Thinning

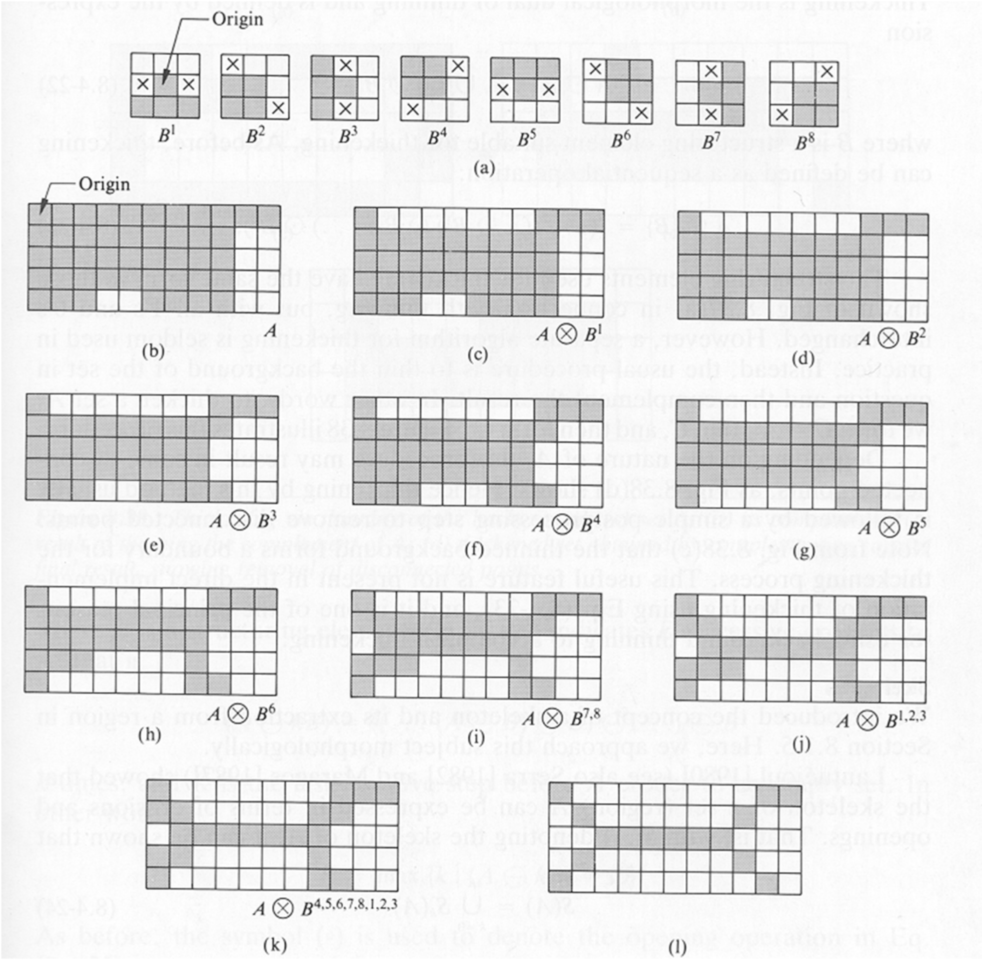
- The thinning of a set A by structuring element B, denoted $A \otimes B$, can be defined in terms of the hit-or-miss transform

$$A \otimes B = A - (A \circledast B)$$

$$= A \cap (A \circledast B)^c$$

- The usual process is to thin A using a sequence of structuring elements $B^1, \ldots B^n$
- In other words, A is thinned by successive passes of structuring elements B^1, $B^2, \ldots$
- The entire process is repeated until no further change occurs

Thinning Example

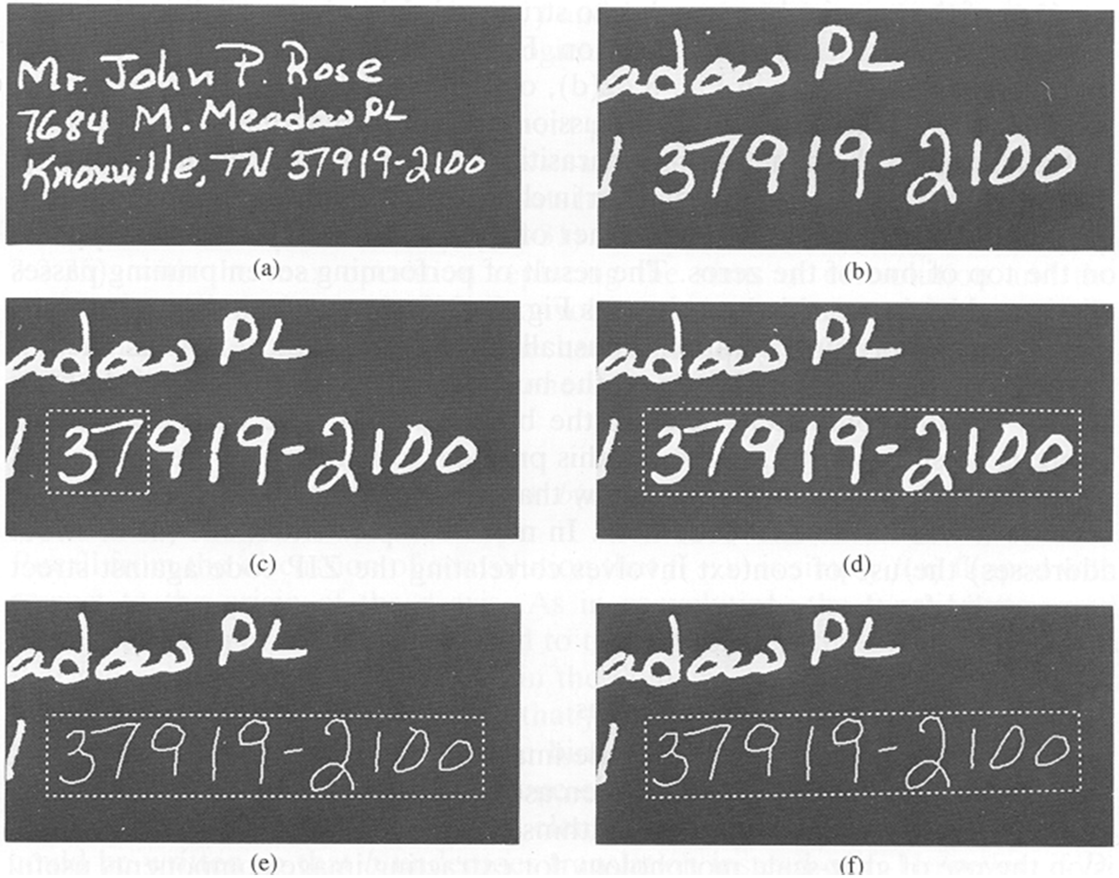


Other Morphological Operations

- We also have definitions for the following operations
  - Thickening
    - make lines thicker
  - Skeletonization
    - extract morphological skeleton
  - Pruning
    - extract parasitic components after skeletonization
- See Gonzalez and Woods, “Digital Image Processing,” pp 518-545 for details

Application

Postcode processing



dilation to bridge breaks in numbers

Erosion to separate numbers

skeleton

pruning

Grayscale Morphology

- Many binary morphological operations are simply extended to grayscale images
- Here we regard the grayscale image as a surface that is eroded and dilated
- Often it is simpler to illustrate the process with 1-D functions, since the extension to 2-D is trivial.

Grayscale Dilation

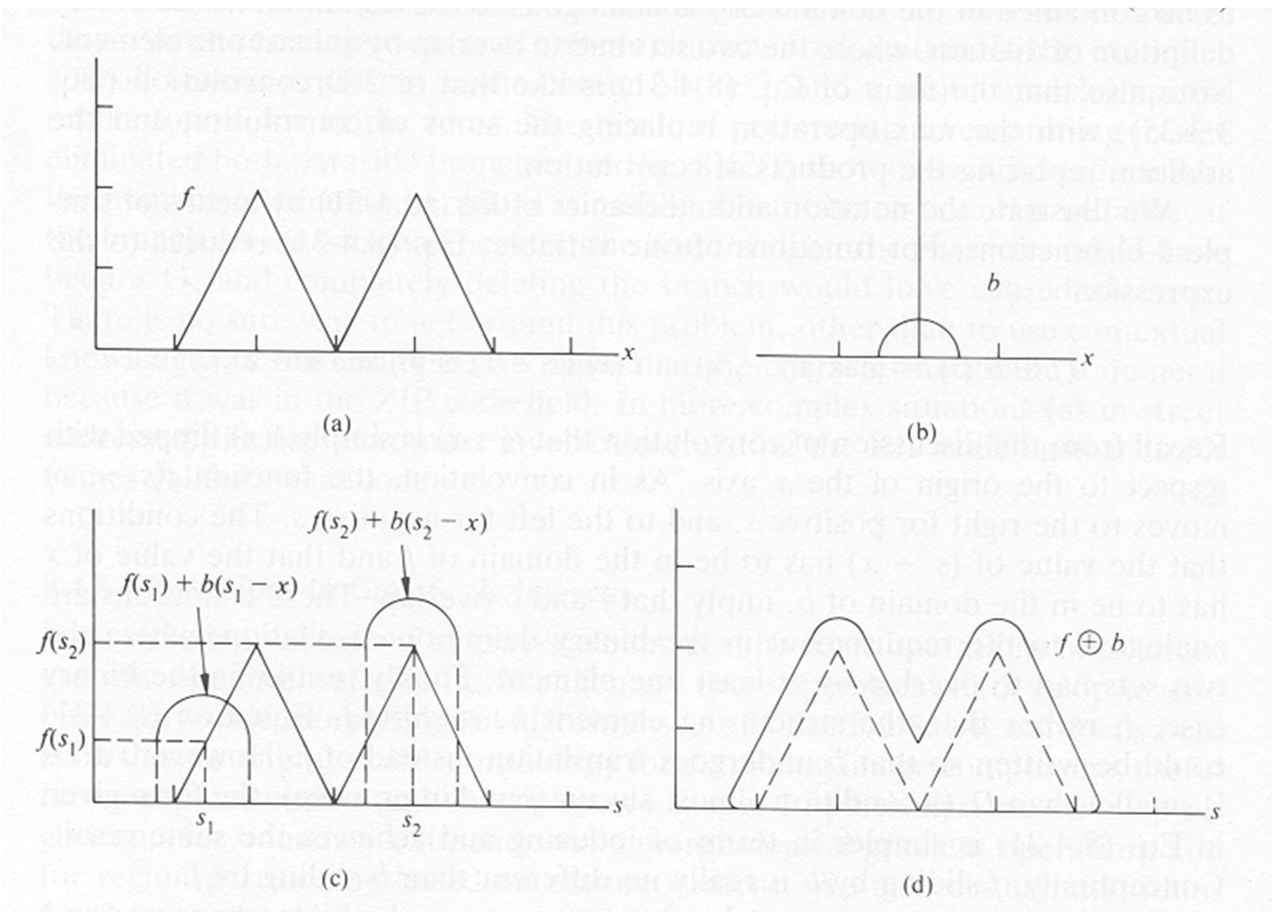
- Grayscale dilation of f by b, denoted f$\oplus$b, is defined by

$$(f \oplus b)(s,t) =$$

$$\max\{ f(s-x,t-y)+b(x,y) \mid (s-x),(t-y) \in D_f ; (x,y) \in D_b \}$$

- In other words, we find the maximum of the function f+b in a neighborhood defined by the structuring element b as we slide b over f.
- This is illustrated graphically on the next slide for a 1-D function

Dilation Example



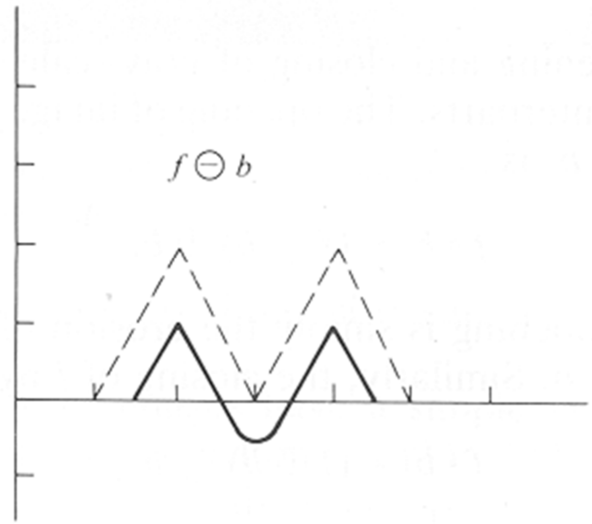
Grayscale Erosion

- Similarly, Grayscale erosion of f by b, denoted f⊖b, is defined by

$$(f \ominus b)(s,t) =$$
$$\min\{ f(s-x,t-y)+b(x,y) \mid (s-x),(t-y) \in D_f ; (x,y) \in D_b \}$$

- In other words, we find the minimum of the function **f+b** in a neighbourhood defined by the structuring element **b** as we slide **b** over **f**.

Erosion Example



Same example as before

Image Example

Original

Dilated

Eroded