CMPEN 455: Digital Image Processing

Project 4 –Image Enhancement: Histogram Modification

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A. Objectives

The first objective is to observe the effect of a 3x3 median filter on two images, particularly the effect this filter has on the filtered image's histogram. The second goal of the project is to use Morphological Processing to isolate the tall letters (D, P, l, I) from the given image and then find each letter's outline.

B. Methods

Question 1: We used the built in MATLAB medfilt2() function to filter the image, but to view the image's histogram, we created the file HISTOGRAMS.m which cycles through the input image and gets the value for each pixel and assigns it to the correct bin accordingly. We enlarged the area which not obvious in histogram and showed it in Figure 2. Discussion of the original images versus the filtered images are in the Results section.

Question 2: Before applying Morphological Processing to the image, we made it binary-valued by setting the gray level of the points on the image to 0 or 255. According to the histogram in figure 1, most gray-level of the pixels in image proj5 are in 0 and 75, so we set the threshold to 75, in other words, if the gray level above the threshold, then set it to 255, elsewise set the value to 0.

First, we needed to isolate the letters 'D', 'P', 'l', and 'I'. To do so, the first morphological operation performed on the image was "opening". "Opening" is equivalent to performing erosion before dilation on the image, it can eliminates areas that are smaller than the target. And we did intersect with the binary-valued image(figure 4) to remove the extra parts.

Then we eroded the image with a 45x4 mask to remove all letters except the tall letters. The reason why we chose the wired size for mask is that this is the minimum size to remove the short characters include "t".

By repeating the file RECONSTRUCT.m 55 times, which dilate the eroded image with a 3x3 mask and intersect the result with the binary-valued image, which gives us the tall letters.

The next operation is listed under part C in the same .m file. This file find the edges of the detected letters by eroding it in the x and y directions, and then combining the two (logically, the "OR" of the images) into pixels that are all inside the letters.

To show just the outlines of the letters, the images of pixels inside the letters is inverted, and then "OR-ed" with the original image, resulting in just the outlines (Figure 13).

C. Results

Question 1

Part a

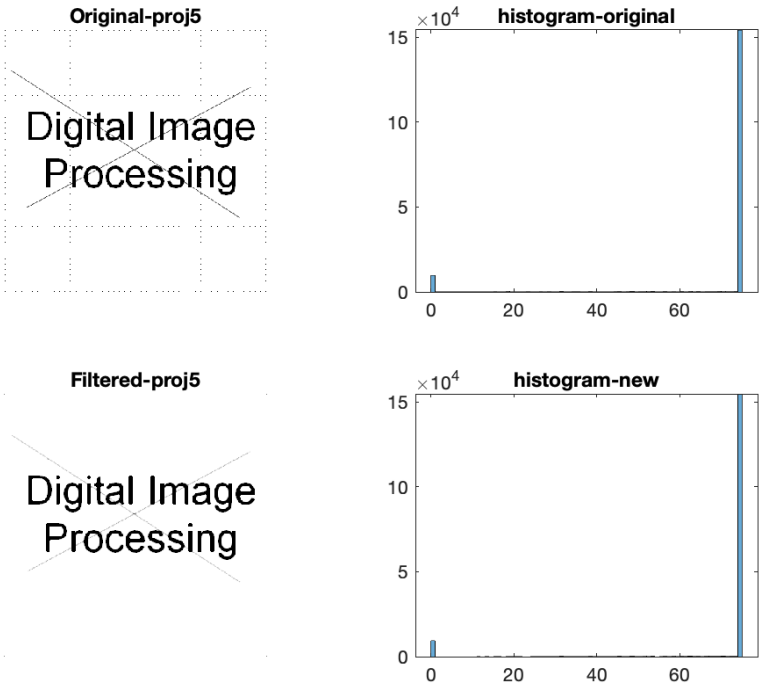

Figure 1 (above) Original f1; (below) Filtered f1

As shown in Figure 1, the filtered image kept the cross on the characteristics. However, the boundary line was eliminated by the filter. The median filter can be considered as an edge-preserve filter. The histogram details are shown below in Figure 2. It will keep the image edge but reducing the tiny dots (noise spikes) on the image.

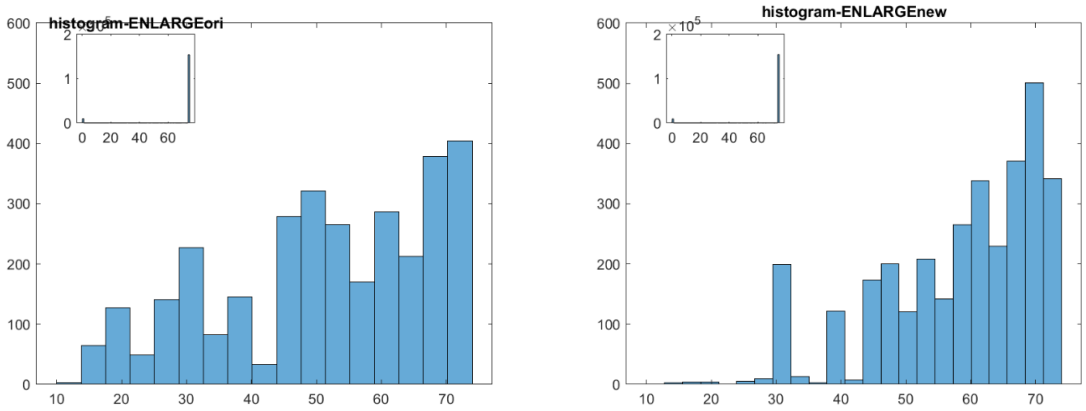

Figure 2 –Histogram(local) of (left) original image; (right) the filtered image

Part b

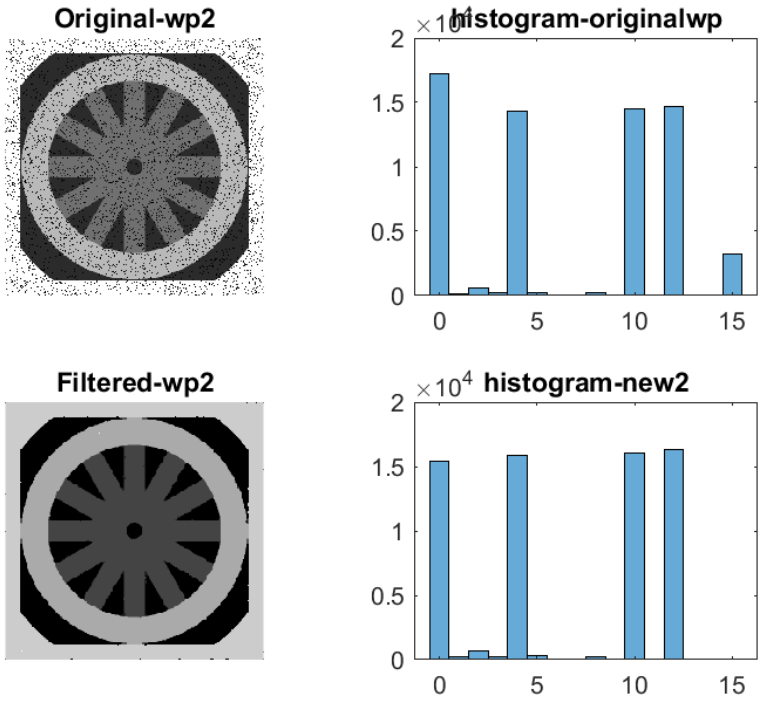

Figure 3 – (above) Original wheelpepper; (below) Filtered wheelpepper

For image ‘wheel pepper’, there is loads of pepper noise in the image. The median filter kept the original edge but largely reduced the noise. In the histogram, the pixels at gray level 15 have been eliminated.

Median filtering adopts a nonlinear method, which is very effective in smoothing the impulse noise. It can protect the sharp edges of the image, and select appropriate points to replace the value of pollution points, so the improving effect is acceptable.

Question 2

Part a

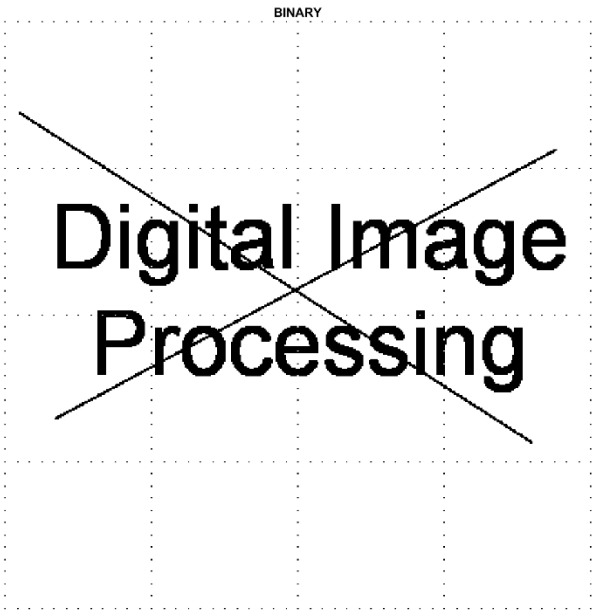

Figure 4 – Binary Valued Image

The binary image(Figure 4) can still reflect the whole and local features of the image through this threshold selection, that is, the whole image presents an obvious black and white effect.

Part b

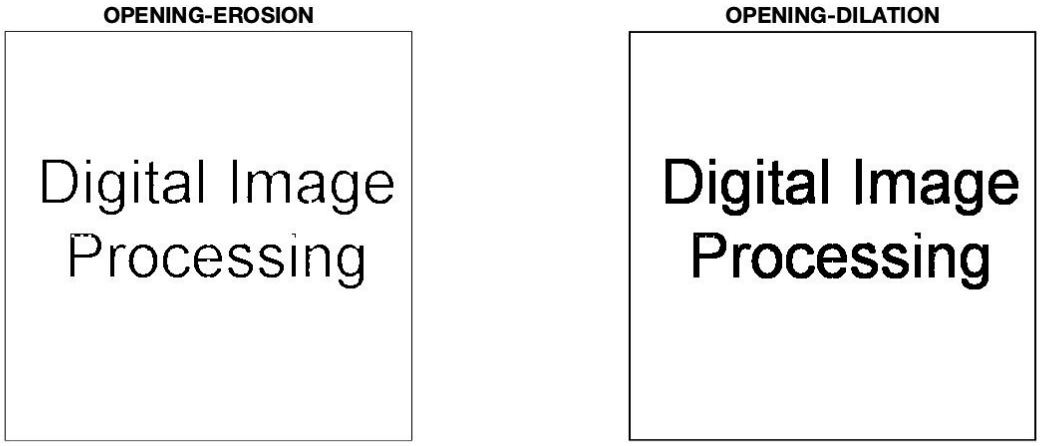

Figure 5 – Opening: Erosion (left) and Dilation (right) the binary image

Do opening to removed all corruptions include the "X" part of the dark line going through the text, as well as the noise spikes, but kept the position and shape by using 3x3 mask.

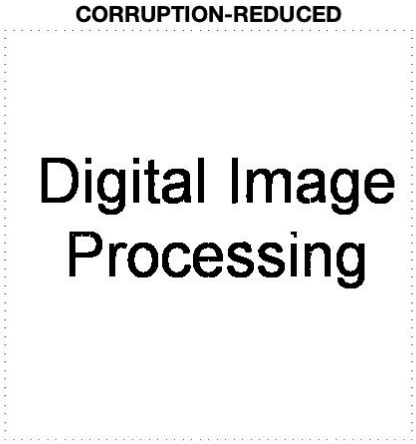

Figure 6 – Corruption-reduced of Figure 5

All corruptions are reduced in Figure 6, this is the prerequisite for us to deleted the target letters.

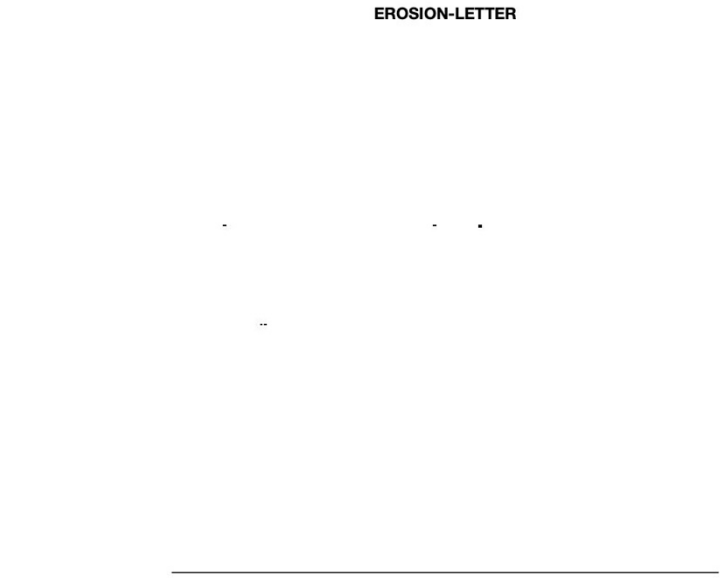

Figure 7 – Erosion of Figure 6

After erosion, several dots represent those tall characters (D, P, l, L) in Figure 7, and there is a black line at the bottom is because it's out of our operating range.

Figure 8 – Reconstruction(1^{st},10^{th})

Figure 9 – Reconstruction(30^{th},55^{th})

As the number of iterations increase, the tall letters gradually be reconstructed.

Part c

Figure 10 – Erosion in x direction

Figure 10 is the erosion of the isolated letters in the x direction, with a 1x3 maximum filter. While the maximum filter operation is normally considered dilation, this is erosion since the object pixels are 0 and the background pixels are 255.

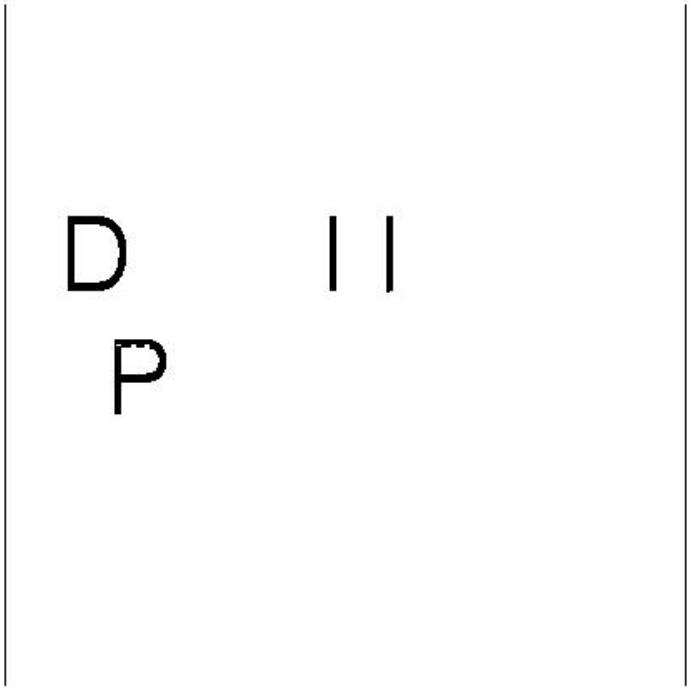

Figure 11 – Erosion in y direction

Figure 11 is erosion done the same way as in Figure 10, but with a 3x1 filter in the y direction.

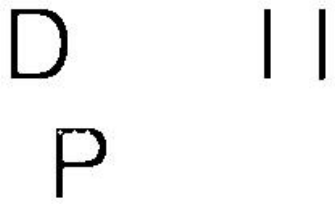

Figure 12 – Logical OR of Figures 10 & 11

This is the result of erosion in both the x and y direction, created by the logical OR of Figures 10 and 11. Effectively, this image would be the result of eroding with a filter that contains all 4-connected pixels.

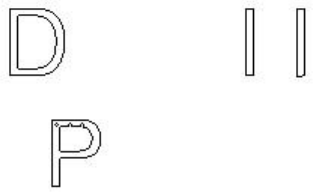

Figure 13 – Isolated Letter Outlines

The figure above is the logical OR of the input image (Figure 9) and the negation of Figure 12. An eroded image, by definition, must be smaller than the original. This means that all pixels in Figure 12 must now be inside the letters. Since we want just the outline of the letters, we can ignore the pixels in Figure 12 by inverting the image, and OR it with the input (Figure 11).

D. Conclusion

In this lab, we observed a median filter can preserve the edges of the image while simultaneously reducing the random noise. We also learned how to combine many morphological operations to extract and isolate certain parts of an image. These operations might seem quite trivial when used independently, but when combined, they can produce results that seem quite sophisticated, such as the isolated letters and finding their respective outlines. The core is the structure element (including its shape and the central location) in all morphological operations, its changes can produce a variety of effects. If we can design the structure element well, we can achieve what we want.