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3-D Image Processing Algorithms

Lab exercises in EIKONA 3D

Chapter 5

Region Segmentation and Edge Detection

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Exercise 5.1: Region Segmentation

In this exercise we use EIKONA3D in order to perform region segmentation on a volume with the following techniques:

- Thresholding
- Region Growing
- Region Splitting
- Region Merging

In all subsequent examples we will assume that the 'head' 3-D image has been loaded in volume 0.

5.1.1 Thresholding

In order to perform segmentation in two regions by thresholding the menu options ***"Operations→Analysis→Region Segmentation→Thresholding"*** should be selected. In the *Select Input Volume* dialog box, we choose volume 0 and in the *Select Output Volume* we choose *New[1]***.** Finally, we set the threshold level (e.g. 40) in the corresponding dialog box.

A frame of the initial volume and the corresponding thresholded one are depicted in Figure 1. Every voxel whose intensity value exceeds 40 in the original image appears white in the output image, whereas voxels with intensities smaller than 40, appear black.

(a) (b)

Figure 1 : (a) A frame of the initial 'head' volume; (b) the same frame after applying thresholding.

5.1.2 Region Growing

To achieve segmentation using the region growing technique we select the menu options ***"Operations→Analysis→Region Segmentation→Region Grow"***. In the *Select Input Volume* dialog box, we select volume 0 and in the *Select Output Volume* we select the volume where the result will be stored, e.g. New[1]. Then we should provide the threshold value in the corresponding dialog box. This value controls the homogeneity of the 3-D regions. Voxels with intensities that differ from the mean

region intensity less that this threshold are assigned to the region during the growing operation. At this stage a dialog box prompts the user to select the seeds of the region growing operation by clicking (left mouse button) on appropriate points of the volume display window. When all seeds have been selected the user should click *OK.* The seeds serve as starting points for the growing procedure and thus their position controls the regions that will be created. The number of regions in the output image is equal to the number of seeds.

Figure 2 illustrates a frame of the original volume with the selected seed depicted as a white dot and the result of the region growing technique (the threshold was set equal to 10).

(a) (b)

Figure 2: (a) A frame of the 'head' volume with the selected seed and (b) the same frame after applying region growing.

5.1.3 Region Splitting

In order to perform region splitting we chose ***"Operations→Analysis→Region Segmentation→Region Split"***. Then we select volume 0 and New[1] from the *Select Input Volume* and the *Select Output Volume* dialog boxes respectively. Setting the homogeneity threshold to 70, the method splits the 3-D image recursively into eight regions until each region satisfies the homogeneity criterion.

A frame of the initial volume and the result of the region splitting technique are displayed in Figure 3.

(a) (b)

Figure 3: (a) A frame of the initial 'head' volume and (b) the same frame after applying region splitting.

5.1.4 Region Merging

If we want to perform region segmentation using the region merging technique we follow the menu path ***"Operations→Analysis→Region Segmentation→Region Merge"*** and then we select the input and the output volumes through the *Select Input Volume* and the *Select Output Volume* dialog boxes respectively. We are then prompted to give the region merging homogeneity threshold. Voxels with intensities that differ from the mean intensity of the region under investigation less than this threshold are merged with the region. Furthermore the user should specify (in the same dialog box) the maximum allowable number of regions that are expected to result from this operation. This should be an integer number in the range 0-255. It is used by the algorithm for memory allocation purposes. Upon completion, the routine reports the number of resulting regions.

In Figure 4 a frame of the original volume and the resulting segmented one are depicted. The threshold value was set to 50 and the maximum number of regions to 10. The number of regions that were actually found in this case was 6.

(a) (b)

Figure 4: (a) A frame of the 'head' volume and (b) the same frame after applying region merging.

Exercise 5.2: Edge Detection

In this exercise we will deal with 3-D edge detection. EIKONA3D supports several techniques for edge detection, including the 3D range, Sobel and Laplace operators. In all the examples that will be presented bellow we will assume that the 'head' 3-D image has been loaded in volume 0.

5.2.1 Range edge detector

The menu option that should be selected in order to perform range edge detection is the following: ***"Operations→Analysis→Edge Detection→Range".*** The user should select volume 0 from the *Select Input Volume* dialog box and New[1] from the *Select Output Volume* dialog box. The dimensions of the 3D window (mask) involved in the range operation are set through the *Give Window Dimensions* dialog box. EIKONA3D

performs edge detection to the input volume and stores the result to the output volume.

A frame of the input 'head' volume and the processed one can be seen in Figure 5. The dimensions of the 3D window were set to 3x3x3 in this specific example.

(a) (b)

Figure 5 : (a) A frame of the 'head' volume and (b) the same frame after applying range edge detection.

5.2.2 Sobel edge detection

3-D edge detection is based on the 3-D extension of Sobel masks and can be performed by selecting ***"Operations→Analysis→Edge Detection→Sobel".*** The user should select the input and output volumes through the corresponding dialog boxes, as described in the previous example. The effect of applying this operation can be seen in Figure 6.

(a) (b)

Figure 6 : (a) A frame of the initial 'head' volume and (b) the same frame after applying the 3D Sobel mask.

5.2.3 Laplace edge detection

To perform edge detection using the Laplace operator we select the menu option ***"Operations→Analysis→Edge Detection→Laplace"*** and specify the input and output volumes as described in the previous example. The results can be seen in Figure 7.

(a) (b)

Figure 7 : (a) A frame of the 'head' volume and (b) the same frame after applying the 3-D Laplace operator

It should be noted here that the output of the edge detection operators described above is not binary. The intensity values in these edge images are proportional to the edge magnitude. If binary edge images are required one can threshold the results using the threshold operation described in the corresponding section of this chapter.