Morphology

- Hit and Fit
- Dilation and Erosion
- Closing and Opening
- Compound Operations
- Boundary Detection

- Morphology operates like the other neighborhood processing methods by applying a kernel to each pixel in the input.
- In morphology, the kernel is denoted a *structuring element and contains '0's and '1's.*
- *You can design the structuring element* as you please, but normally the pattern of '1's form a box or a disk.

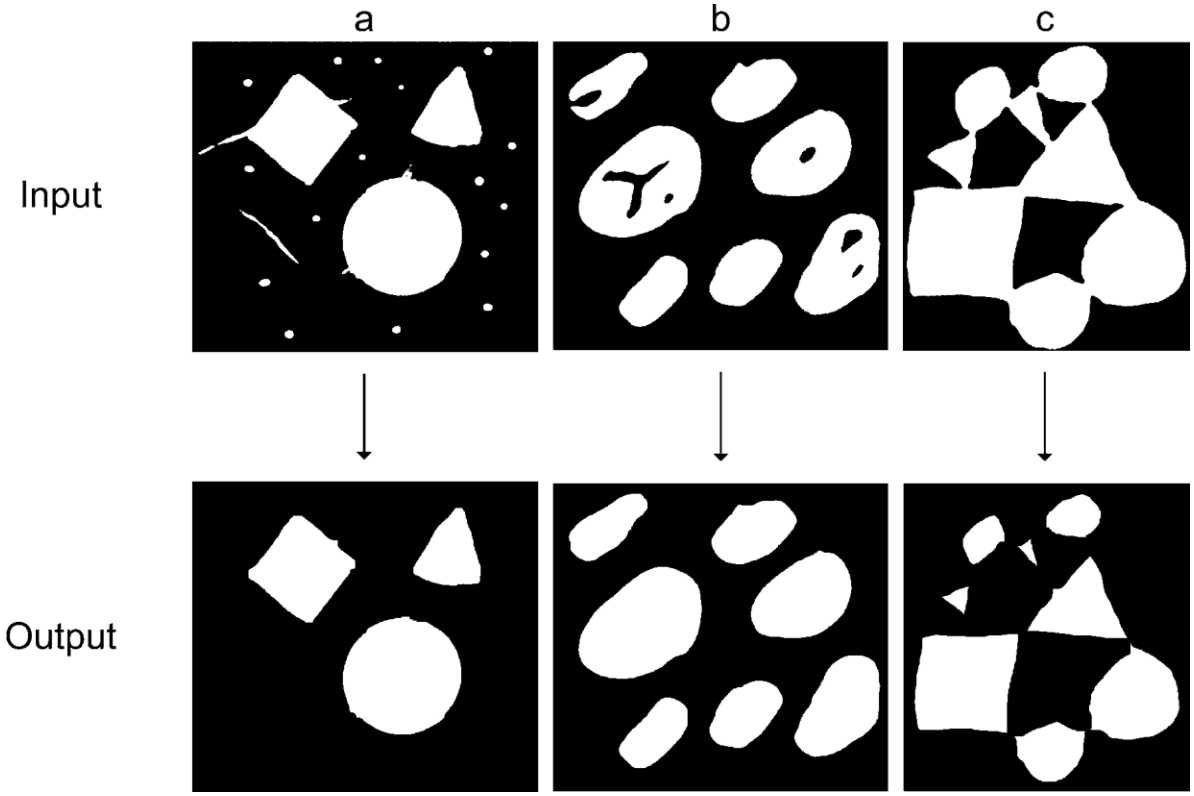


Fig. Three examples of the uses of morphology.

(a) Removing small objects.
(b) Filling holes.
(c) Isolating objects

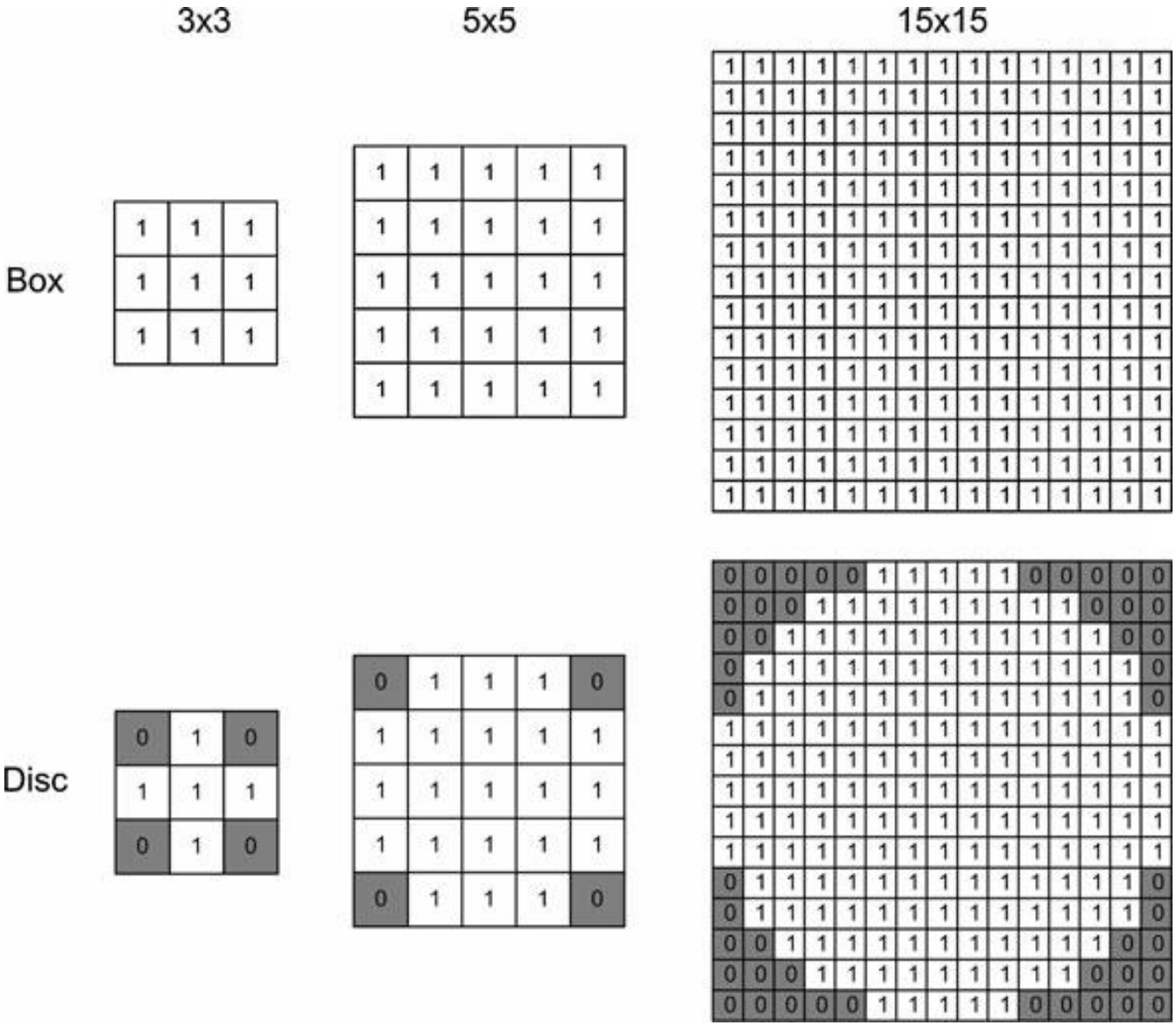


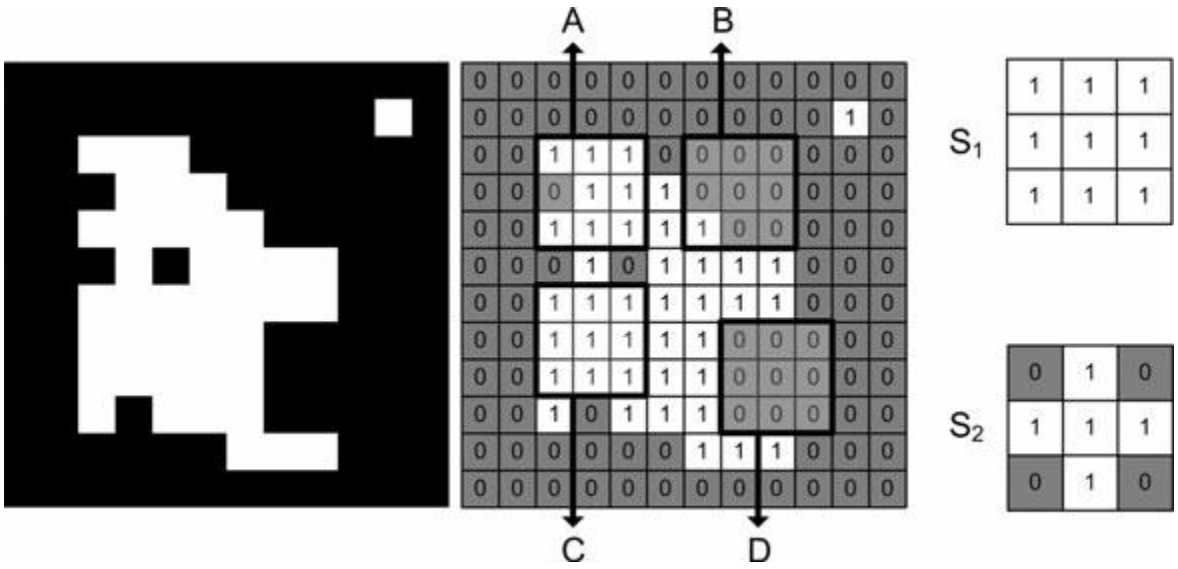
Fig. Two types of structuring elements at different sizes

Hit

- For each '1' in the structuring element we investigate whether the pixel at the same position in the image is also a '1'.
- If this is the case for just one of the '1's in the structuring element we say that the structuring element *hits the image at the pixel* position in question (the one on which the structuring element is centered). This pixel is therefore set to '1' in the output image. Otherwise it is set to '0'.

Fit

- For each '1' in the structuring element we investigate whether the pixel at the same position in the image is also a '1'.
- If this is the case for *all the '1's in the structuring* element we say that the structuring element *fits the image at the pixel position in* question (the one on which the structuring element is centered). This pixel is therefore set to '1' in the output image. Otherwise it is set to '0'.



Position	*SE*	Fit	Hit
A	S_1	No	Yes
A	S_2	No	Yes
B	S_1	No	Yes
B	S_2	No	No
C	S_1	Yes	Yes
C	S_2	Yes	Yes
D	S_1	No	No
D	S_2	No	No

Dilation

Applying Hit to an entire image is denoted *Dilation and is written as*

$$g(x, y) = f(x, y) \oplus SE$$

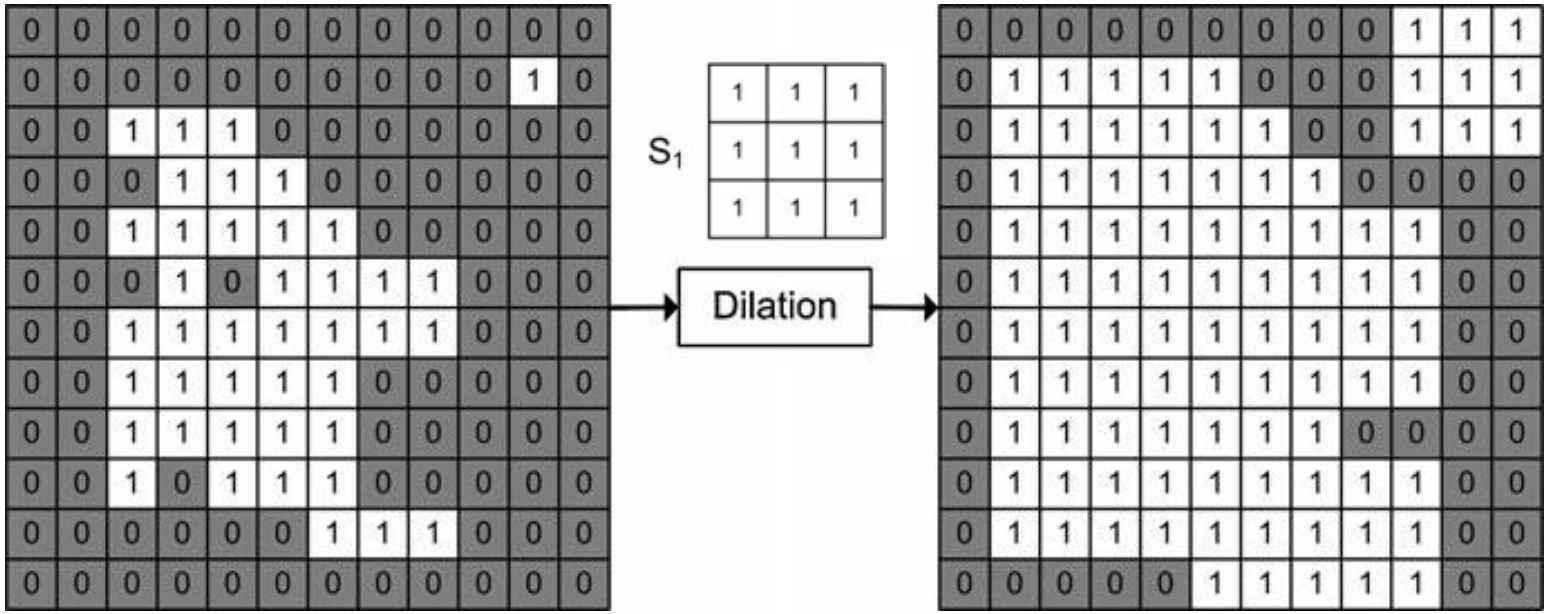


Fig. Dilation of the binary image using *S1*

- The term *dilation refers to the fact that the object in the binary image is increased* in size.
- In general, dilating an image results in objects becoming bigger, small holes being filled, and objects being merged.
- How big the effect is depends on the size of the structuring element.
- It should be noticed that a large structuring element can be implemented by iteratively applying a smaller structuring element.

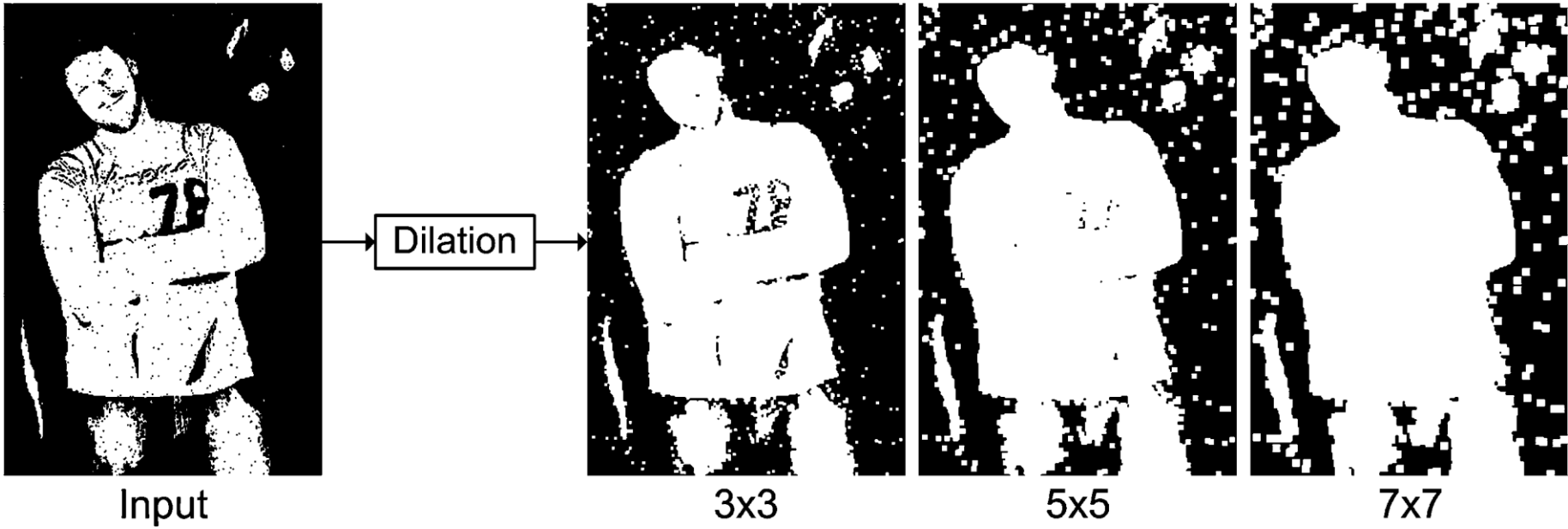
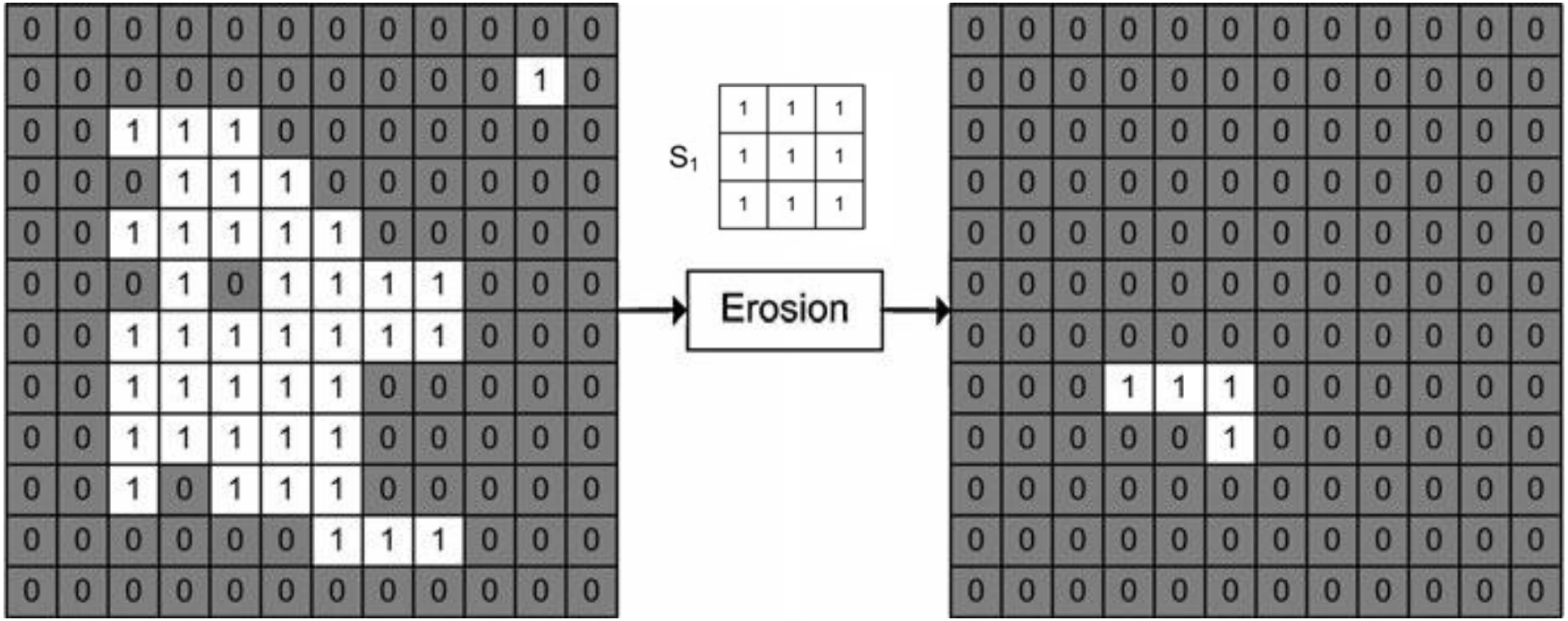


Fig. Dilation with different sized structuring elements

Erosion

Applying Fit to an entire image is denoted Erosion and is written as

$$g(x, y) = f(x, y) \ominus SE$$



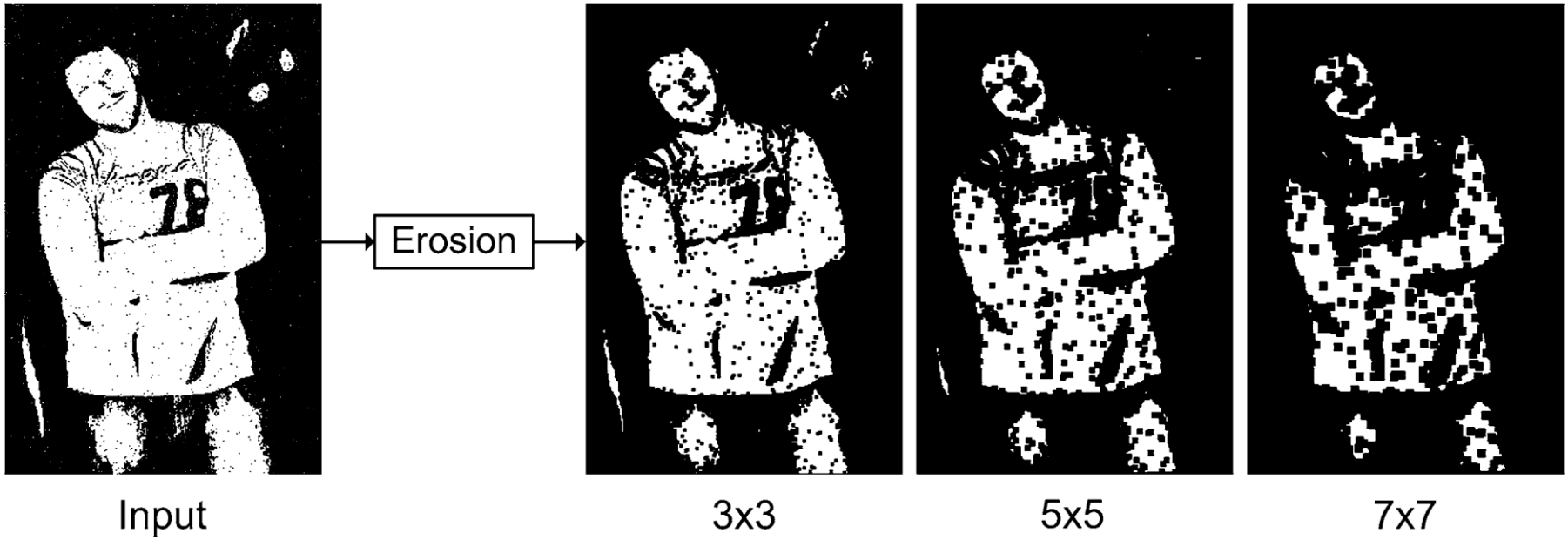


Fig. Erosion with different sized structuring elements

Compound Operations

Closing

$$g(x, y) = f(x, y) \bullet SE = \left(f(x, y) \oplus SE\right) \ominus SE$$

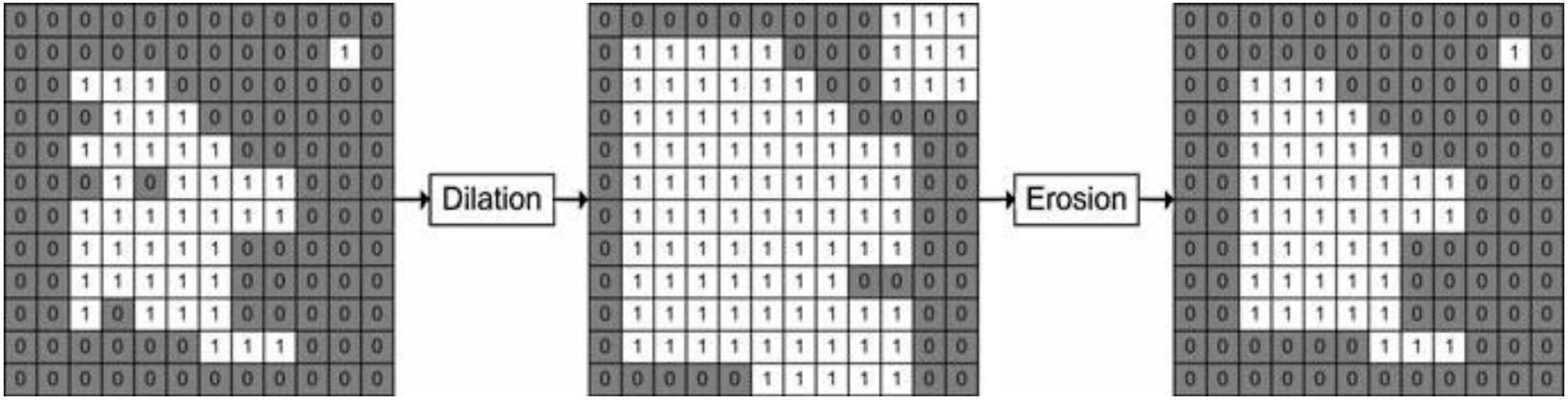


Fig. Closing of the binary image using *S1*

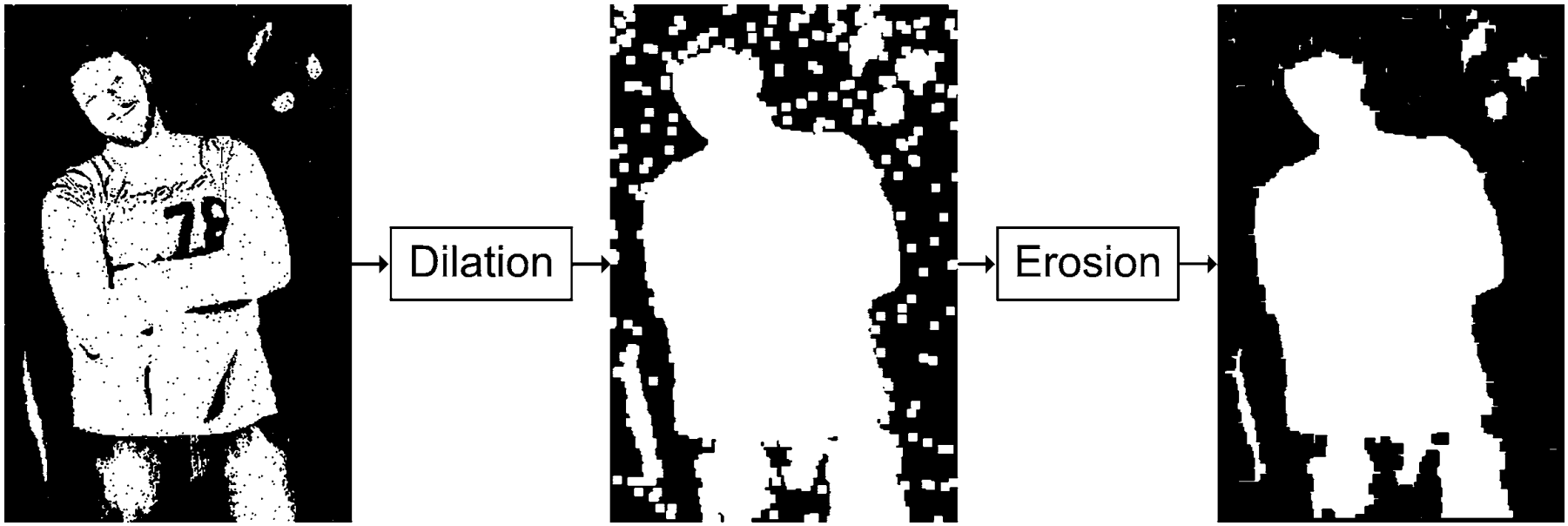


Fig. Closing performed using 7 ×7 box-shaped structuring elements

Opening

$$g(x, y) = f(x, y) \circ SE = \left(f(x, y) \ominus SE\right) \oplus SE$$

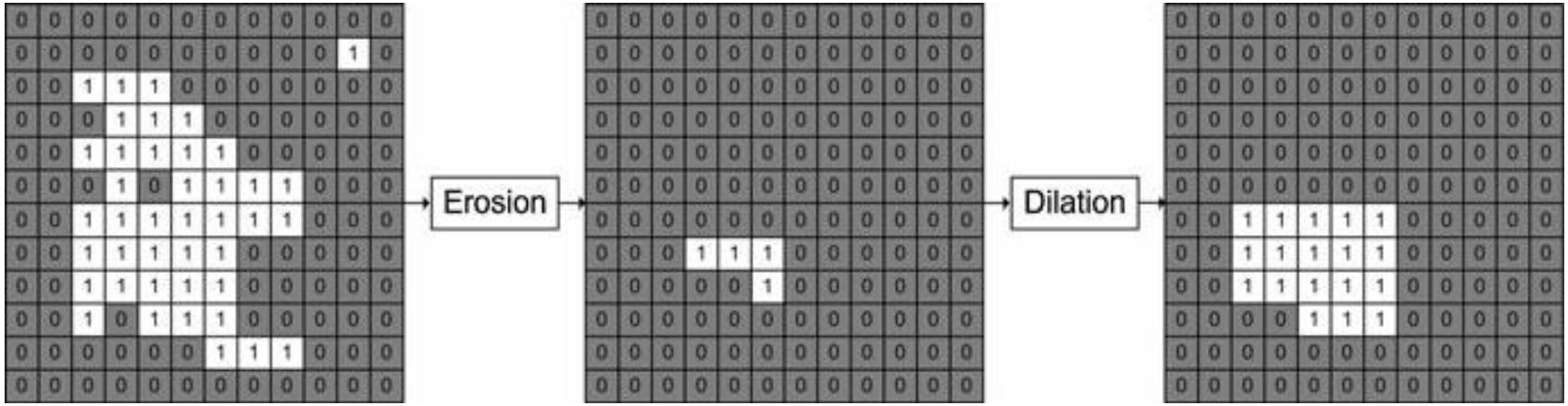


Fig. Opening of the binary image using *S1*

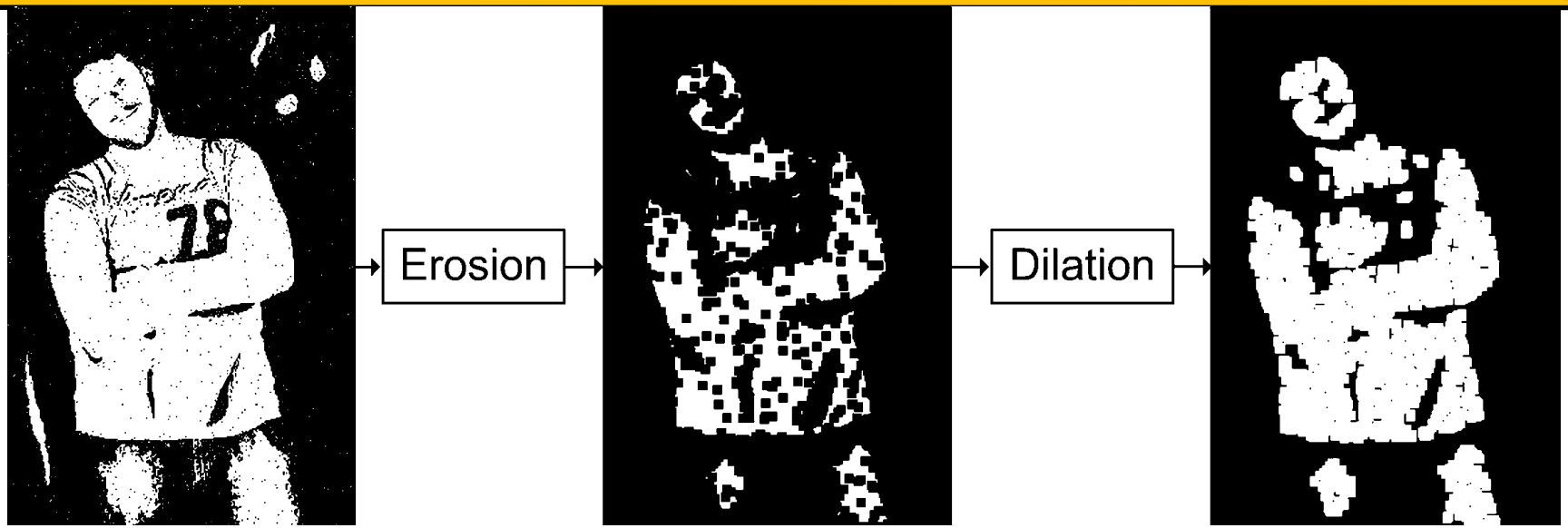


Fig. Opening performed using a 7×7 box-shaped structuring element

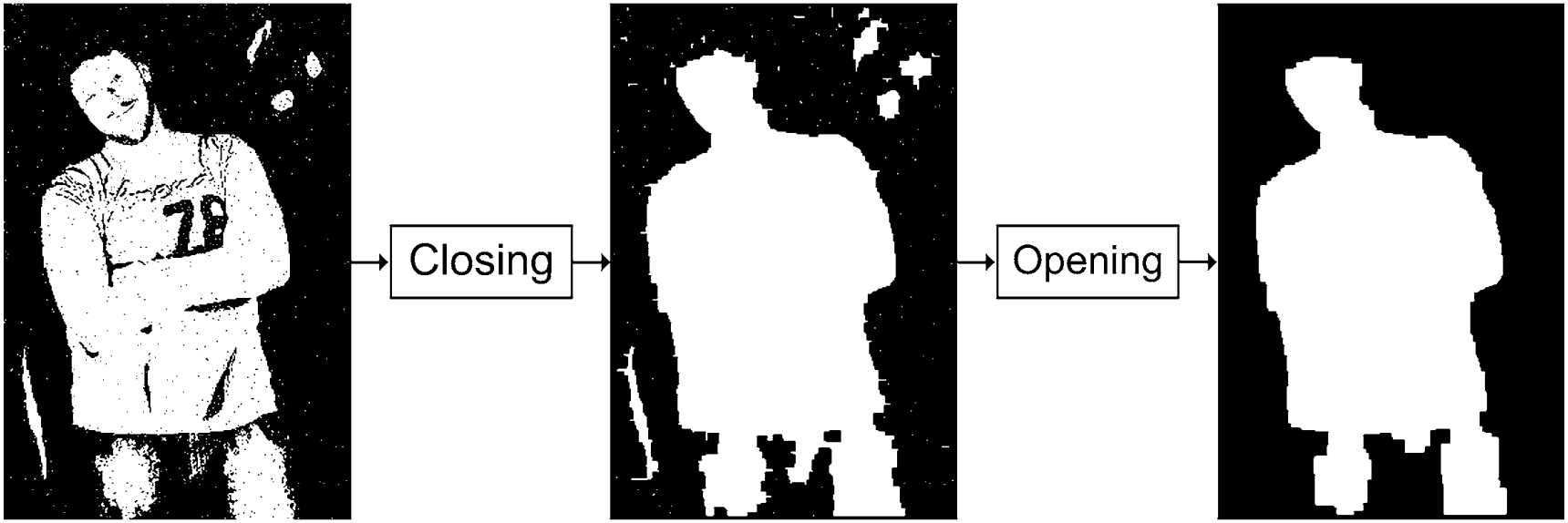


Fig. Filtering a binary image where both holes and small noisy objects are present

Application: Boundary Detection

$$g(x, y) = f(x, y) - \left(f(x, y) \ominus SE\right)$$

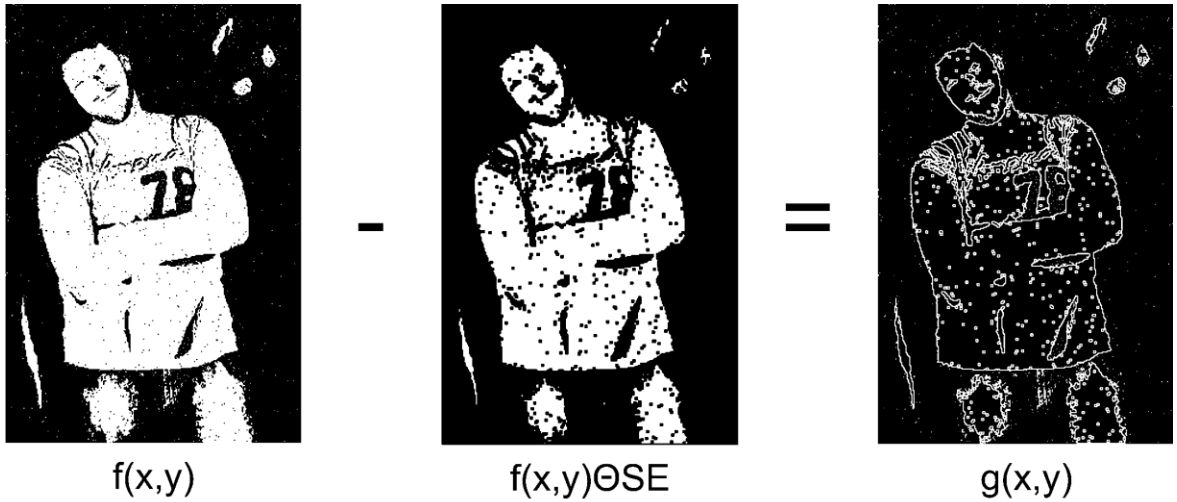


Fig. Boundary detection