

Morphological Operation: Closing

What are Morphological Operations: Morphology means the study of shape of things. In Image Processing, the operations performed based on shape are called morphological operations. We apply structuring element to the input image and perform the operation to get the output image. The input and output images are of the same dimensions. The value of the pixel in the output image is based on the comparison of the corresponding pixel in the input image with its neighbours.

What is Structuring Element: It is a 2D matrix which identifies the pixel to be processed and the neighbouring pixels used in the processing. We choose a structuring element according to the shape of the object we want to process in the input image.

Origin: Generally, the centre of the structuring element is called the origin. It identifies the pixel being processed. The origin need not always be the centre but might be even outside of the structuring element.

Closing: Closing is an important morphological operation along with Opening. These operations are derived from dilation and erosion operations. This operation is normally used with binary images but can also be extended to grayscale images.

Closing is Dilation followed by Erosion.

The fundamental of closing process has similar effect as dilation which is to add pixels to the boundary of the input image making the object more visible and fill small voids in the image. Although, it is less destructive than dilation in nature.

Closing operator takes two inputs, one is the image and the other one is the structuring element. The structuring element determines the effect of closing on the input image. Same structuring element is used for both operations.

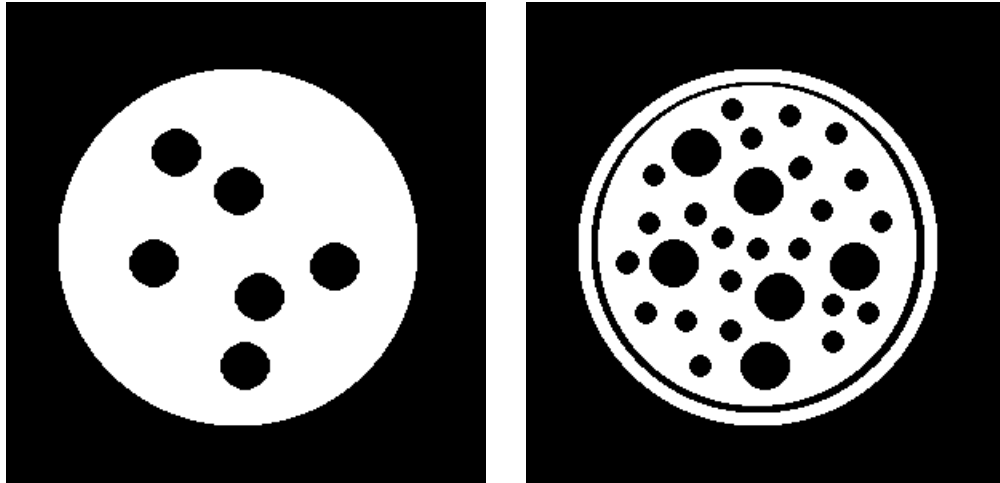
Process- The closing operation is performed on the input image which provides dilated image as output. This dilated image is then served as input image for the erosion process which provides the final output image.

Key points about Closing-

- Closing is the dual of opening.
- Size of input and output image is same.
- It grows the object and fill any voids in the input image, same as dilation.
- The nature of thickening is determined by the structuring element.
- Closing can be performed on Binary images as well as Grayscale images.

Applications of Closing-

1. **Filling background regions-** Closing process can be used for filling background regions. The closing is performed in the input image(left) to remove the smaller circles in the output image(right) with the help of a disk shaped structuring element of appropriate size.



2. **Removing Pepper Noise-** The dilation process can be used to remove pepper noise from an image but this affects the quality of the image. As a result closing process(dilation followed by erosion) is generally used for this purpose.

Closing Code using OpenCV — Python

Code-1. Binary Closing- Using input image in the form of a numpy array.

```
import numpy as np
import cv2
# In binary sometimes we express a black pixel and a white pixel as 0 and 1 respectively.
# In the following code 0 denotes a black pixel and 255 denotes a white pixel. Read observations at
the bottom to get full idea.
# input image array
img = np.array([[ 1, 1, 0, 0, 0],
                 [ 1, 1, 1, 0, 1],
                 [ 0, 1, 1, 0, 1],
                 [ 0, 1, 1, 0, 1],
                 [ 0, 0, 0, 0, 0],
                 [ 1, 1, 0, 0, 0]], np.uint8)
# kernel array
kernel = np.array([[1, 1, 0],
                   [1, 1, 0],
                   [1, 1, 0]], np.uint8)
# performing closing using dilation followed by erosion
```

```

dilation = cv2.dilate(img,kernel,iterations = 1)
erosion = cv2.erode(dilation, kernel, iterations = 1)
# performing closing using its function
closing = cv2.morphologyEx(img, cv2.MORPH_CLOSE, kernel)
print(erosion)
print(closing)
print(erosion==closing)
# Conclusion
# Closing is just another way of saying dilation followed by erosion
# Observations:
# The 0s and 1s in the numpy array 'img' does not denote white and black.
# It represents the actual pixel value in grayscale range 0-255.
# To output the array in the form of the image will result in an image showing pixel value 1 which appears to be black.
# To get black and white image output, replace 1 with 255 in 'img' array

```

Code-2. Grayscale Closing- Using input image in the form of a numpy array.

```

import numpy as np
import cv2
# input image array
img = np.array([[3, 4, 8, 1, 7],
                [9, 4, 2, 1, 6],
                [7, 8, 8, 1, 1]], np.uint8)
# kernel array
kernel = np.array([[0, 1, 0],
                   [1, 1, 0],
                   [0, 1, 0]], np.uint8)
# performing closing using dilation followed by erosion
dilation = cv2.dilate(img,kernel,iterations = 1)
erosion = cv2.erode(dilation, kernel, iterations = 1)
# performing closing using its function
closing = cv2.morphologyEx(img, cv2.MORPH_CLOSE, kernel)
print(erosion)
print(closing)
print(erosion==closing)

```