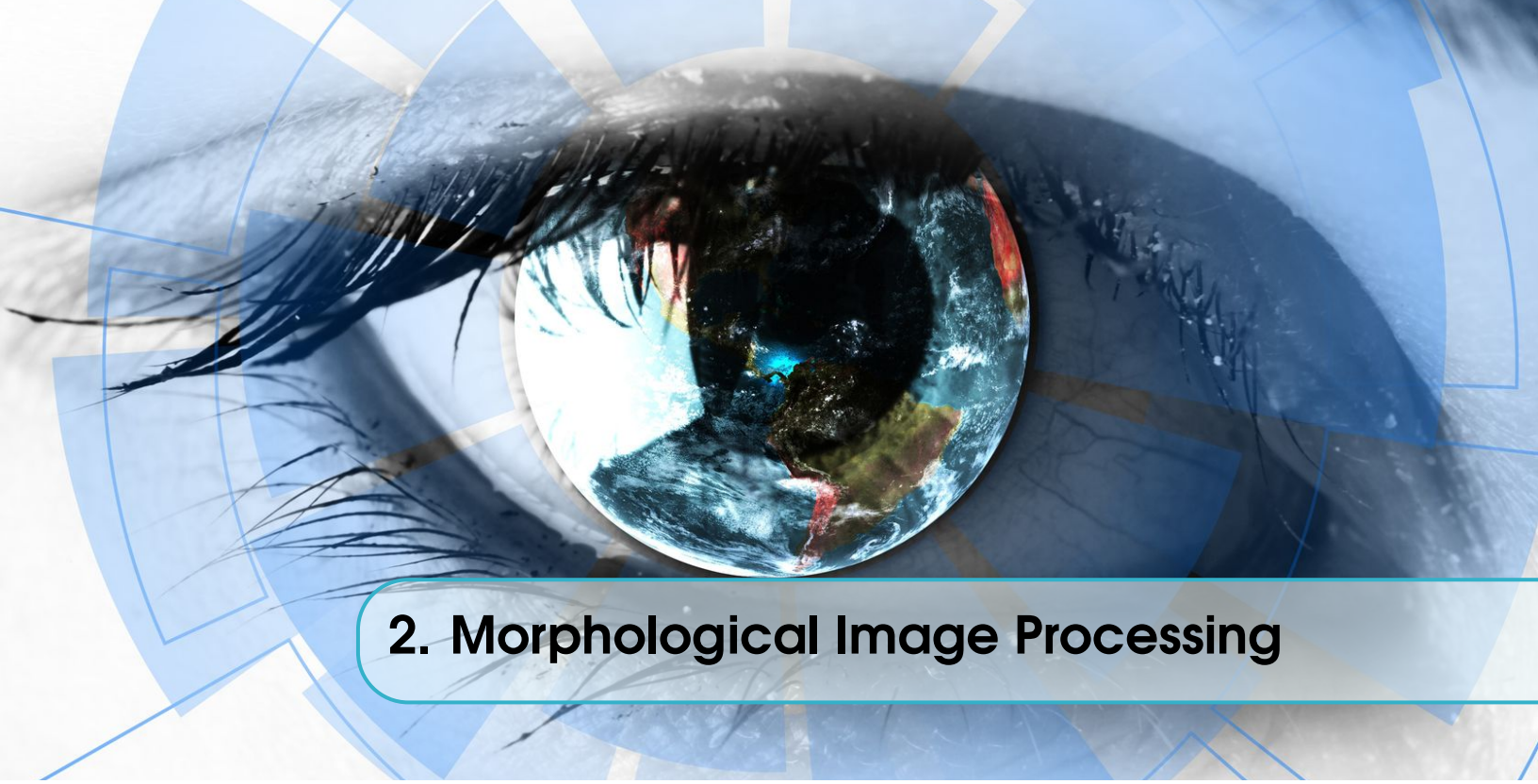

2. Morphological Image Processing

2.1 Dilation and Erosion

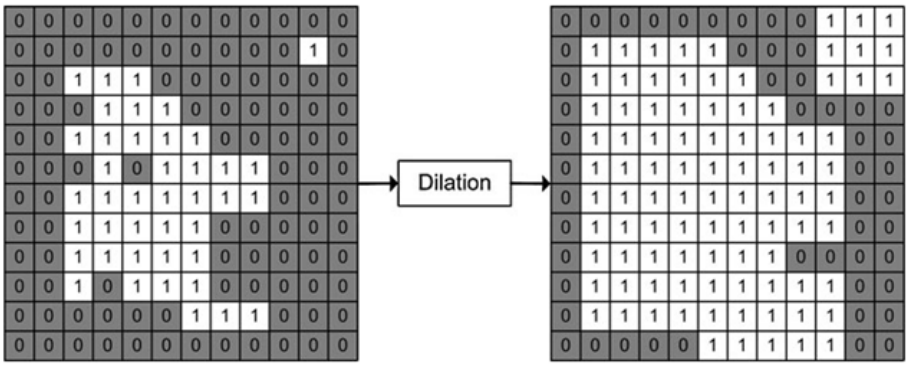

Figure 2.1: An illustration of dilation operation.

Dilation is an operation that grows or thickens objects in a binary image. The specific manner and extent of this thickening is controlled by a shape referred to as a structuring element. The dilation operation can be used in bridging the small breaks or gaps in the binary image.
The dilation of A by B (B is the structuring element) then is the set of all displacements, z, such that B and A overlap by at least one element. Based on this interpretation, the above equation can be shown as

$$A \oplus B = B \oplus A = \{z|[(B^s)_z \cap A \neq \emptyset]\} \tag{2.1}$$

where B^s denotes the symmetric of B, meaning $B^s = \{x|-x \in B\}$.
Erosion shrinks or thins objects in a binary image. The manner and extent of shrinking is also controlled by a structuring element. Erosion operation can be used to eliminate the noise in the binary image.For sets A and B, the erosion of A by B, is defined as:

$$A \ominus B = \{z|B_z \subseteq A\} \tag{2.2}$$

You can view erosion as a reversed version of Dilation which simply substitutes the positive and negative pixel values in this operation. In our case, assume dilation is to enlarge the regions with 255 to the regions with 0; erosion can be viewed as dilate regions with 0 to regions with 255.

1. Convert the colour image to grey scale image: $G(v) = 0.212671R + 0.715160G + 0.072169B$
2. Convert the grey scale image to binary image, since tasks below are performed on binary images. If the grey scale value is less than 128, set it to 0; otherwise, 255.
3. (Hint for Step 2) $(threshold = ((image > thresholdvalue) + np.zeros(image.shape)) * 255)$. Think about why we need to add $np.zeros(image.shape)$.
4. Perform dilation to the image
5. Perform erosion to the image

We thank Marek A. Perkowski for the example sources.

2.2 Opening and Closing

Opening generally smooths the contour of an object, breaks narrow isthmuses, and eliminates thin protrusions.The opening of A by B is obtained by the erosion of A by B, followed by dilation of the resulting image by B.

Closing also tends to smooth sections of contours but, as opposed to opening, it generally fuses narrow breaks and long thin gulfs, eliminates small holes, and fills gaps in the contour.The closing of A by B is obtained by the dilation of A by B, followed by erosion of the resulting structure by B.

First turn the RGB images in *samplelab2* folder into binary ones. Then please perform opening and closing to the them respectively and compare the effects.

2.3 Evaluate your result

In OpenCV library, there are specific functions for enrosion, dilation, openning and closing operation. After finishing your own functions, try to compare your results with those from OpenCV library.

```
import cv2  # opencv library in python

erosion = cv2.erode(image, kernel, iterations = 1)

dilation = cv2.dilate(image,kernel,iterations = 1)

opening = cv2.morphologyEx(image, cv2.MORPH_OPEN, kernel)

closing = cv2.morphologyEx(image, cv2.MORPH_CLOSE, kernel)
```

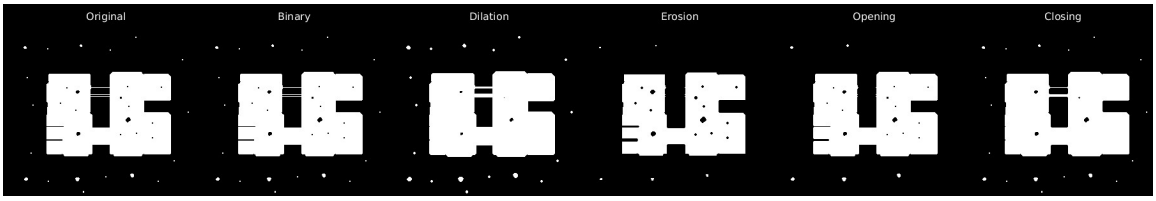

Figure 2.2: The expected results of these operations.

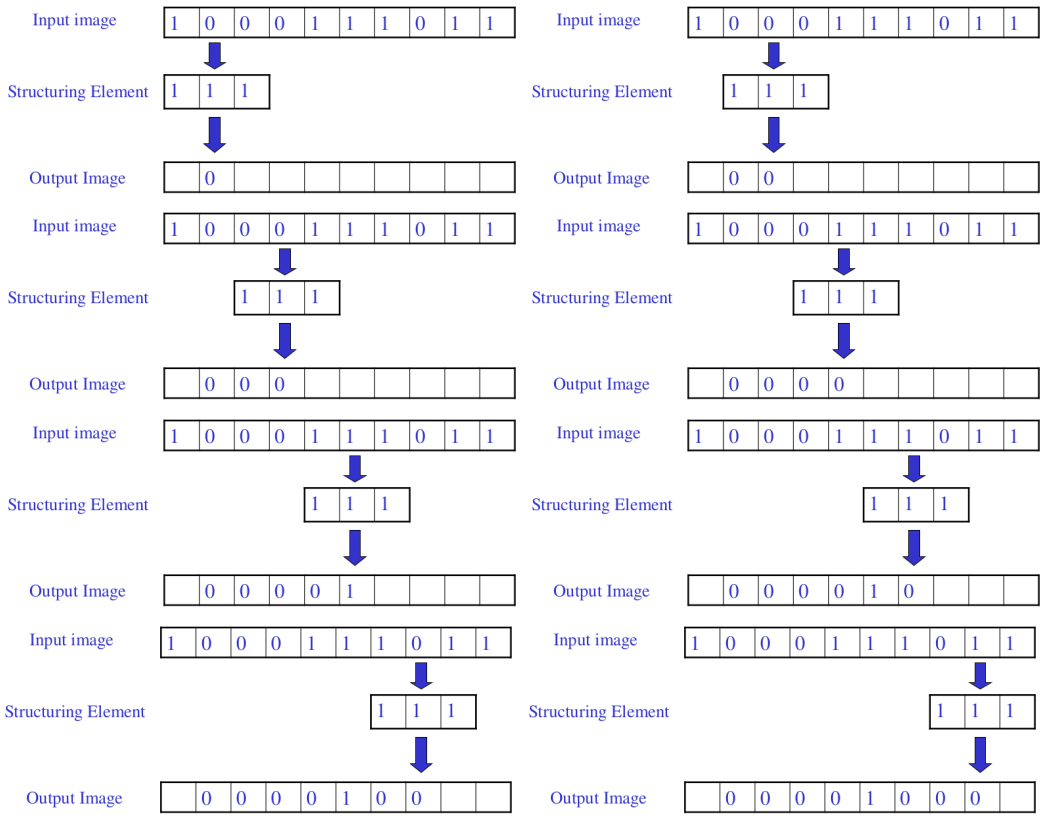

Figure 2.3: An example of Erosion

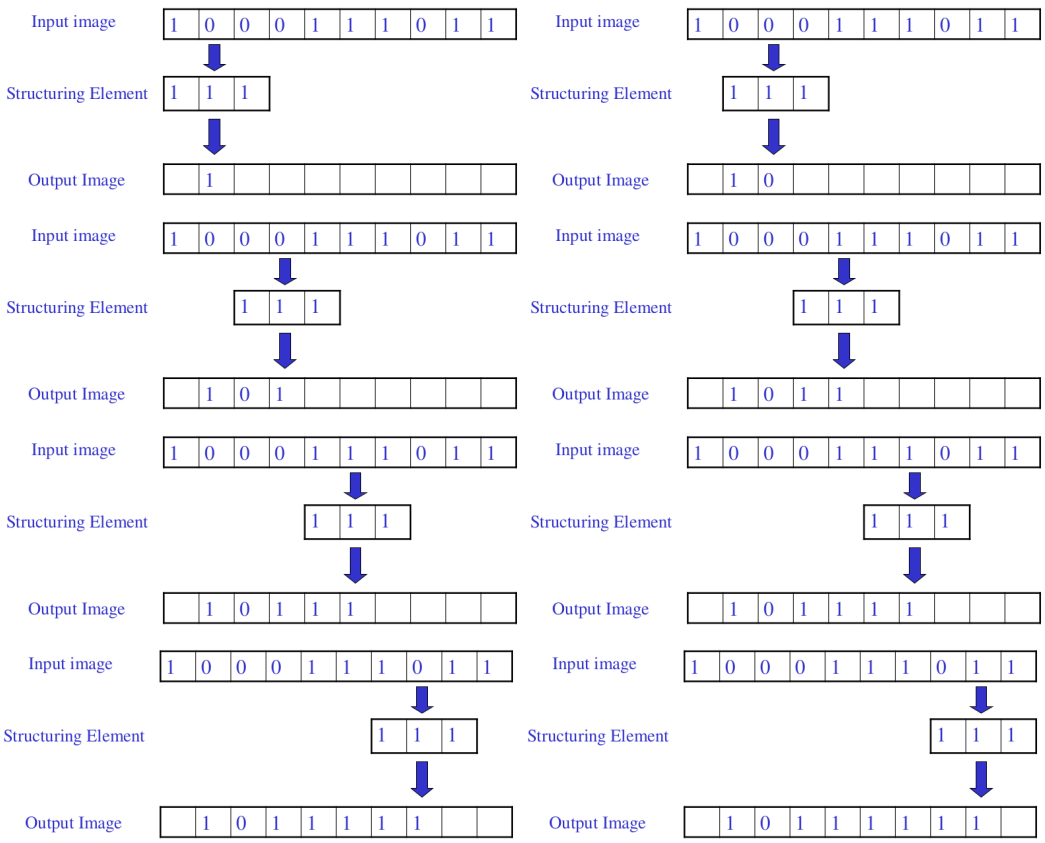

Figure 2.4: An example of Dilation