CMPEN/EE455: Digital Image Processing I

Computer Project # 5:

Morphological Image Processing

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A. Objectives

This project's main purpose is to:
- Introduce morphological reconstruction methods in Matlab
- Introduce edge detection in Matlab

B. Methods

We have created 2 files in our directory. The first is Project5.m that performs all needed morphological transformations needed to get the correct image. The second file is reconstruct.m and it performs image reconstruction needed to clearly get the "tall" letters as specified by the project prompt.

To run the files, simply run Project5.m. The reconstruct.m file serves as a function to the main Project5.m file. The files save and show the figures as needed.

Part a:

When examining the image, we notice that the maximum pixel value intensity is 75. We chose a threshold of 37.5 as it is half of 75 and makes sense logically. We noticed that when we choose a threshold of 75 and start decreasing it, the image gets more corrupted and unclear.

Part b 1):

To remove the thin lines and the pepper effect in the image, we use a 3x3 cross mask filter to perform erosion. We then perform dilation to improve image clarity. Both erosion and dilation implementations were heavily inspired by the contents of Lecture 25 page 2 as follows:

Erosion by B:

$$f(x,y) \ominus B = \begin{cases} 1, & \text{if all pixels in } N \times N \text{ neighborhood about } (x,y) = 1 \\ 0, & \text{otherwise} \end{cases}$$

$$f(x,y) \ominus B = \min_{(s,t) \in N(x,y)} \{f(s,t)\}$$

where $N(x,y) = N \times N$ neighborhood centered about (x,y).

Dilation by B:

$$f(x,y) \oplus B = \begin{cases} 1, & \text{if any pixel in } N \times N \text{ neighborhood about } (x,y) = 1 \\ 0, & \text{otherwise} \end{cases}$$

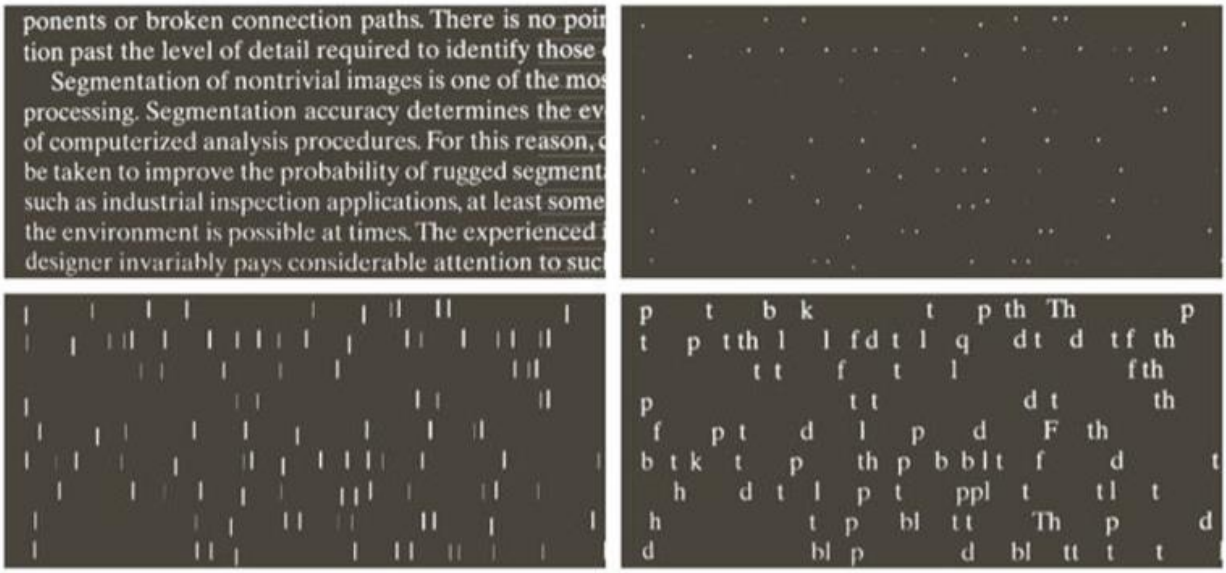
$$f(x,y) \oplus B = \max_{(s,t) \in N(x,y)} \{f(s,t)\}$$

$\Rightarrow$ Dilation and Erosion are simple (nonlinear) mask operations!

Part b 2):

This part is rather complex. To obtain the “tall” letters, a series of operations have to be performed. In lecture 25, we can find a figure describing the opening algorithm and exactly what we need to do:

Opening using elongated 51×1 B to extract elongated characters



a b
c d

(a) Text image of size 918 × 2018 pixels. The approximate average height of the tall characters is 50 pixels. (b) Erosion of (a) with a structuring element of size 51 × 1 pixels. (c) Opening of (a) with the same structuring element, shown for reference. (d) Result of opening by reconstruction.

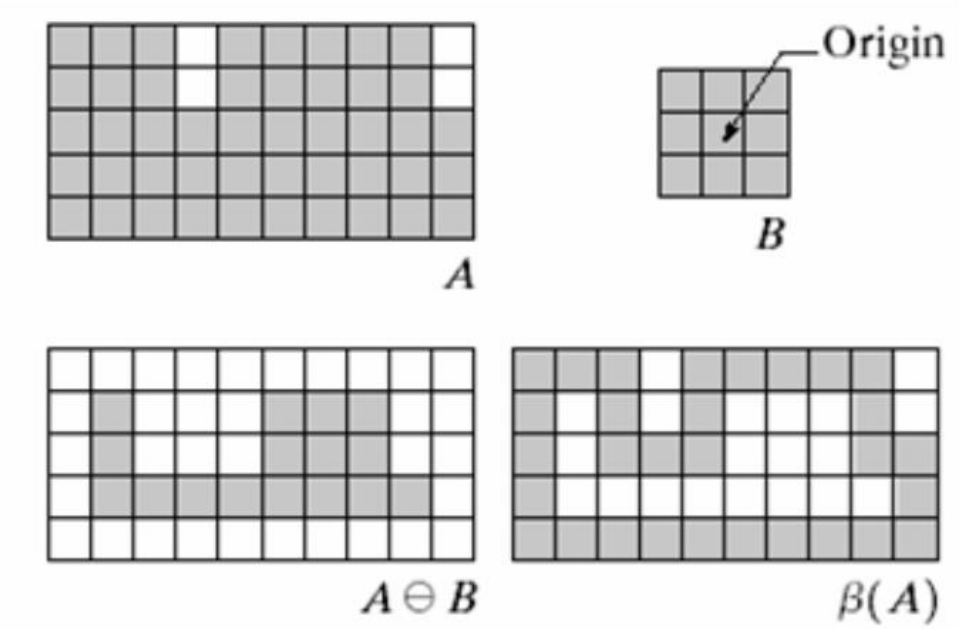
We must first perform erosion as specified followed by the opening to extract letters and then dilation. We also have to reconstruct the image into what we need.

Part c:

In lecture 26, we can find a description of boundary detection needed to obtain the edges of the letters:

a) Boundary (edge) detection:

$$\beta(A) = A - (A \ominus B)$$



C. Results

Figure b 1): Uncorrupted image

Figure b 2) a: Eroded image

Figure b 2) b: Opened Image

Figure b 2) c: Reconstructed Image

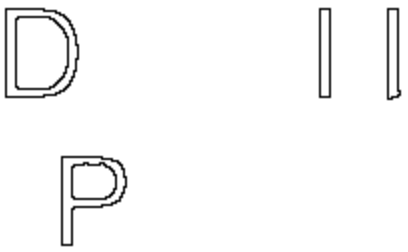


Figure b 2) d: Edge detection

Observations:

There are many observations that we noted during this project. The first is mentioned in the beginning of the report. We noticed that when decreasing the threshold, the image gets less clear and more linear. This should be happening because of some pixel intensity values that are neither 75 nor 0 and are somewhere in between, that give a “polished” feeling to the image. When performing erosion, we clearly saw its power in handling the pepper effect and other corruptions. Combined with dilation, we can obtain a smooth and clear image. We also learned how to use the opening algorithm to get what we want from an image, which can be very helpful in many scenarios when combined with reconstruction.

D. Conclusions

The project addresses peculiar questions concerning morphological image processing. The key points to take out are:

- A binary image is needed to easily perform operations such as dilation and erosion
- Erosion helps eliminate corrupting components from an image
- Dilation helps smooth an image and its edges
- A combination of erosion, opening, dilation and reconstruction can have very interesting effects and can for example help us extract a selection of letters from a textual image
- Edge detection is a powerful method that shows the outlines of connected components in images

In conclusion, these morphological image processing techniques are extremely useful in real life. For example, in a police investigation, applying erosion coupled with dilation to a picture with visual artifacts will make it clearer and help identify criminals and clues. In cryptography, we can use the erosion, opening, dilation and reconstruction combination on a picture to separate symbols from each other allowing us to see the image in a different way.