Analysis of Image Processing Using Morphological Erosion and Dilation

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Analysis of Image Processing Using Morphological Erosion and Dilation

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Abstract. Digital image processing is important for image information extraction. One of the image processing methods is morphological image processing. This technique uses erosion and dilation operations to enhance and improve the image quality by shrinking and enlarging the image foreground. However, morphological image processing performance depends on the characteristics of structuring elements and their foreground image that need to be extracted. This paper studies how the structuring elements affect the performance of morphological erosion and dilation on binary images. The experimental result shows that choosing the right structuring element for morphological erosion and dilation can significantly influence the foreground and background structure of the output image.

1. Introduction

Deoxyribonucleic acid (DNA) microarray technology is a popular technique for clinical diagnosis, drug and gene discovery [1], where it monitors thousands of gene expressions simultaneously [2]. The hybridization process consists of two samples: the target complementary-DNA (cDNA) and the reference cDNA labeled with different fluorescent dyes [3]. The target sample is labeled as red, while the reference sample is labeled as green. These two samples are then hybridized on the solid surface array. Finally, the result of the hybridization process is scanned to produce a microarray image [4].

During the scanning process, there may be a problem where the noises are included in the microarray image, which results in poor image quality. This situation may affect the DNA microarray analyzer in detecting the spot locations on the microarray images, and thus, the information extraction. To avoid these problems, enhancing and improving the images are needed. Therefore, morphological image processing will be used in this work to enhance and differentiate the spots on the microarray images by using the erosion and dilation process.

In this paper, the erosion and dilation operations will be analyzed, especially on how the structuring elements could affect morphological erosion and dilation performances. The rest of the paper is organized as follows. Section II discusses existing literature that uses erosion and dilation in their work. Section III describes the experimental setup performs in this work. In Section IV, the experimental results of the erosion and dilation using different structuring elements are discussed. Finally, the conclusion of the work is highlighted in Section V.

2. Literature Review

This section reviews the existing works on image processing that utilize erosion and dilation. In paper [5], the iris recognition system (IRS) has difficulty identifying and verifying a person's iris because of the low quality of the captured eye image, varying lighting conditions, and noises. During the frame detection operation, the color images are converted into the hue-saturation-value (HSV) color space to improve detection. Later, the image information is being extracted by using a Sobel operator and high pass filter. Next, the images undergo the dilation operation before continuing to the iris segmentation process. The function of the dilation operation is to fill the discontinued edges of the frame. Using this method, the frame detection rate can achieve over 80.0%, with the accuracy of the iris localization, upper eyelid localization, and iris recognition system over 96.5%.

In the paper [6], the authors used morphological image processing to filter the salt and pepper noise of color images. This work aims to de-noise the color images by using the dilation operation with a 3×3 structuring element. First, the authors identify the corrupted pixels that consist of a minimum (0's) and maximum (255's) intensity value on the images. Then, suppose certain pixels are identified as corrupted. In that case, the dilation operation will remove the neighborhood pixels and replace them with the median value of the uncorrupted neighborhood pixels. This method successfully removes the noisy pixels with a density of 10% to 90%.

The authors in [7] use image processing to improve gene expression translation where erosion and dilation are used to enhance the image. The microarray images also undergo a threshold process to eliminate some noises on the images. The proposed method is reported to give a higher peak signal-to-noise ratio (PNSR) and a lower mean squared error (MSE) than the Wiener filter, low pass filter, and median filter.

In paper [8], the research is focused on the intelligent transportation system, especially on curve estimation while driving. Firstly, the input images are converted into shadow-free color images to remove the shadow regions of the input images. Next, the seed distribution is used to determine the road region. After differentiation is made between the sky and road region, the pixel that falls inside the road region is converted to white pixels. In contrast, other pixels will be converted to black. Finally, the dilation process is performed on the road region. This method gives 81% accuracy for this road segmentation process.

In paper [9], an automatic intelligent surveillance system is proposed to detect humans based on motion object extraction and head-shoulder features. In this method, the input frame images are first extracted to obtain the background images. Next, the process extracts the foreground object by subtracting the image background using an adaptive threshold. Then, the dilation and erosion process will be performed on the image to remove the false object and noises. Finally, the human-object discrimination algorithm based on head-shoulder feature module operation is performed. The author report that this method provides an 86% recognition rate.

Table 1 summarizes the methods that have been discussed in this section. These algorithm has been targeted for various application from microarray image processing to human detection. In these algorithms, dilation and erosion have played an important role as part of the step to perform image processing. In the next section, we will study the performance of erosion and dilation when applied to our selected test images.

3. Methodology

Erosion and dilation are the basic operations of morphological image processing. The erosion process shrinks the foreground structures while the dilation process enlarges them. The performance of both operations depends on their structuring element shape. In this study, the erosion and dilation operations are programmed using the MATLAB simulation tools.

Three binary images are used as the input images, as shown in Figure 1, and one structuring element is used for each input image, as shown in Figure 2. The characteristic of structuring elements is chosen depending on the pattern of the input images so that the effect of structuring elements on the output image can be studied. Each structuring element is chosen based on the pattern of the input images shown in Figure 1. The differences in size and shape of structuring elements may give a different morphological result. Thus, choosing a suitable structuring element could provide better morphological operations on the input images.

The program for both processes is written using the MATLAB simulation tools. Figure 3 shows the flowchart for the erosion process. First, the input image is being padded by the elements 255's. Then, a matrix with the same size as the input image was generated with all elements inside 0's. During the scanning process, the structuring element will shrink the foreground structures if the 1's on the structuring element and the input image were met.

Table 1. Comparison between different applications

Method	[5]	[6]	[7]	[8]	[9]
Application	IRS	Colour image denoising	DNA microarray	ITS	ISS
Type of image	Colour	Colour	Colour	Colour	Grayscale
Threshold	Yes	No	Yes	Yes	Yes
Accuracy	80.0% to 90.5%	N/A	N/A	81.0%	86.0%
Complexity	Medium	Low	Medium	High	High
Special feature	Using two gradients with fuzzy logic and dilation	N/A	N/A	N/A	N/A

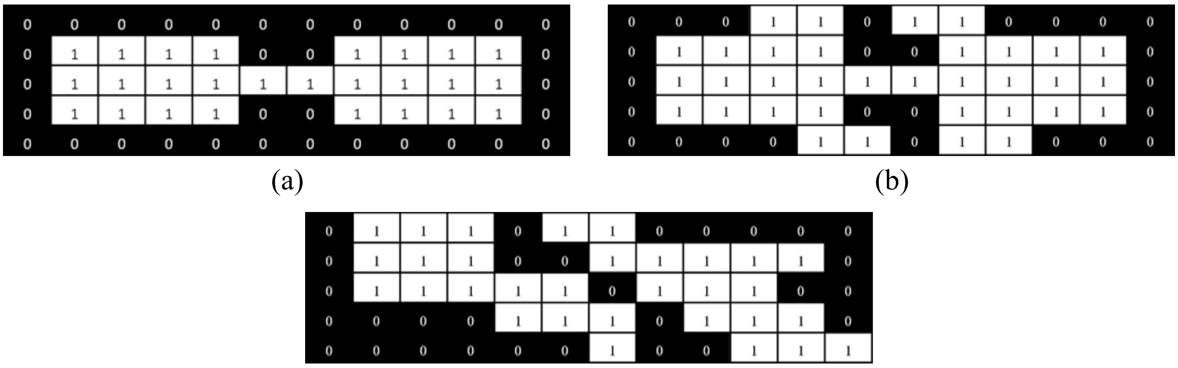


Figure 1. (a) Input image 1, (b) input image 2, and (c) input image 3

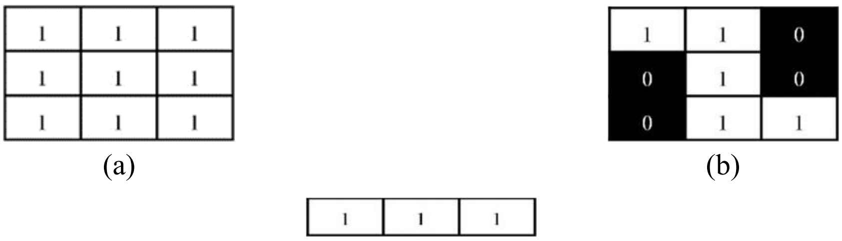


Figure 2. The structuring element for (a) input image 1, (b) input image 2, and (c) input image 3

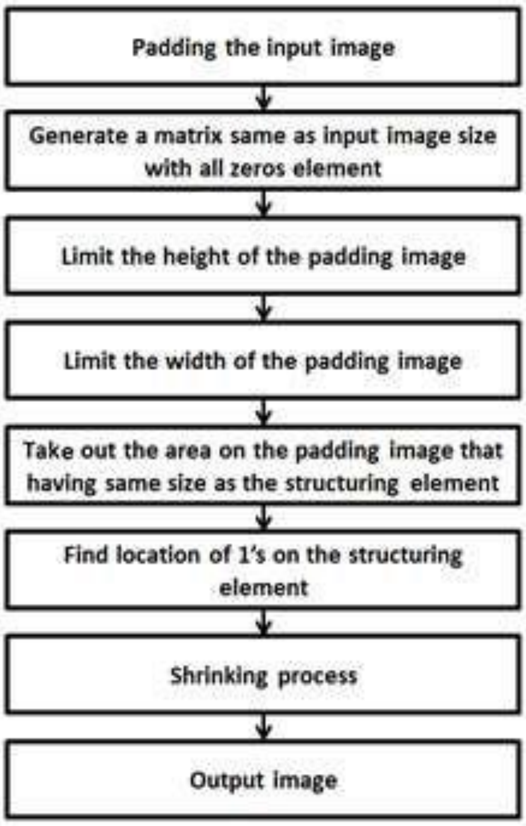


Figure 3. Flowchart of the erosion process

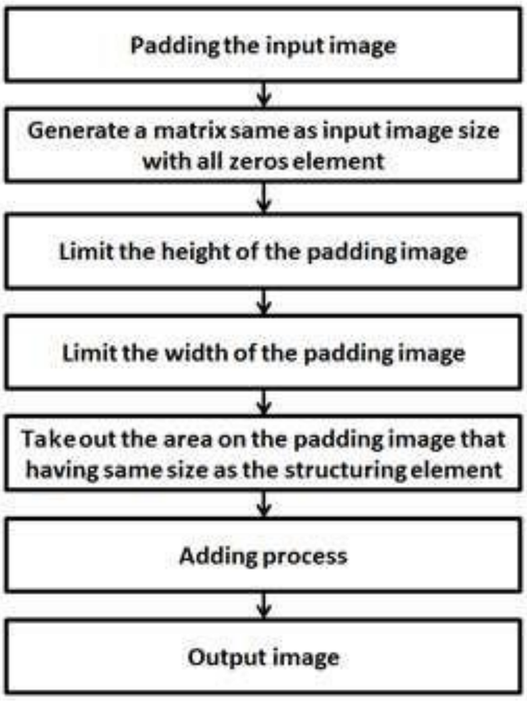
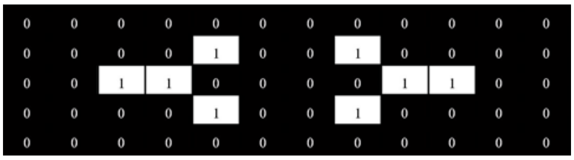
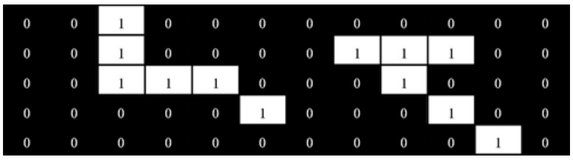


Figure 4. Flowchart of the dilation process

(a)

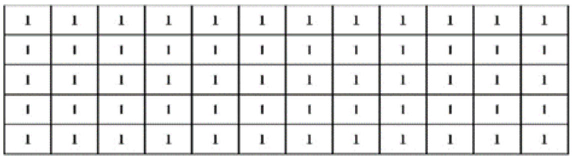


(b)

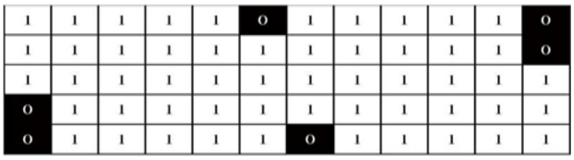


(c)

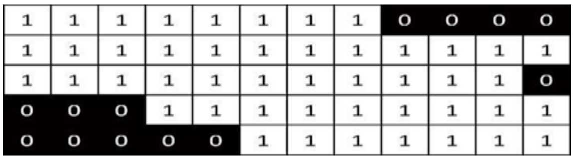
Figure 5. The erosion result of (a) input image 1 with structuring element 1, (b) input image 2 with structuring element 2, and (c) input image 3 with structuring element 3



(a)



(b)



(c)

Figure 6. The dilation result of (a) input image 1 with structuring element 1, (b) input image 2 with structuring element 2, and (c) input image 3 with structuring element 3

Figure 4 shows the flowchart of the dilation process. Dilation operates when any pixels with a value of 1's on the structuring element overlap with pixels with a value of 1's on the input image. Thus, in the dilation process, the input image must be padded to reserve an area for the structuring element. During the scanning process, the foreground will enlarge the foreground structures when any location of 1's on the structuring element were overlaps with 1's on the input image.

4. Result and Discussion

Figure 5 shows the results after each input image undergoes the erosion process using different characteristics of structuring elements. The erosion process shrinks the foreground structures of the image. Therefore, the final images have an increased background area as compared to the original input images. The 3×3 square shape of structuring element scans through input image. The erosion process will occur when the structuring element fit in the foreground structures of the input image.

Figure 6 shows the input image undergoes the dilation process using different structuring elements. The dilation process enlarges the foreground of the image. Therefore, the final images have an increased foreground area compared to the original input images. The dilation enlarges the foreground whenever 1's in structuring element were overlap with any locations of 1's on the input image. As a result, the image fully covers by the foreground structures. Figure 6 clearly show that the dilation process increases the foreground area of the input image.

5. Conclusion

In this paper, the basic operations of morphological image processing, namely erosion and dilation, show a promising medium in digital image processing. Depending on the structuring elements, the erosion operation shrinks the foreground. In contrast, the dilation operation enlarges the foreground on the image. Thus, this process can be used to eliminate the noises in an image. Furthermore, choosing the right structuring element is important since it can influence the final image processing result. In the future, this work will implement image morphological erosion and dilation on DNA microarray images.

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