
Morphological Image Processing



Structuring Element

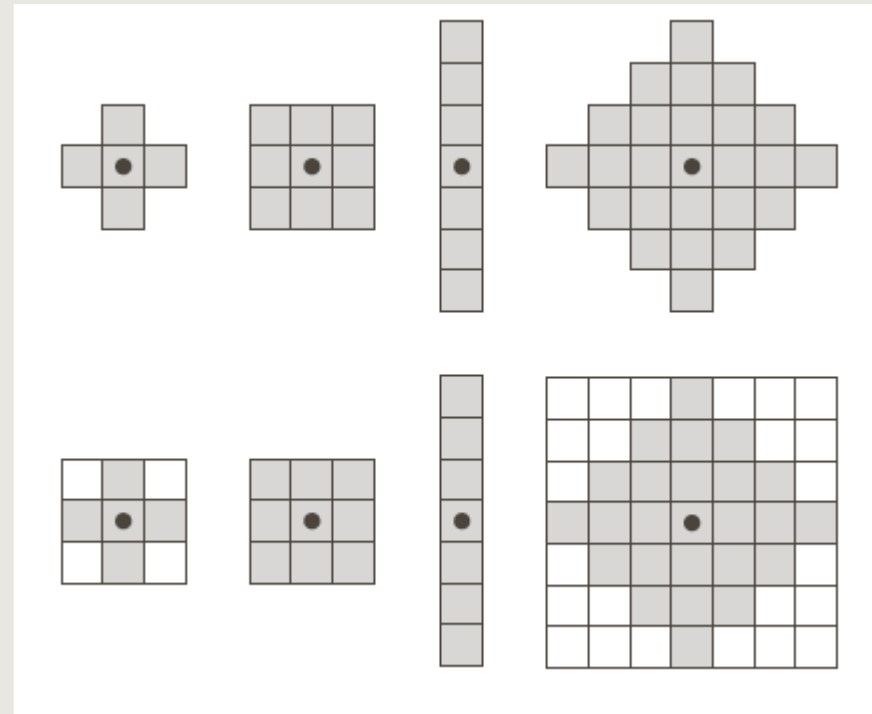
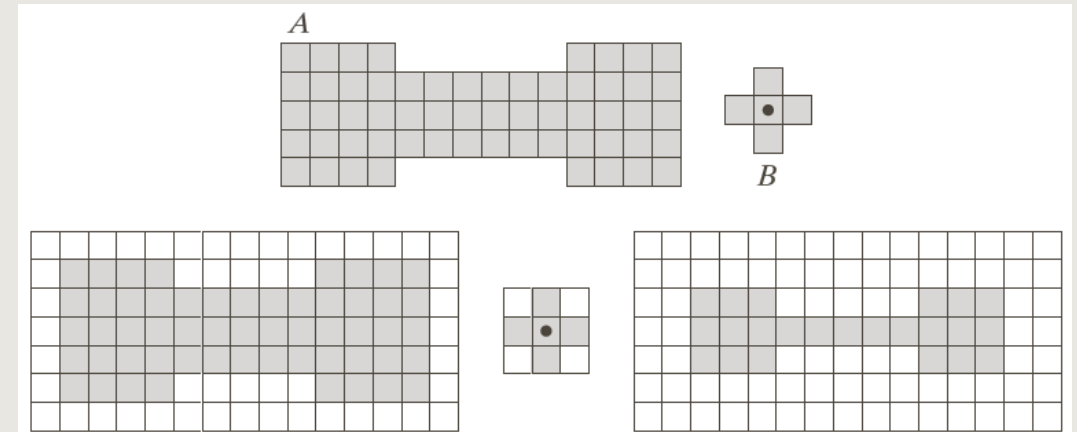


FIGURE 9.2 First row: Examples of structuring elements. Second row: Structuring elements converted to rectangular arrays. The dots denote the centers of the SEs.

Applying Structuring Element



a	b
c	d e

FIGURE 9.3 (a) A set (each shaded square is a member of the set). (b) A structuring element. (c) The set padded with background elements to form a rectangular array and provide a background border. (d) Structuring element as a rectangular array. (e) Set processed by the structuring element.

Erosion

$$A \ominus B = \{z | (B)_z \subseteq A\}$$

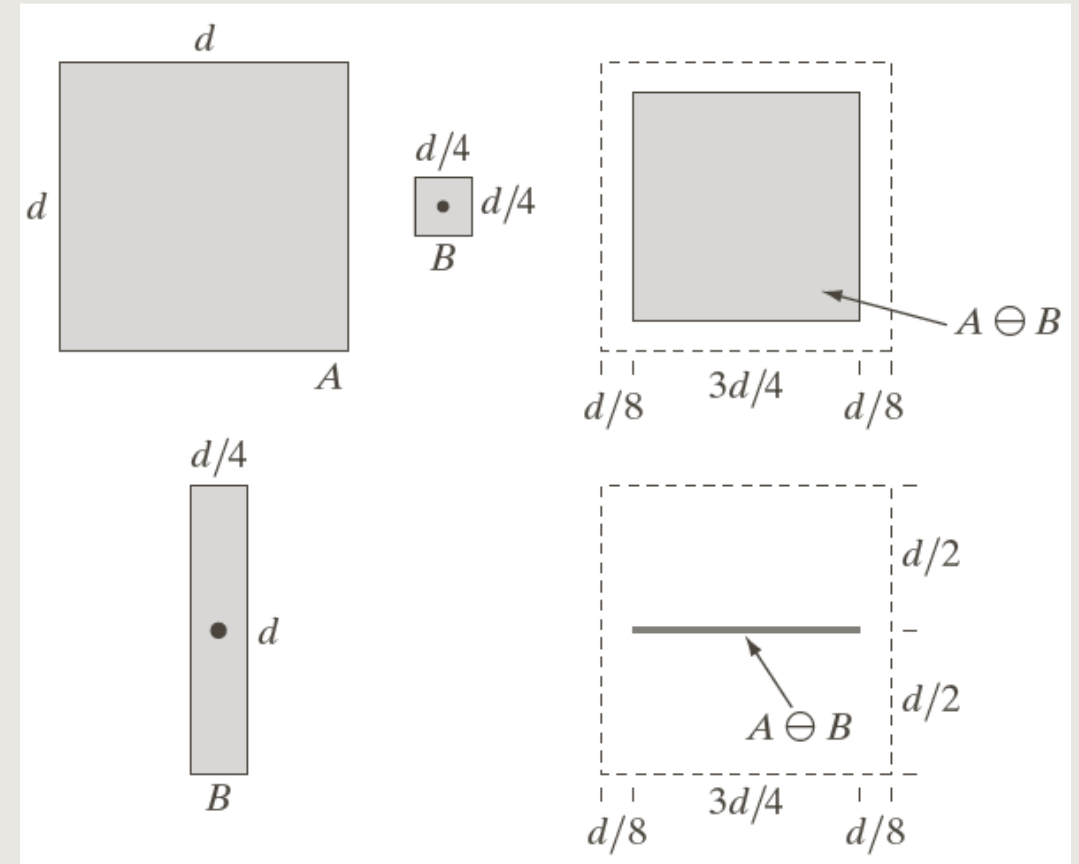
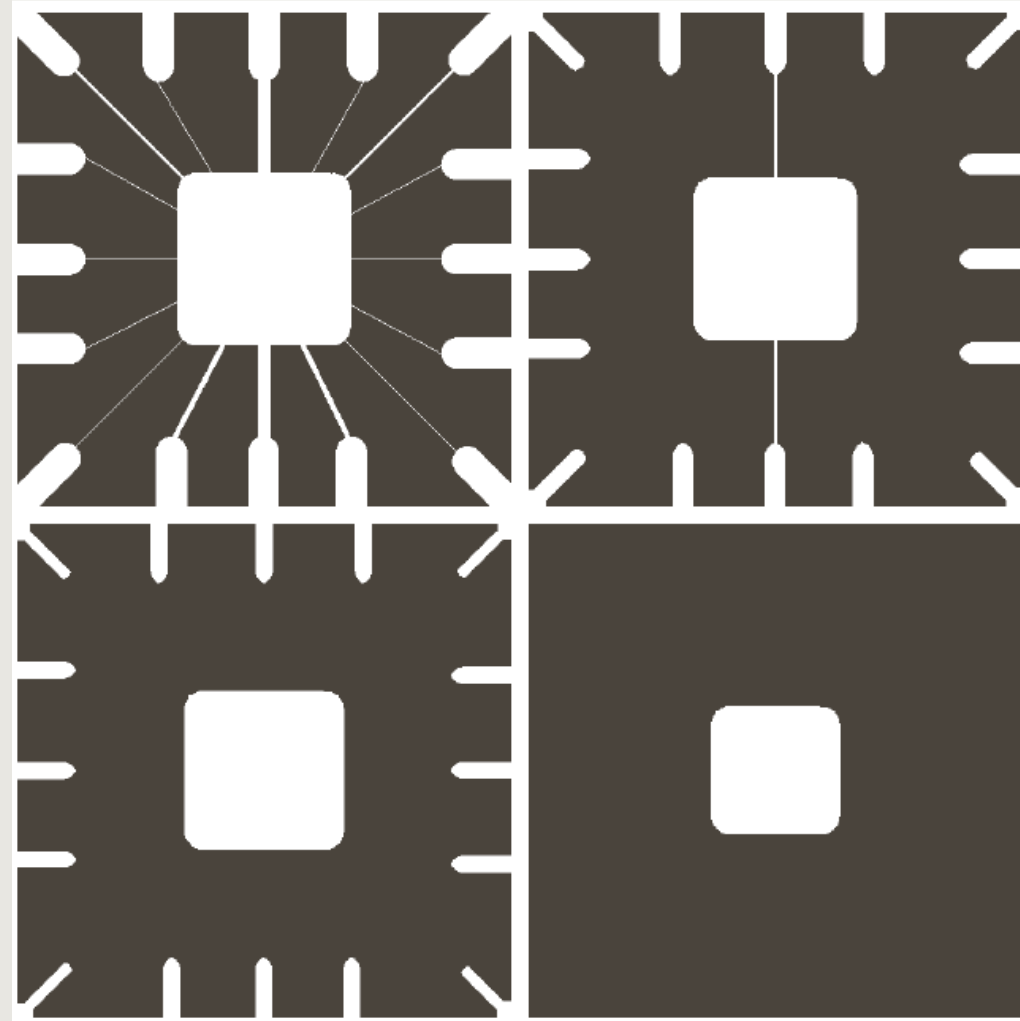


FIGURE 9.4 (a) Set A . (b) Square structuring element, B . (c) Erosion of A by B , shown shaded. (d) Elongated structuring element. (e) Erosion of A by B using this element. The dotted border in (c) and (e) is the boundary of set A , shown only for reference.

Erosion example

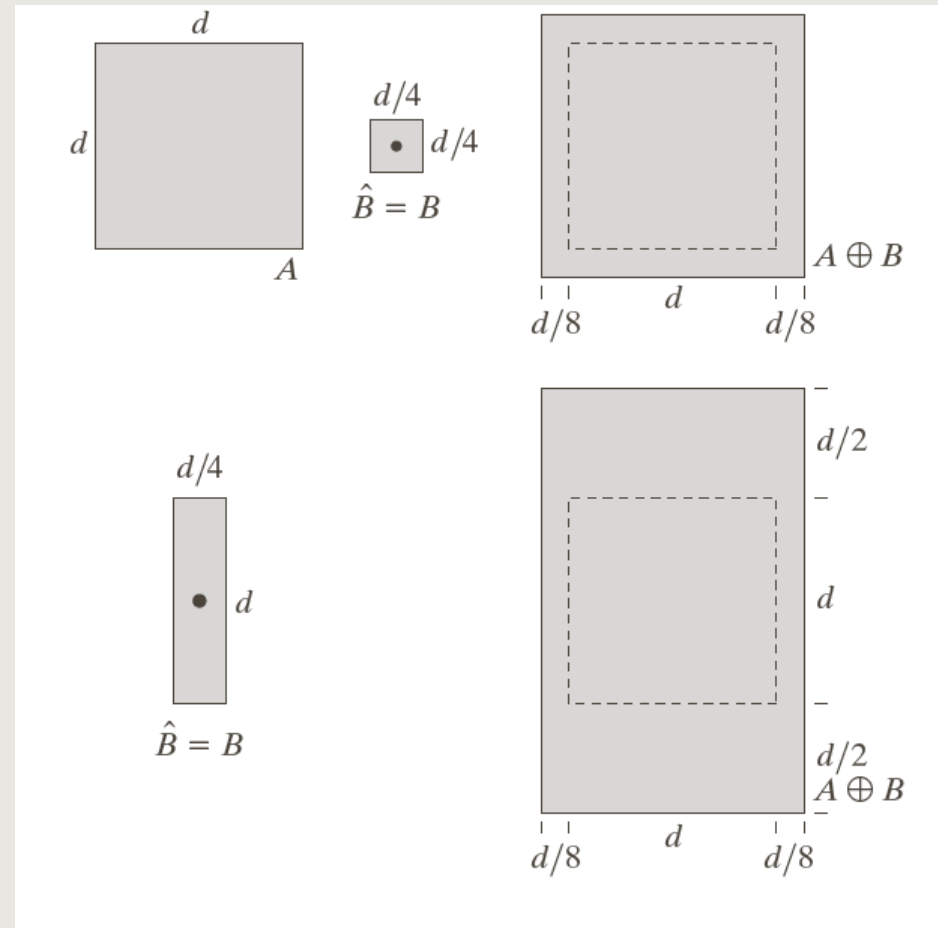


a	b
c	d

FIGURE 9.5 Using erosion to remove image components. (a) A 486×486 binary image of a wire-bond mask. (b)–(d) Image eroded using square structuring elements of sizes 11×11 , 15×15 , and 45×45 , respectively. The elements of the SEs were all 1s.

Dilation

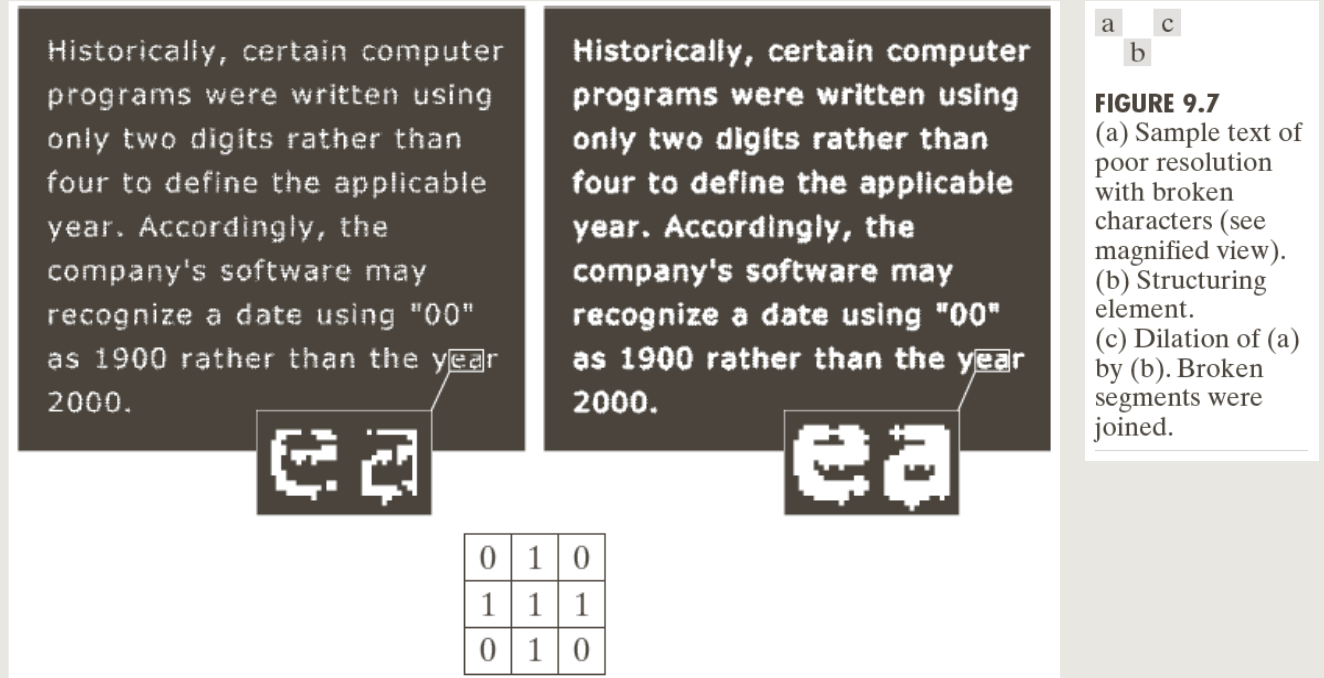
$$A \oplus B = \{z | (\hat{B})_z \cap A \neq \emptyset\}$$



a	b	c
d	e	

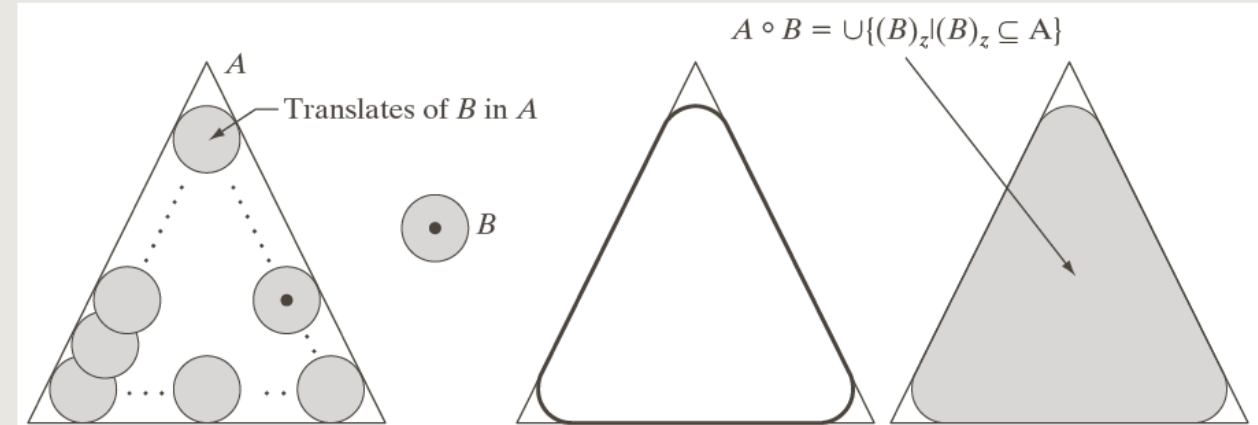
FIGURE 9.6
 (a) Set A .
 (b) Square structuring element (the dot denotes the origin).
 (c) Dilation of A by B , shown shaded.
 (d) Elongated structuring element.
 (e) Dilation of A using this element. The dotted border in (c) and (e) is the boundary of set A , shown only for reference

Dilation example



Opening

$$A \circ B = (A \ominus B) \oplus B$$

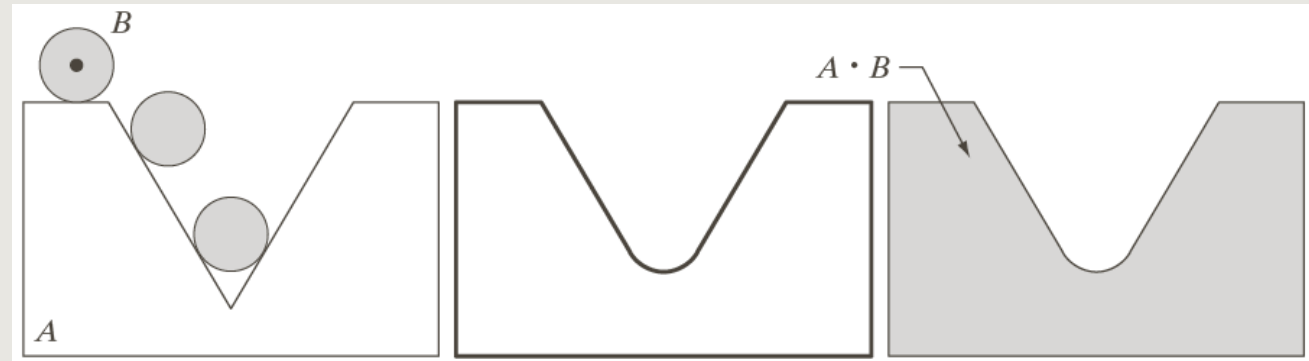


a b c d

FIGURE 9.8 (a) Structuring element B “rolling” along the inner boundary of A (the dot indicates the origin of B). (b) Structuring element. (c) The heavy line is the outer boundary of the opening. (d) Complete opening (shaded). We did not shade A in (a) for clarity.

Closing

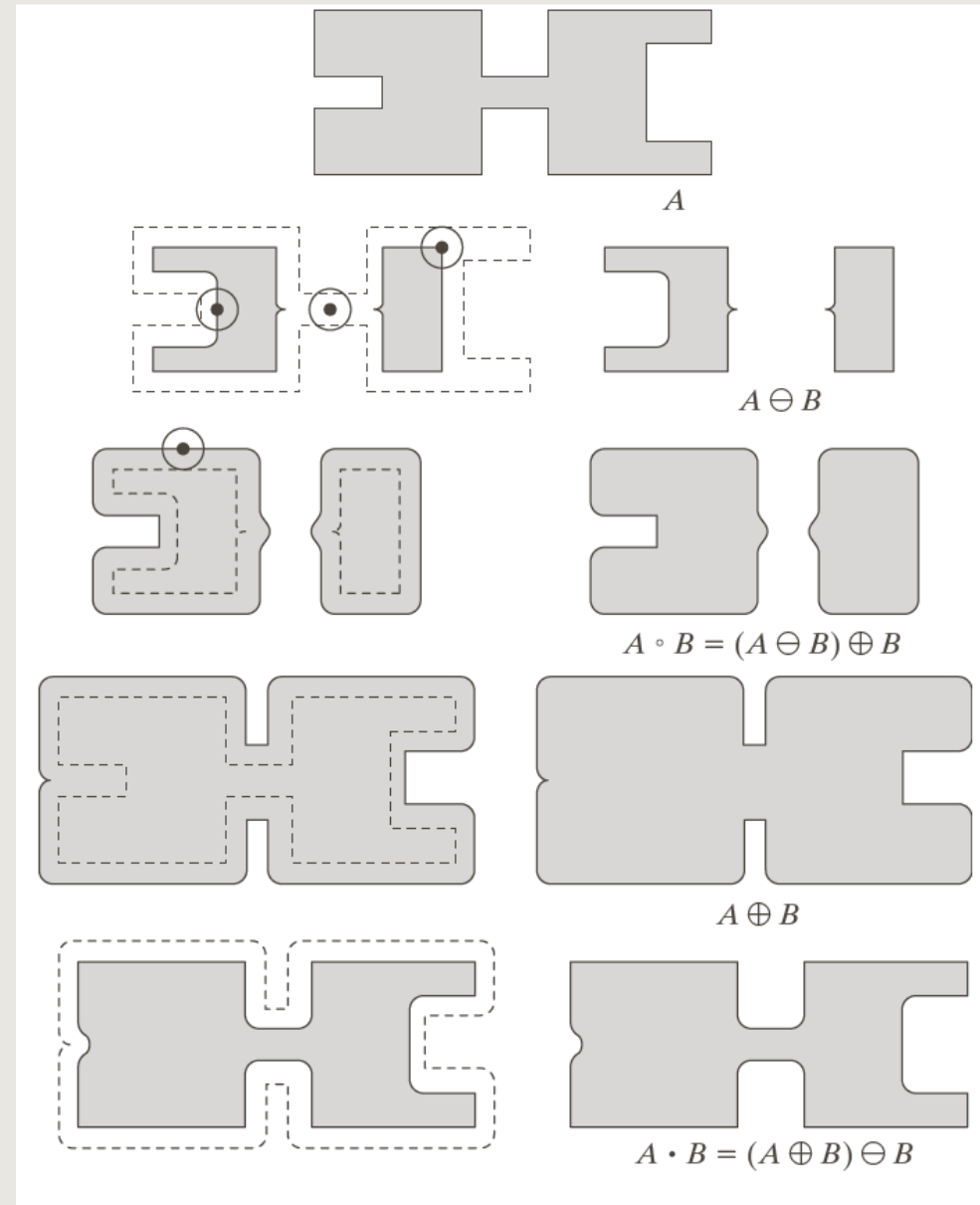
$$A \bullet B = (A \oplus B) \ominus B$$



a b c

FIGURE 9.9 (a) Structuring element B “rolling” on the outer boundary of set A . (b) The heavy line is the outer boundary of the closing. (c) Complete closing (shaded). We did not shade A in (a) for clarity.

Opening and Closing



a
b c
d e
f g
h i

FIGURE 9.10 Morphological opening and closing. The structuring element is the small circle shown in various positions in (b). The SE was not shaded here for clarity. The dark dot is the center of the structuring element.

Opening and Closing

