$

F_0 -5 =(*	*	-5	-3	-4	0	4	1	-4	-5)
F_{-1}-5 = (*	-5	-3	-4	0	4	1	-4	-5	*)
F_{-2}-4 = (-4	-2	-3	1	5	2	-3	-4	*	*)
$F \$_g k$ = (*	*	-5	-4	-4	0	-3	-4	*	*) min

Grayscale Erosion

Source image

Eroded image

Grayscale Erosion

Source image S

$S \ominus_g r_5 K_{square}$

$S \ominus_g r_{11} K_{square}$

Grayscale Erosion

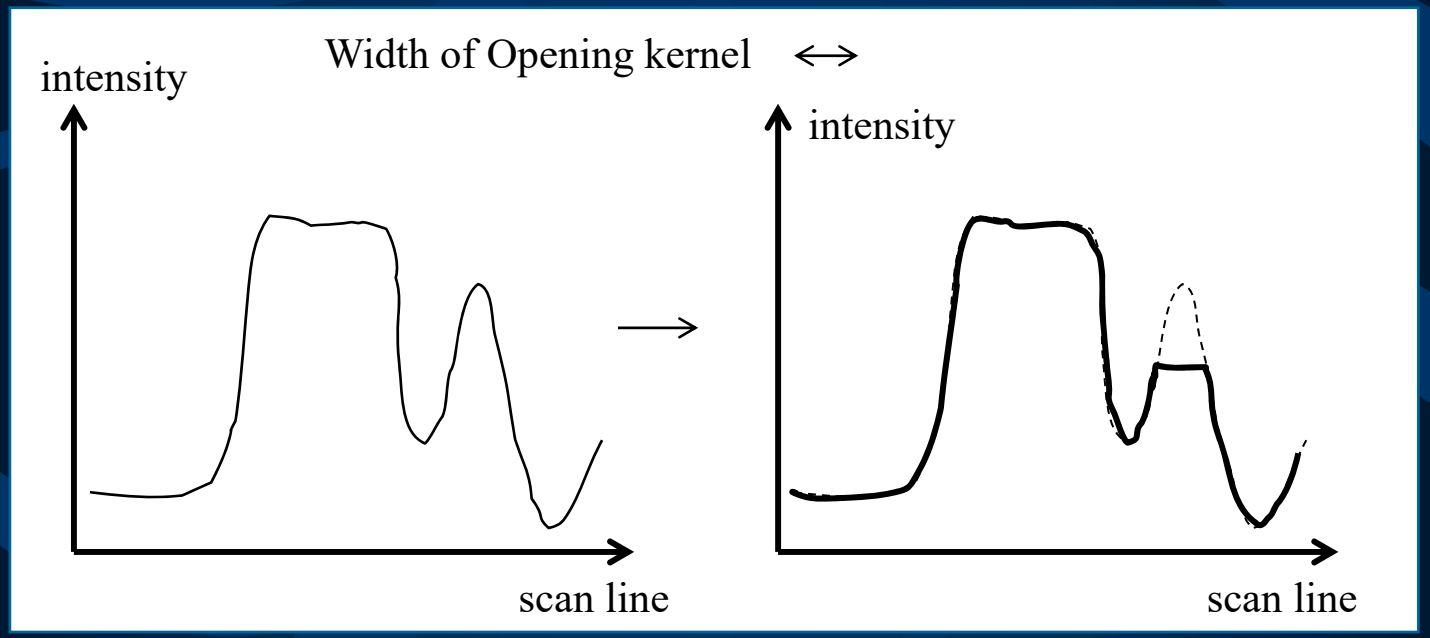
- Bright regions surrounded by dark regions shrink in size, and dark regions surrounded by bright regions grow in size.
- Small bright spots in images will disappear as they get eroded away down to the surrounding intensity value, and small dark spots will become larger spots.
- The effect is most marked at places in the image where the intensity changes rapidly, and regions of fairly uniform intensity will be left more or less unchanged except at their edges.

Grayscale Opening

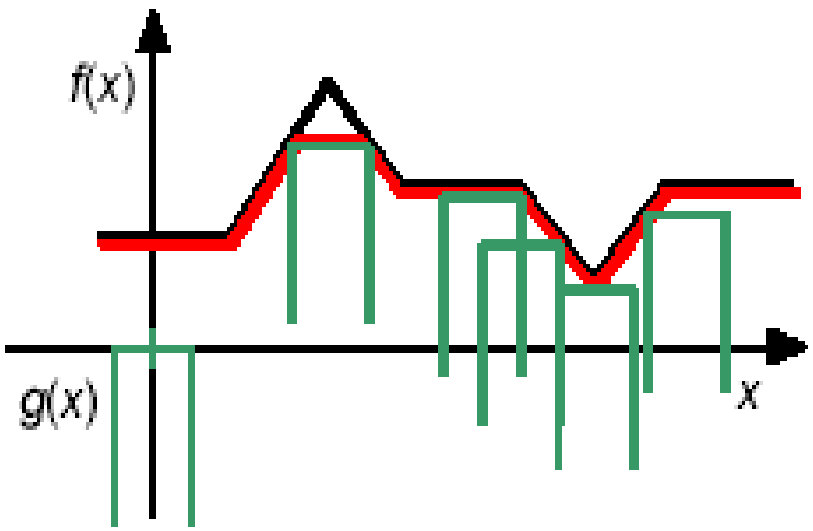
- Grayscale Opening: A grayscale image F opened by a grayscale SE K is defined as:

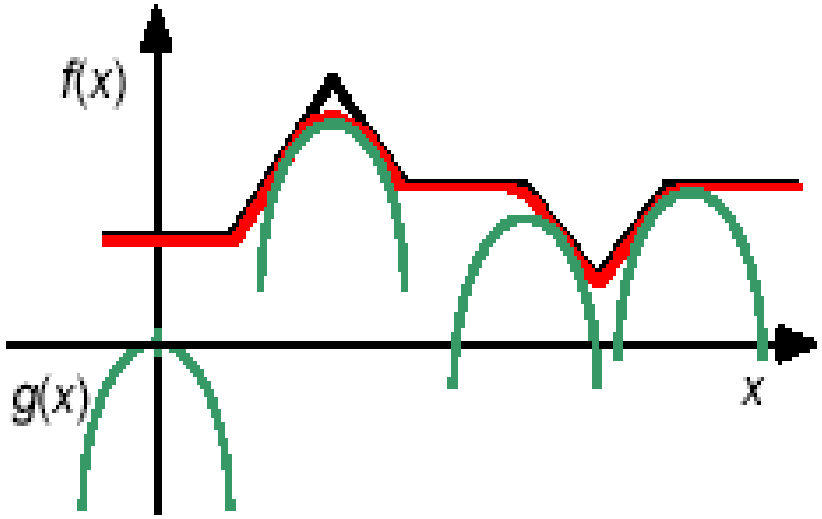
$$O_G(F, K) = F \circ_g K = (F \ominus_g K) \oplus_g K$$

- It can be used to select and preserve particular intensity patterns while attenuating others



Grayscale Opening





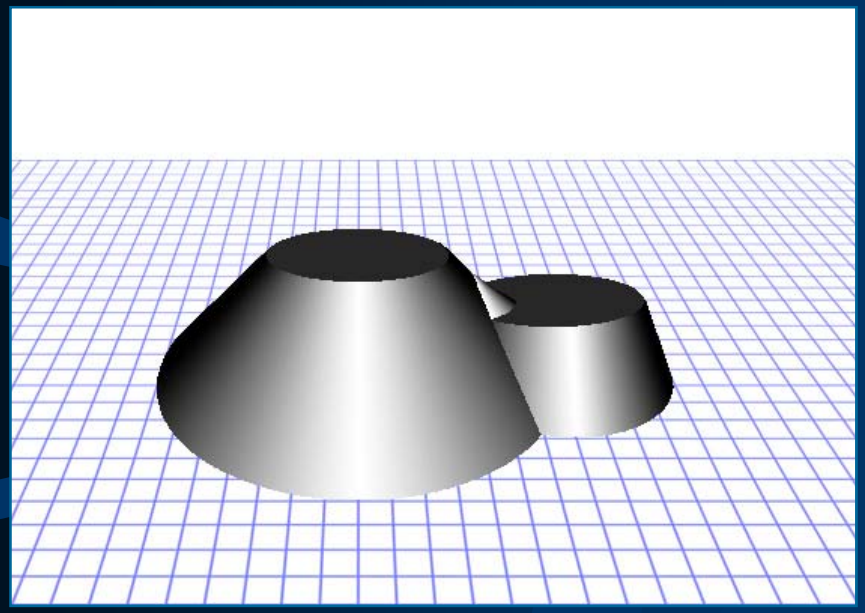
Grayscale Opening

$F = (7\ \ 9\ \ 8\ \ 3\ \ 8\ \ 9\ \ 9);$ $k = (-3\ \ 0_{\#}\ \ -3)$

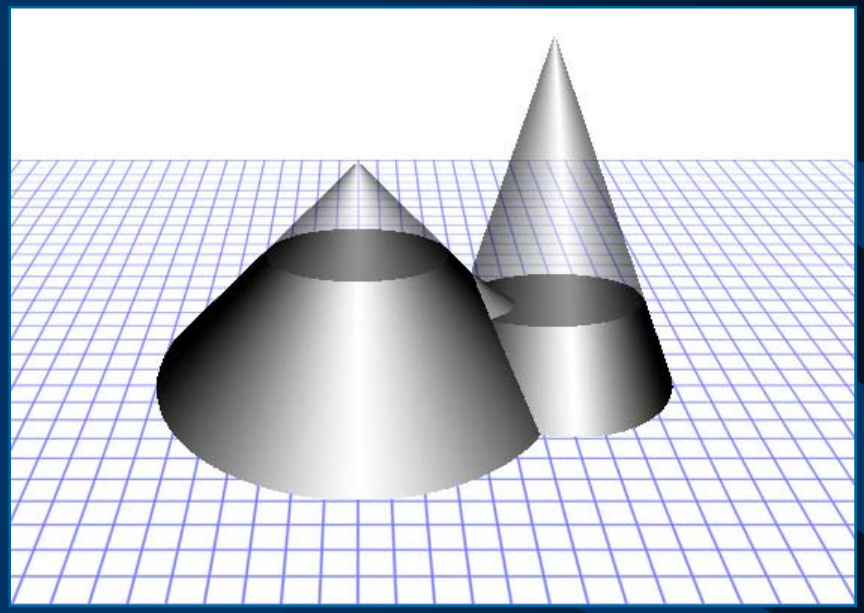
$F' = F\ \$_g k = (*\ \ *\ \ 9\ \ 6\ \ 3\ \ 6\ \ 9\ \ *\ \ *)$

$F'_{-1}-3 = (*$	6	3	0	3	6	*	*	*)	
$F'_{0}+0 = (*$	*	9	6	3	6	9	*	*)	
$F'_{+1}-3 = (*$	*	*	6	3	0	3	6	*)	
$F \circ_g k = F' \oplus_g k = (*$	6	9	6	3	6	9	6	*)	max

Grayscale Opening



opening



opened & original

Grayscale Opening

Source image

Opened image

Grayscale Opening

Source image S

$S \circ_g r_5 K_{square}$

$S \circ_g r_{11} K_{square}$

Grayscale Opening

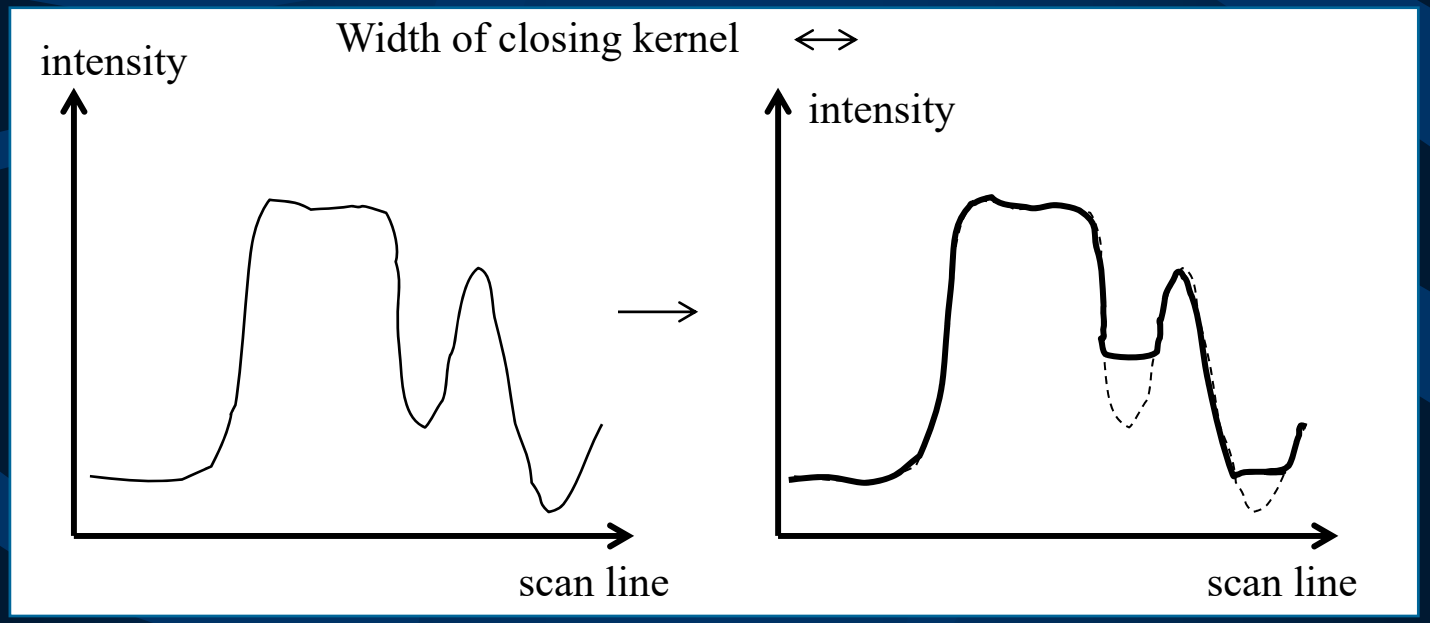
- Gray scale opening can be imagined as an operation which use SE to fit the gray signal upward from below side.
- The important thing to notice here is the way in which bright features smaller than the structuring element should be greatly reduced in intensity, while larger features have remained more or less unchanged in intensity.

Grayscale Closing

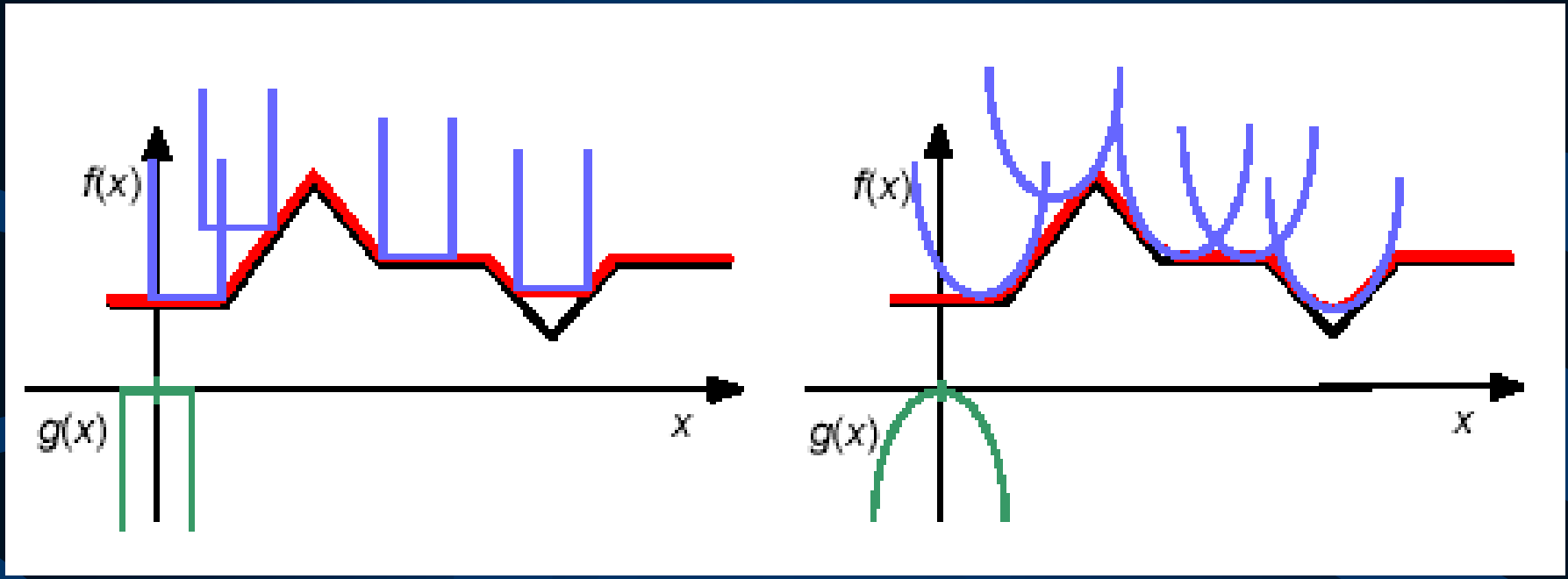
- Grayscale Closing: A grayscale image F closed by a grayscale SE K is defined as:

$$C_G(F,K) = F \bullet_g K = (F \oplus_g K) \$_g K$$

- It is another way to select and preserve particular intensity patterns while attenuating others.



Grayscale Closing



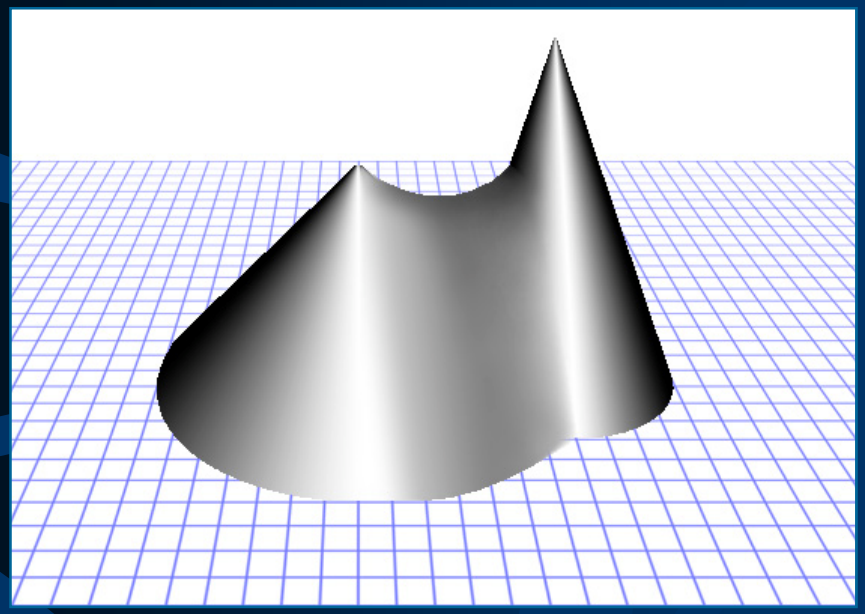
Grayscale Closing

$F = (7\ \ 9\ \ 8\ \ 3\ \ 8\ \ 9\ \ 9);$ $\quad k = (-3\ \ 0_{\#}\ \ -3)$

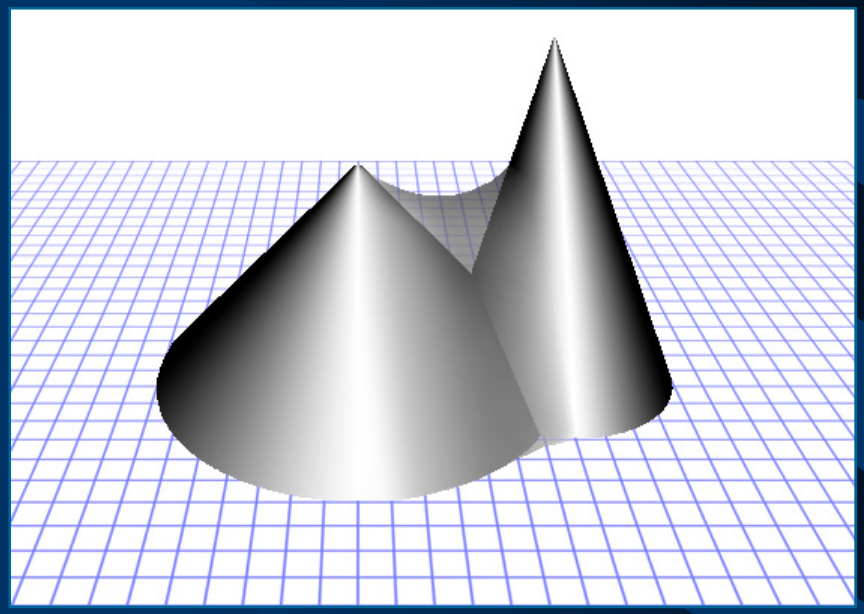
$F' = F \oplus_g k = (4\ \ 7\ \ 9\ \ 8\ \ 5\ \ 8\ \ 9\ \ 9\ \ 6)$

$F'_{-(-1)}-(-3) = (*$	*	7	10	12	11	9	11	12	12	9)	
$F'_0-0 = (*$	4	7	9	8	5	8	9	9	6	*)	
$F'_{-1}-(-3) = (7$	10	12	11	8	11	12	12	9	*	*)	
$F \bullet_g k = F' \$_g k = (*$	*	7	9	8	5	8	9	9	*	*)	min

Grayscale Closing



closing



closing & original

Grayscale Closing

Source image

Closed image

Grayscale Closing

Source image S

$S \bullet_g r_5 K_{square}$

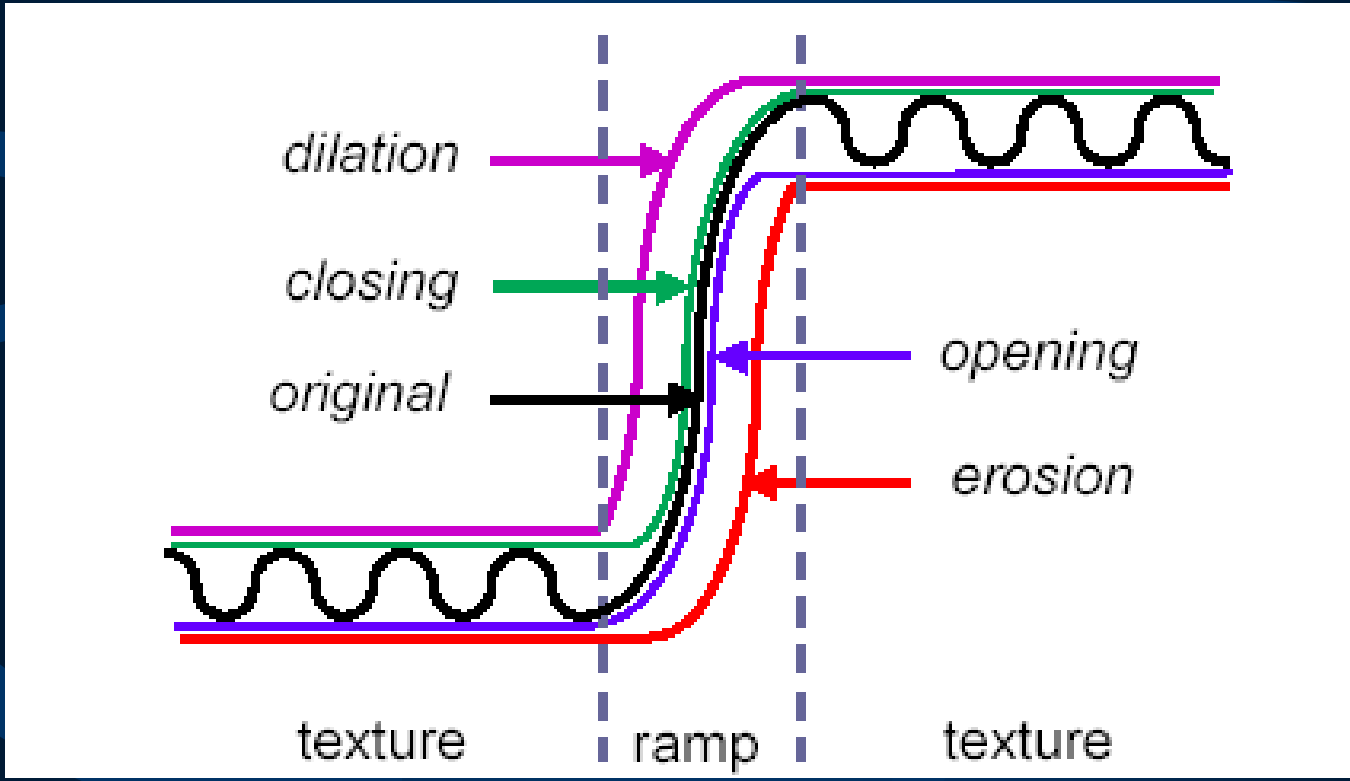
$S \bullet_g r_{11} K_{square}$

Grayscale Closing

- Gray scale closing can be imagined as an operation which use SE to fit the gray signal downward from up side.
- The important thing to notice here is the way in which dark features smaller than the structuring element should be greatly increased in intensity, while larger features have remained more or less unchanged in intensity.

Difference

- Morphological filters can unravel an image into ramps and textures



VTK Function

- VTK:
  - vtkImageContinuousDilate3D()
  - vtkImageContinuousErode3D()

Discussion