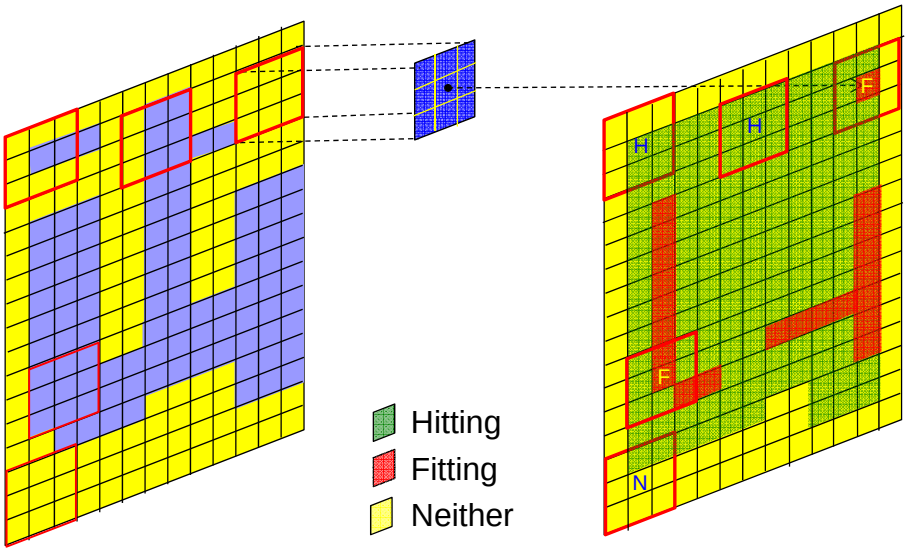
IVS Intelligent Vision Systems New Zealand

COMPSCI 373 S1C: Computer Graphics and Image Processing

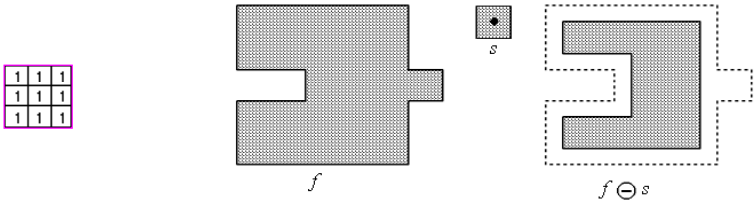
Part 3 – Image Processing

Course Review

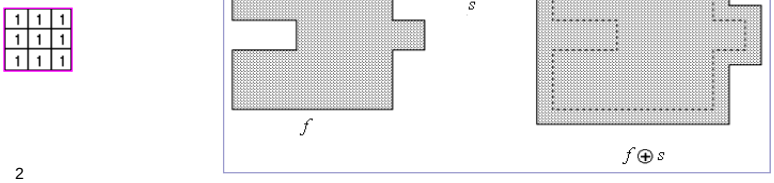
Probing with a Structuring Element



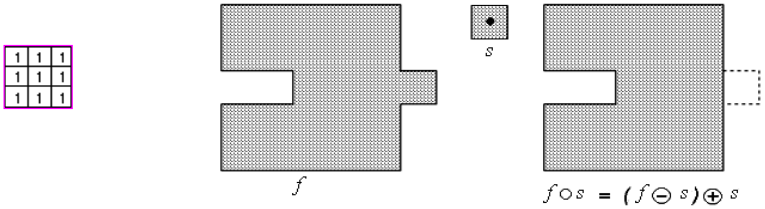
- **Erosion** $f \ominus s$ of a binary image f by an SE s produces a new image with ones in all locations where s fits f



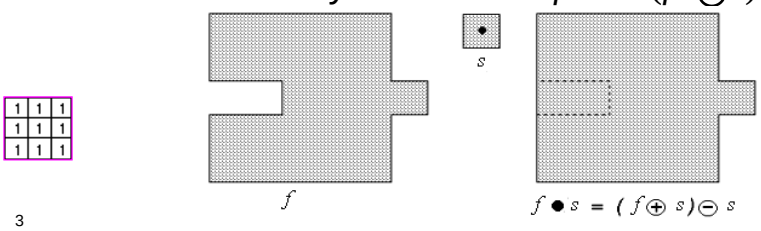
- **Dilation** $f \oplus s$ of a binary image f by a SE s produces a new image with ones in all locations where s hits f



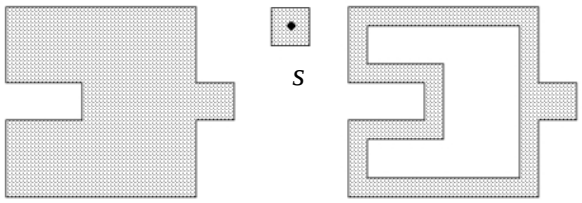
- **Opening** $f \circ s$ of an image f by a structuring element s is an *erosion* followed by a *dilation*: $f \circ s = (f \ominus s) \oplus s$



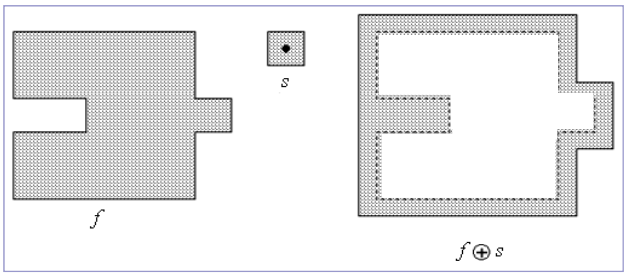
- **Closing** $f \bullet s$ of an image f by a structuring element s is a *dilation* followed by an *erosion*: $f \bullet s = (f \oplus s) \ominus s$



- Internal gradient: $f - (f \ominus s)$



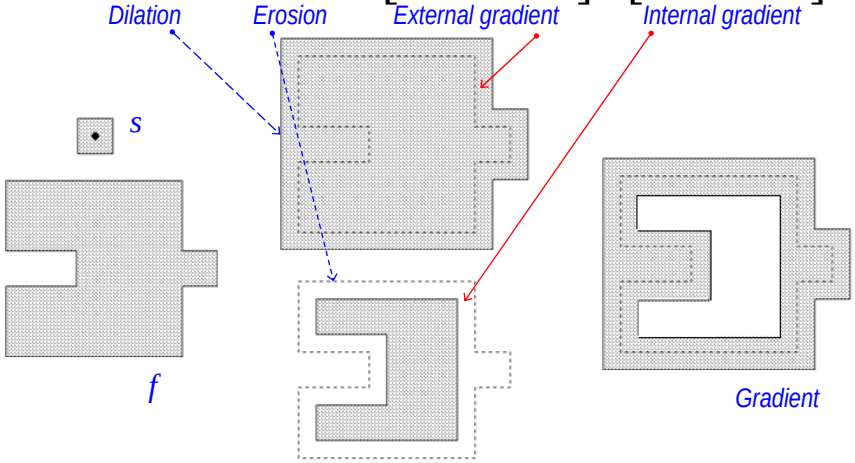
- External gradient: $(f \oplus s) - f$



Morphological Gradient

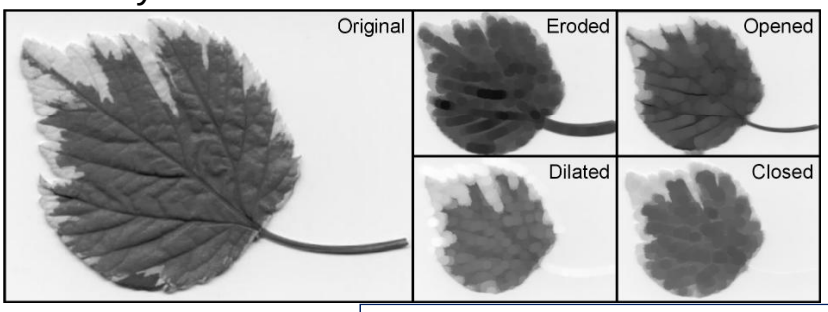
- Difference between the dilation and erosion:

$$\nabla f = (f \oplus s) - (f \ominus s) \equiv [(f \oplus s) - f] + [f - (f \ominus s)]$$



Greyscale Morphology

- The SE is sometimes referred in the greyscale morphology to as a ***structuring function***
- Zero value is now significant: pixels that do not participate in morphological operations have to be indicated by some other means

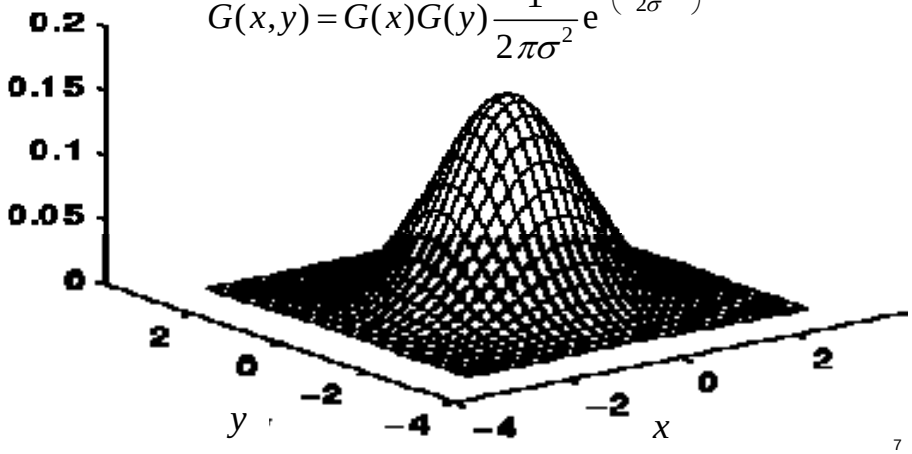


http://rsb.info.nih.gov/ij/plugins/images/gray-morphology.jpg

Gaussian Linear Filtering

- 2D Gaussian filter is built using the 2D Gaussian

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



Gaussian Linear Filtering

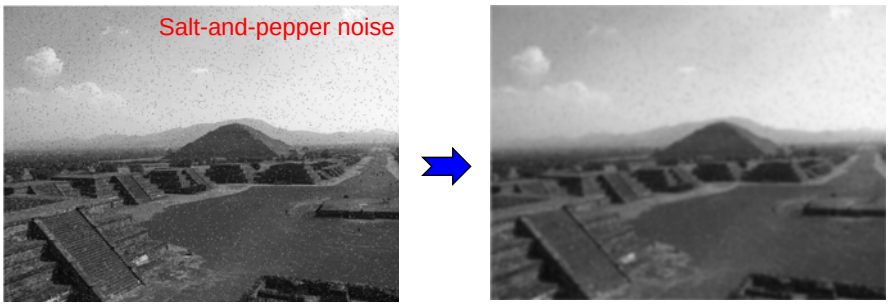
- Filter kernel s: an integer-valued approximation of digitised continuous 2D Gaussian function
  - Example: 5 × 5 window; $\sigma = 1$

$$\frac{1}{273}\begin{bmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 26 & 16 & 4 \\ 7 & 26 & 41 & 26 & 7 \\ 4 & 16 & 26 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{bmatrix}$$

  - The larger the value of σ, the wider the peak of the Gaussian and the larger the blurring

Gaussian Linear Filtering

- Non-uniform averaging: low pass filtering
- Rotational symmetry with no directional bias
- Fast computations due to separability (2D=1D×1D)
- Might not preserve image brightness



MWT Based Edge Detection

- Noise smoothing using a low-pass filter (mean, Gaussian, etc)
  - Separable Prewitt kernels (for the 3 x 3 averaging):

$$\frac{1}{6}\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \qquad \frac{1}{6}\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

  - Separable Sobel kernels (for the 3 x 3 weighed mean):

$$\frac{1}{8}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad \frac{1}{8}\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Edge Detection Using Gradients

- Initial image

http://www.eecs.berkeley.edu/Research/Projects/CS/vision/bsds/bench/gray/gm_2_4/130026.html

Edge Detection Using Gradients

- Automatically detected edges

http://www.eecs.berkeley.edu/Research/Projects/CS/vision/bsds/bench/gray/gm_2_4/130026.html

Edge Detection Using Gradients

- Human sketch of the meaningful boundaries

http://www.eecs.berkeley.edu/Research/Projects/CS/vision/bsds/bench/gray/gm_2_4/130026.html