CENG466 - Fundamentals of Image Processing Take Home Exam 3 Report

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***Abstract*—Mathematical morphology and segmentation are important concepts in digital image processing. Various tasks such as object detection and counting, separating an image into its regions can be done with the help of morphological operations.**

***Index Terms*—image processing, image segmentation, object detection, object counting, morphological operations, edge detection**

I. Introduction

This document is prepared to explain methodologies and techniques used in Take Home Exam 3 for given tasks. Those tasks include counting flying baloons and segmentation of images into their regions.

II. Question 1

In this part the goal is to detect the flying balloons in the image and count them. Main technique to achieve this goal is converting the images to grayscale, and applying thresholding to separate the balloons from their backgrounds. After this point, some morphological operations might be needed to achieve more convenient output images, and also count more accurately. Next, counting is done by enumerating connected regions using `bwlabel` function. In the resulting image, the land part in the image is considered the same as the balloons, so that part is removed from the image.

For morphological operations, a structuring element is needed. As structuring elements, disk-shaped matrices are used. A custom function `disk_matrix(r)` was written to create disk matrices with given radius `r`.

A. A1

After thresholding, a closing operation was applied to complete the fragments inside balloons in the thresholded image.

Fig. 2 shows the output for A1. 4 balloons were detected by the script.

B. A2

After thresholding, an opening operation was applied to remove some small regions in the thresholded image that are not balloons.

Fig. 4 shows the output for A2. 6 balloons were detected by the script. Unfortunately, some balloons where the background is land instead of sky, are missed.

Fig. 1. A1 original image

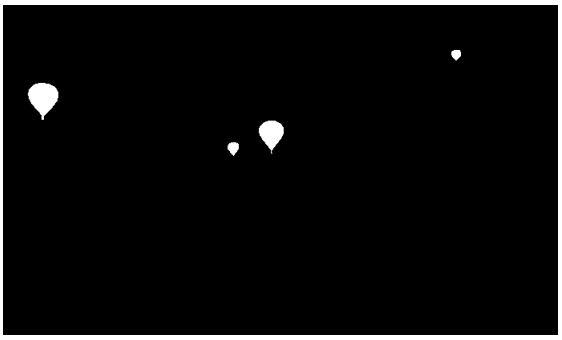

Fig. 2. Output for A1

Fig. 3. A2 original image

Fig. 4. Output for A2.

C. A3

Fig. 5. A3 original image

Fig. 5 is a complicated image to detect and count flying baloons. The background of many balloons are not sky, which does not create much contrast for thresholding. Also many balloons are in contact with each other in 2 dimensional plane of the image. Those features of the image make it very hard for the script to count the balloouns accurately.

Different approaches were tried to achieve the most accurate result, however, none of them gave a more accurate result than the usual grayscale thresholding method.

An opening operation was applied to separate the balloons as much as possible.

Fig. 6. Output for A4

Fig. 6 shows the output image. 15 balloons were detected by the script.

Fig. 7. A4 original image

D. A4

After thresholding, an opening operation was applied to remove some small fragments in the thresholded image.

Fig. 8. Output for A4

Fig. 8 shows the output image. 9 balloons were detected by the script.

E. A5

Fig. 9. A5 original image

After thresholding, an opening operation was applied to remove some small fragments and fully separate close balloons in the thresholded image.

Fig. 10 shows the output image. 16 balloons were detected by the script.

III. Question 2

In this part, the task is to develop an image segmentation algorithm that can separate water, land and sky in the given images. `segmentation_function` was created and used for this purpose. All output images were created using the same function, so the algorithm is generalized for all inputs.

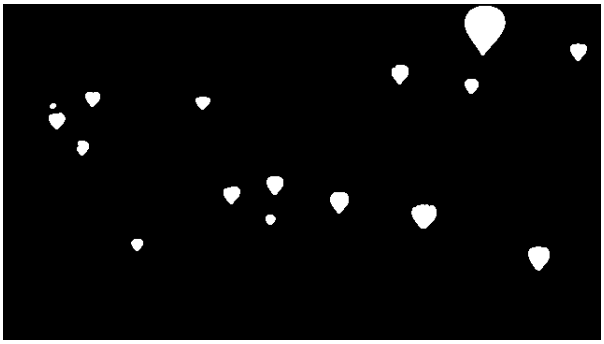

Fig. 10. Output for A5

The main methodology is to use edge detection to find the edges between sky, land and water. The main problem here is, the edges between desired segments are not the only edges. For example, a simple edge detection algorithm shows a lot of edges in land where trees exist. To solve this problem input image is processed through opening and closing operations, respectively. As the structuring element, a large disk matrix is used. This process flattens the regions in the input image, resulting a more convenient image for edge detection.

Another problem with this approach is differences in illumination of different images, and of different areas of an image. This problem is solved by modifying the processed (opened & closed) image by changing the values of some brightness bands, mainly enhancing contrast.

After the operations above, edge detection is applied to get fully separated regions in the image. The inverted edge map gives the regions, and those regions are then colored.

To show the process more clearly, the intermediate results of those steps are included in B1 part.

A. B1

Fig. 11. B1 original image

Fig. 11 shows the original image. The first step is to convert the image to grayscale. Next, opening and closing operations are applied.

Fig. 12 shows the image after flattening process. Regions are now more clear.

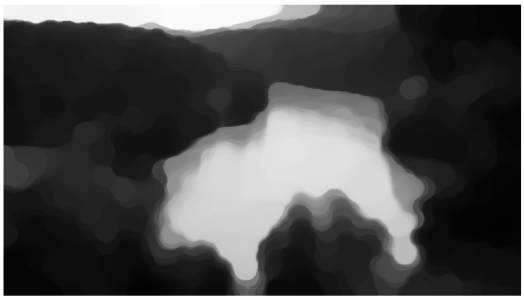

Fig. 12. Processed B1, regions flattened

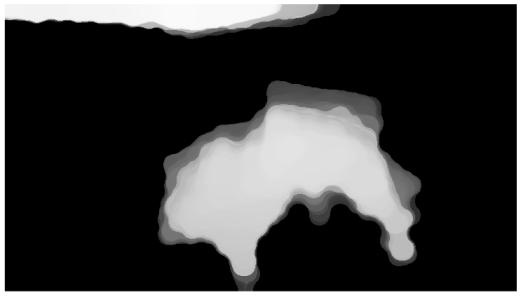

Fig. 13. Processed B1, contrast enhanced

Next step is to modify this image to enhance contrast.

Fig. 13 shows the result after enhancing contrast. Now the image is suitable for applying edge detection.

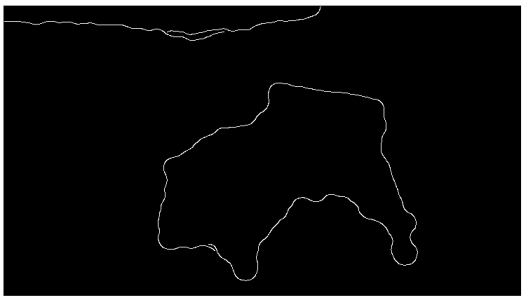

Fig. 14. Edges of B1

Fig. 14 shows the image after applying edge detection. One slight problem here is the edges might not be connected. To resolve this, a closing operation was applied.

Fig. 15 shows the edges after closing operation. The edges are fully connected now.

Next, the edge map is inverted to obtain regions.

Fig. 16 shows the regions of the image.

Finally, the regions are colored.

Fig. 17 shows the final output. 3 regions; water, land and sky are clearly shown.

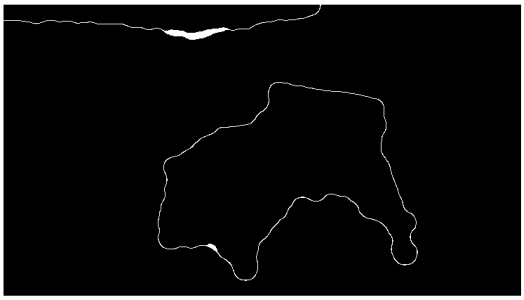

Fig. 15. Edges of B1, fully connected

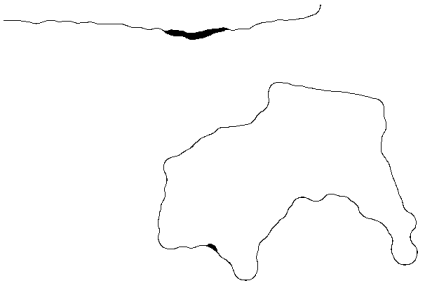

Fig. 16. Regions of B1

Fig. 18. B2 original image

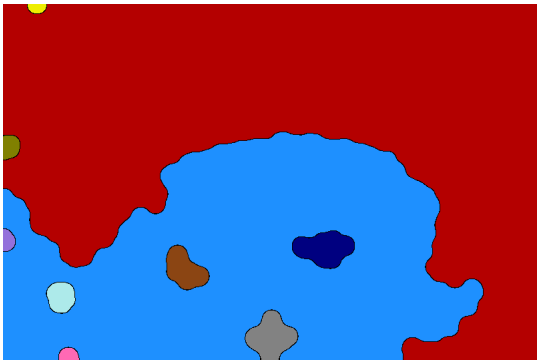

Fig. 19. Output for B2

B. B2

Fig. 18 shows the original image. In this image, there is a gradual transition between land an water, which makes the edge detection method flawed for this image. The wooden ladder and diving man also make the problem more difficult. As in B1, firstly B2 is converted to grayscale then opening and closing operations were applied. Then contrast enhancing technique was used to make image more appropriate for edge detection. In case of unclosed edges one more closing operation was applied and final coloring process used.

Fig. 19 shows the output. The wooden ladder and little rock are considered as different regions since they are not part of water. Red color represets land and blue color represents water.

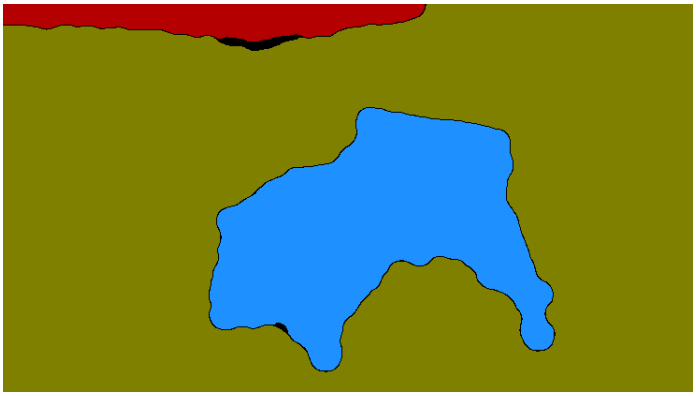

Fig. 17. Output for B1

C. B3

Fig. 20. B3 original image

In Fig. 20, B3 is displayed. It is easier for segmentation of land,water and sky compared to B2. Same process for B1 and B2 is also used for B3. Firstly B3 was converted to grayscale image and then opening and closing morphological operations were applied for better edge detection. After detecting edges in case of unclosed edges one more closing operation was applied. Then regions are colored for illustrative purposes.

The output in Fig. 21 was obtained from B3.

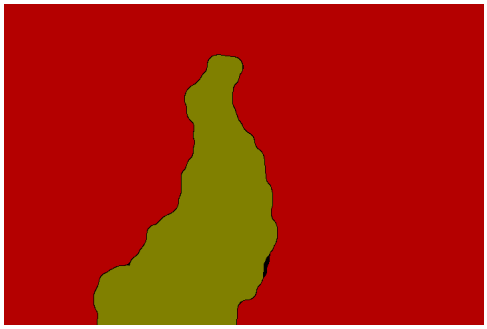

Fig. 21. Output for B3

IV. Conclusion

To conclude, morphological operations are very handy for object detection/counting and segmentation. In the first part, flying balloons were detected and counted using thresholding with morphological operations. Although this method was quite convenient for detecting balloons where the background is bright sky, it could not quite detect the ones with land background.

In the second part, given images are segmented into their sky, land and water regions. Edge detection is used to find the regions, but a preprocessing with morphological operations was required. This method mainly worked for the purpose.