Morphological Image Processing

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1 Objective

To de-noise the given image using Morphological Image Processing as well as to find object boundaries in the image using the same technique.

2 Analysis

Some of the concepts that were used to solve this task are covered here.

2.1 Morphological Operations

As the name suggests morphology in Image Processing is a technique used to modify and change the contents of an image to achieve a particular goal. It is usually performed on a binary image with an object represented using 1 and the background represented using 0. A structuring element with a required shape and origin can be used to perform logical operations as defined by set theory on a certain widow in the image (same size as the structuring element) to achieve a desired output which will help in the analysis of the image.

2.2 Erosion

It is a morphological operation whereby, the pixel on the image corresponding to the origin of the structuring element in a window where the image in the window defined by the structuring element are all ones is set to one, and is set to zero in all other cases. It is thus useful in removing salt noise, but reduces the size of objects in the image as well.

2.3 Dilation

It is a morphological operation whereby, the pixel on the image corresponding to the origin of the structuring element in a window where any pixel in the image window defined by the structuring element is one is set to one, and is set to zero in all other cases. It is thus useful in removing pepper noise, but increases the size of objects in the image as well.

2.4 Opening

An erosion operation followed by a dilation operation on the image results in an opening. Since both the operations decrease and increase the size of the object, it is left unchanged after both operations are performed in sequence. This operation removes salt noise and retains the size of the object.

2.5 Closing

A dilation operation followed by an erosion operation on the image results in an closing. Since both the operations decrease and increase the size of the object, it is left unchanged after both operations are performed in sequence. This operation removes pepper noise and retains the size of the object.

2.6 De-noising

Since the opening operation removes salt noise and the closing operation removes pepper noise, a combination of the 2 removes both kinds of noise and is used for de-noising a binary image. This can be extended to gray level images as well, and provides a practical method to remove salt and pepper noise in an image.

2.7 Boundary detection

In a given image with an object and a background, the lines separating the object and the background can be detected using morphological operators. An erosion operation on the image followed by the subtraction of the eroded image from the given image gives the boundary between the object and the background, since the remaining pixels will be the ones on the object that have not been eroded away. It can also be found by performing dilation on the image followed by the subtraction of the given image from the dilated image.

3 Method

The following steps were followed to de-noise the image and find the boundary of its objects.

Structuring element A square structuring element of size (3,3) with all ones and origin at the centre (1,1) was used to perform all morphological operations here.

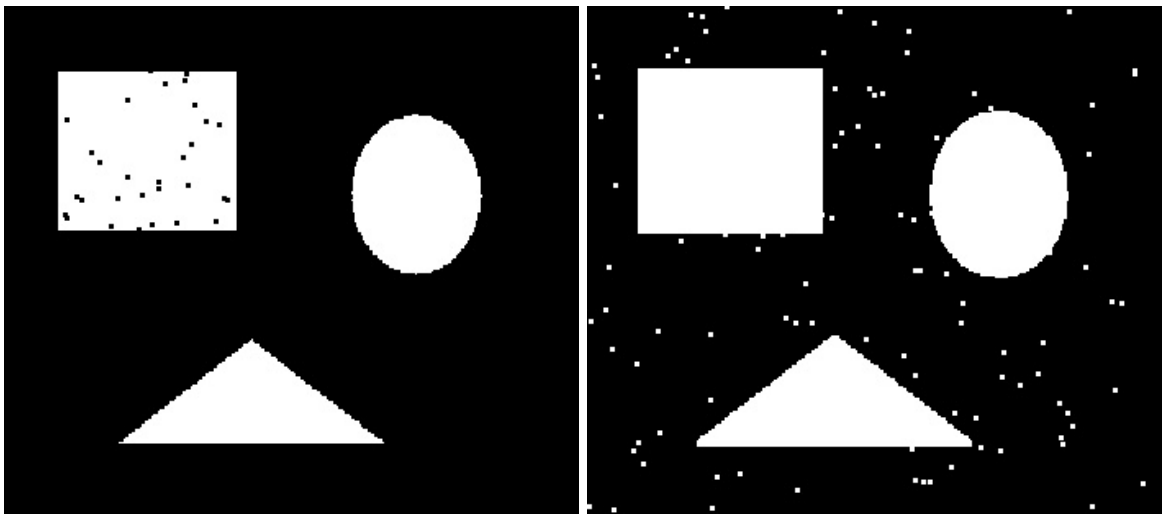
1. Functions to perform each morphological operation, i.e dilation, erosion, opening, closing were laid using the description of each operation as shown in the previous section.
2. The opening and closing of the image were performed, after which the closing of the opening and the opening of the closing of the image were performed to obtain 2 de-noised images. The results of these operations were stored.
3. The subtraction of the ersion of the de-noised images from the de-noised images gave the boundaries of the both the de-noised images. The result of this operation were stored.

4 Results

The following results show the images that were obtained by performing different morphological operations for de-noising as well as detecting boundaries of the objects in the given image.

It can be observed that the images obtained by different orders of opening and closing give nearly the same output.

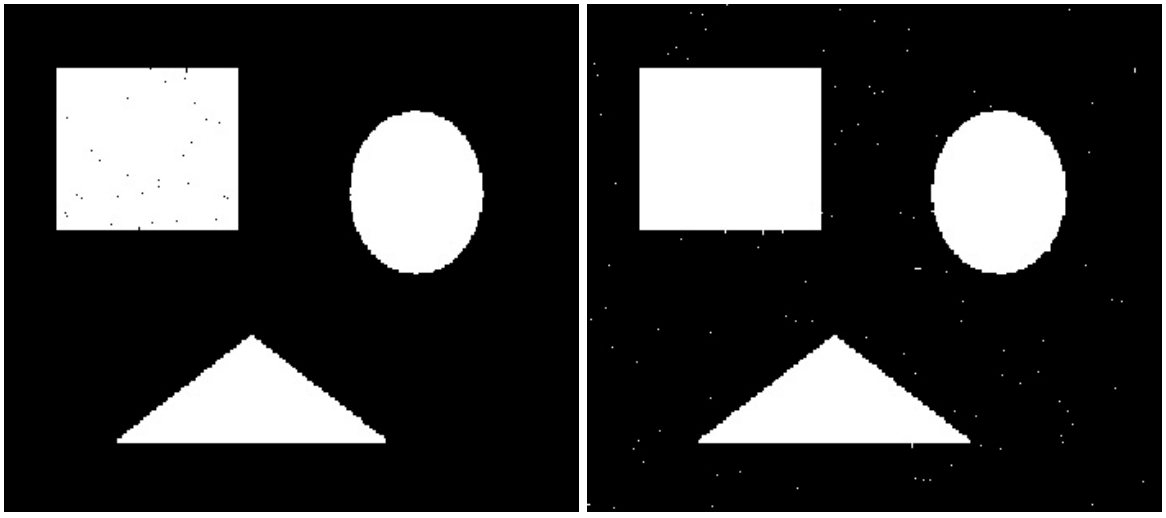
Minor differences in pixel values especially at the boundary of the circle can be observed. This is a consequence of noise being present near the boundary of the object, and since closing was performed first in the first image, it added some of the noise pixels to the object before noise was fully removed, resulting in the difference. Other than this minor difference both the images are nearly equal. The following images show intermediate results that were achieved while de-noising the image.



(a) Result of applying erosion on the image.

(b) Result of applying dilation on the image.

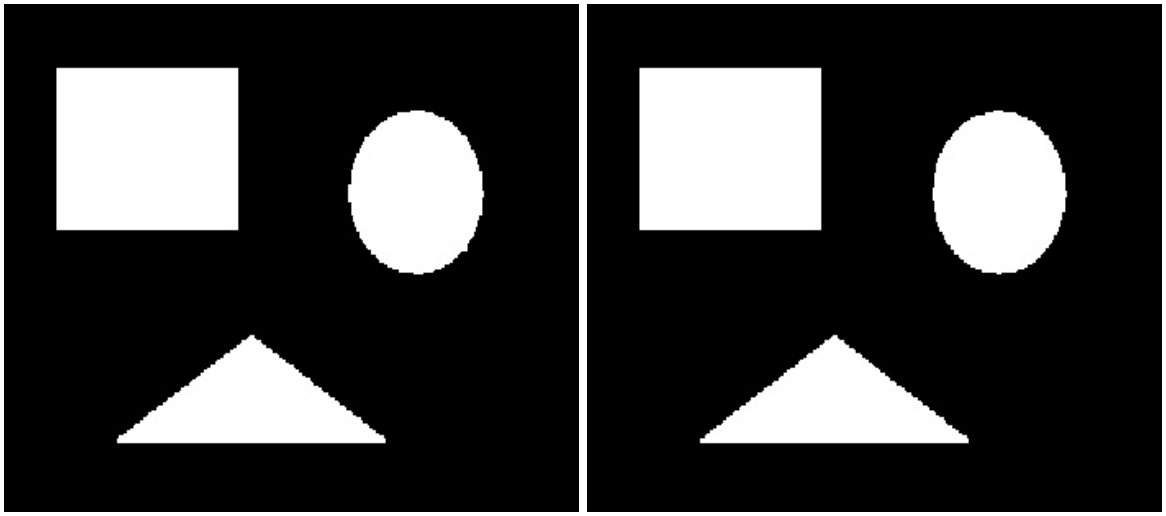
Figure 1: Intermediate results.



(a) Result of applying dilation on the erosion of the given image. (Opening)

(b) Result of applying erosion on the dilation of the given image. (Closing)

Figure 2: Intermediate results (cont.)

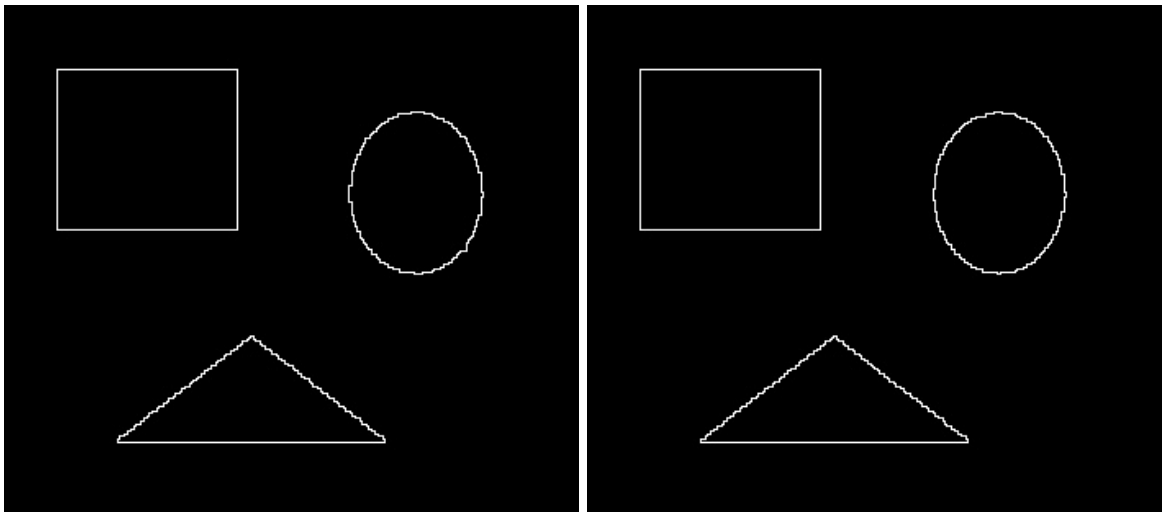


(a) Result of applying opening after closing on the given image.

(b) Result of applying closing after opening on the given image.

Figure 3: De-noised images.

The following images were obtained by subtracting the image with its erosion.



(a) Boundaries detected on 1st de-noised image.

(b) Boundaries detected on 2nd de-noised image.

Figure 4: Boundaries detected on the de-noised images.