Universitat De Girona

E-Health

LAB 2: Software Tools

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1 Introduction

Image segmentation is the partition of an image into several regions which exhibit same characteristics. This image processing technique is often the first step for image analysis and is a key basis of many higher-level activities such as visualization, compression, medical diagnosis and other imaging applications [2]. Figure 1 is an example of medical image segmentation. There exist several approaches to segment an image. Some of these techniques include edge based, region based, clustering based and many others.

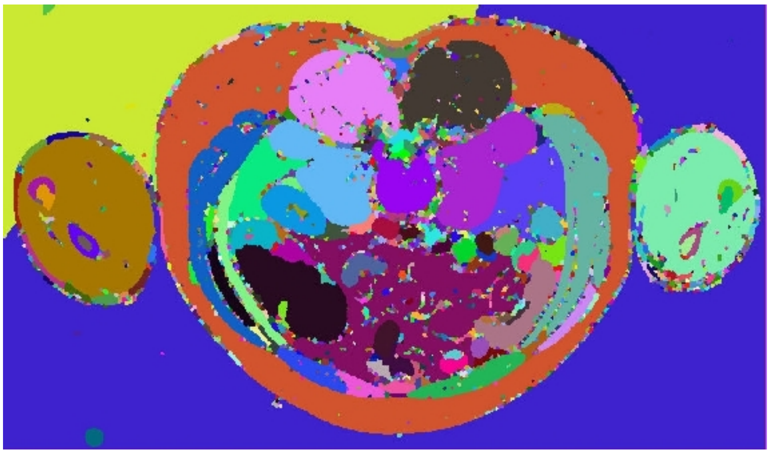

Figure 1: Medical Image Segmentation [1]

In this exercise, our goals were as follows:

- To understand some software tools used for medical image annotation and visualization.
- To familiarize ourselves with software tools such as ITK-SNAP and 3D Slicer by loading and viewing 3D volumes.
- To visualize the 3D rendering of the knee image with its labels.
- To perform semi-automated segmentation of the tibia by adopting the edge attraction, clustering and classification approaches.
- To compute the dice coefficient using the "DiceComputation" extension in the 3D slicer software.

The steps taken to accomplish these tasks are explained into details in the next sections.

2 3D Rendering of Knee MRI

For this task, we have used ITK-SNAP. The steps are as follows:

1. From the top menu, under "File", select "Open Main Image" and browse to the file "image-080.mhd". The knee MRI volume is loaded.

2. From the top menu, under "Segmentation", select "Open Segmentation" and browse to the file "labels-080.mhd". The different parts of the knee are now labelled with different colors.

3. Under the bottom-left viewer widget, click on the "update" button to generate a 3D rendering of the MRI volume.

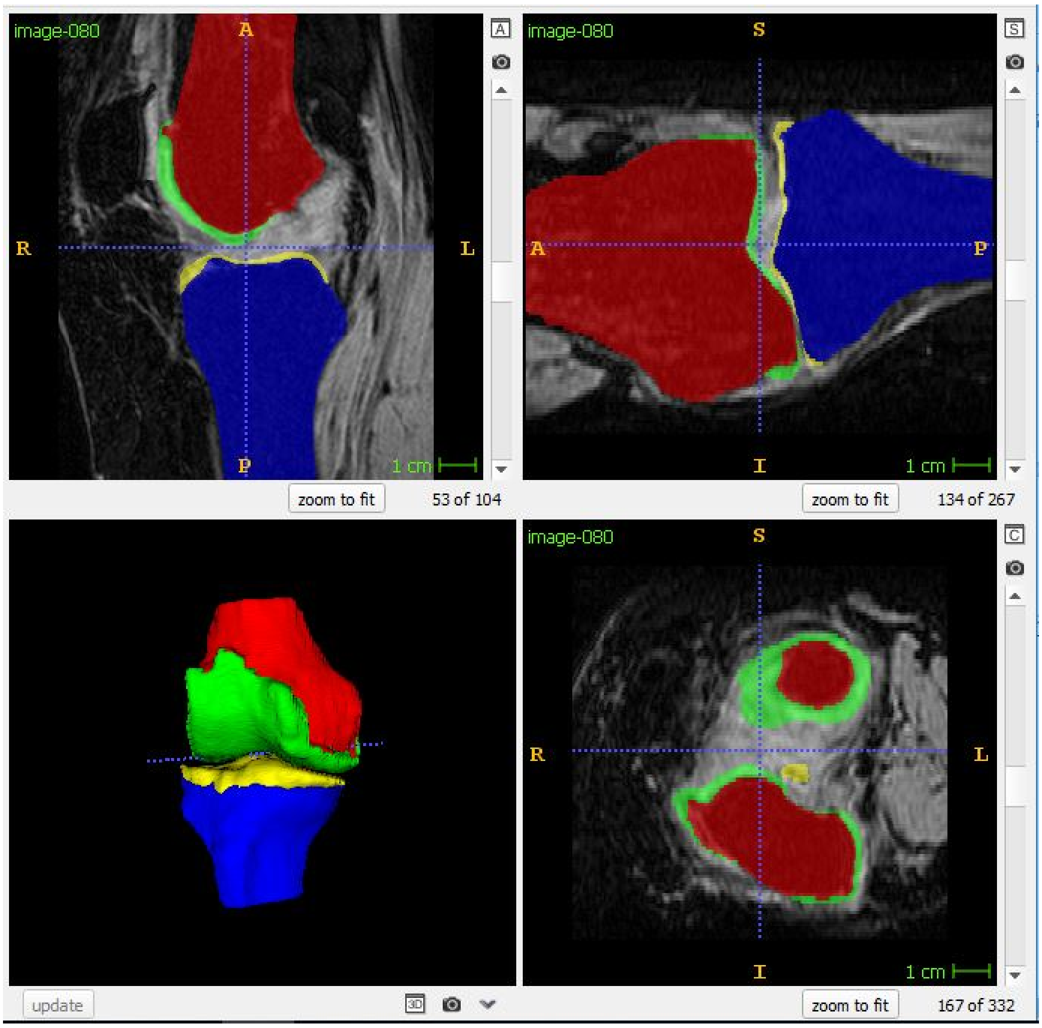

Figure 2: 3D rendering of a labelled knee MRI.

3 Tibia Segmentation

Using the ITK-snap software tool, we performed 3 semi-automated segmentation using edge attraction, clustering and classification approaches. Each of these approaches are explained into details below.

1. The image file ('image-081.mhd') was loaded using the 'Open Main Image' command under 'File' button located at the top-left corner of the ITK snap interface (Figure 3).

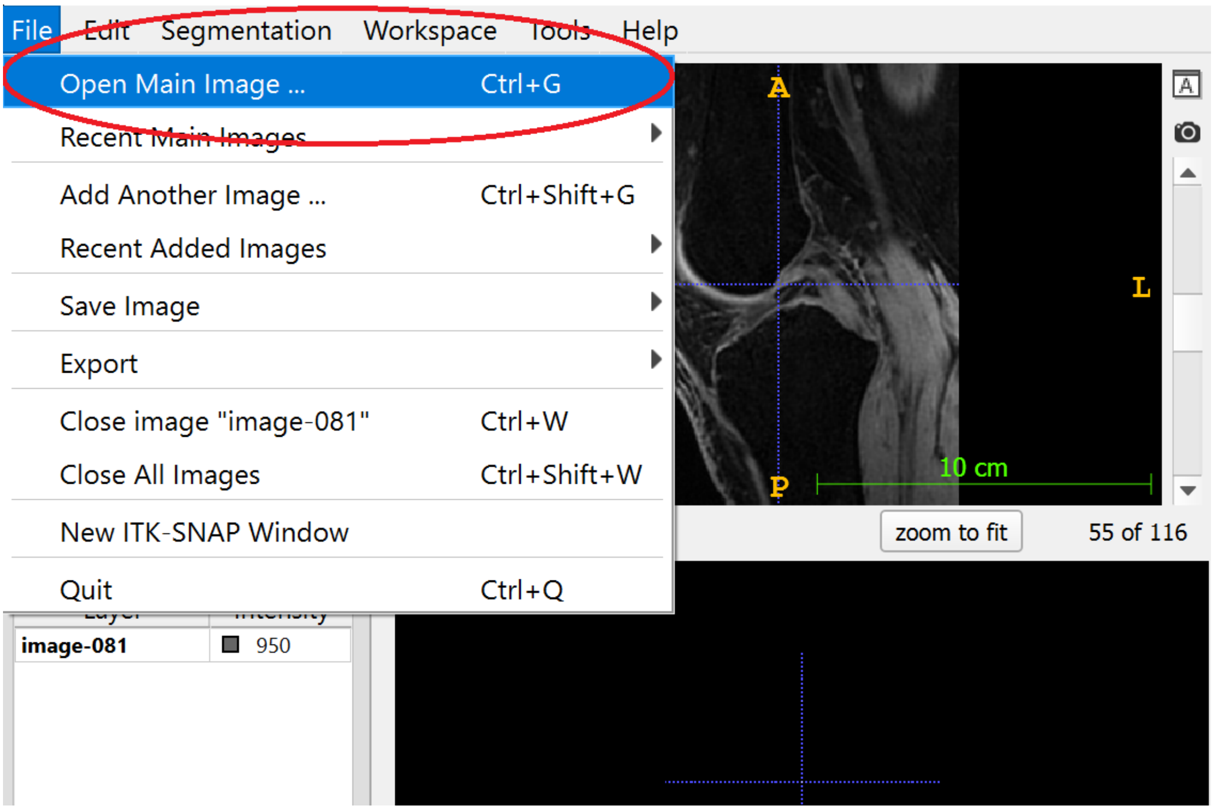

Figure 3: Loading image into ITK-snap

2. The next step was to select the "Active Contour Segmentation Mode" from the main toolbar (Figure 4).

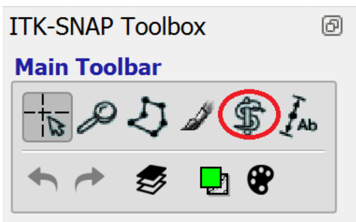

Figure 4: Selection of active contour mode

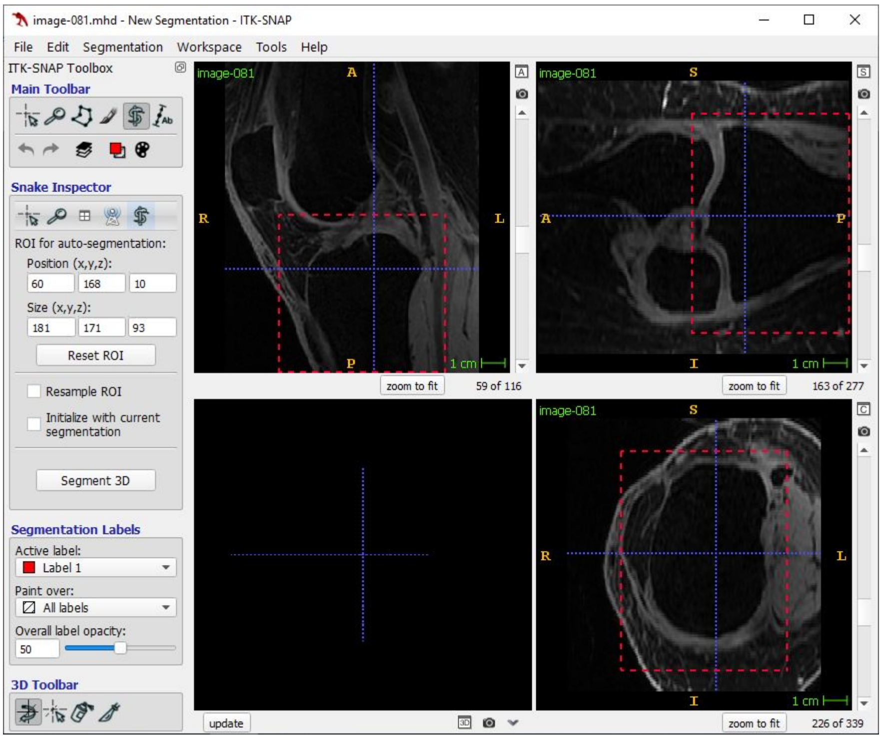

Figure 5: Selection of region of interest

3. Next, we delineated a region of interest (ROI) (Figure 5) and the 'Segment 3D' button was clicked to keep the ROI and open the segmentation toolbox. From here there are different types of segmentation approaches that can be selected.

4. Depending on the type of segmentation selected, different options appear in the segmentation toolbox:

   - **Classification** based segmentation: we drew the tibia as one label and the remaining parts as another label only in one slice as shown in Figure 6.

   - **Clustering** based segmentation: we need to specify the number of clusters as shown in Figure 7.

   - **Edge Attraction** based segmentation: The default parameter for smoothing factor was kept as shown in Figure 8.

5. The segmentation was proceeded by adding bubbles (Figure 9) at the next stage using the 'Add Bubble at Cursor' button. Different number of bubbles were used for the different segmentation approaches.

6. The last but the not least step was to configure the set parameters and execute or control the evolution using the 'play' button as shown in Figure 10. This step was crucial because the final output of the segmentation was partially dependent on this stage and hence precautions were taken to correctly tune

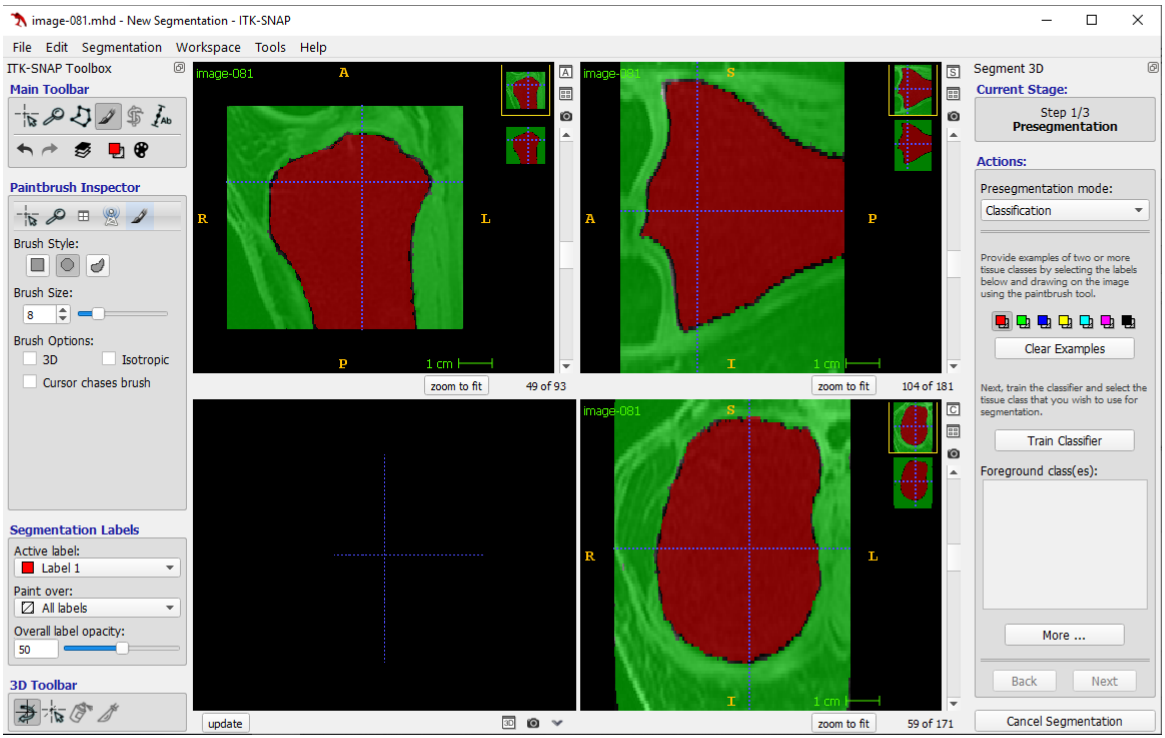

Figure 6: Drawing the tibia (label 1) and remaining parts (label 2)

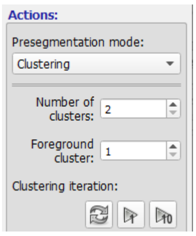

Figure 7: Options for the cluster-based segmentation

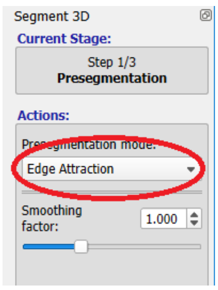

Figure 8: Options for the edge-based segmentation

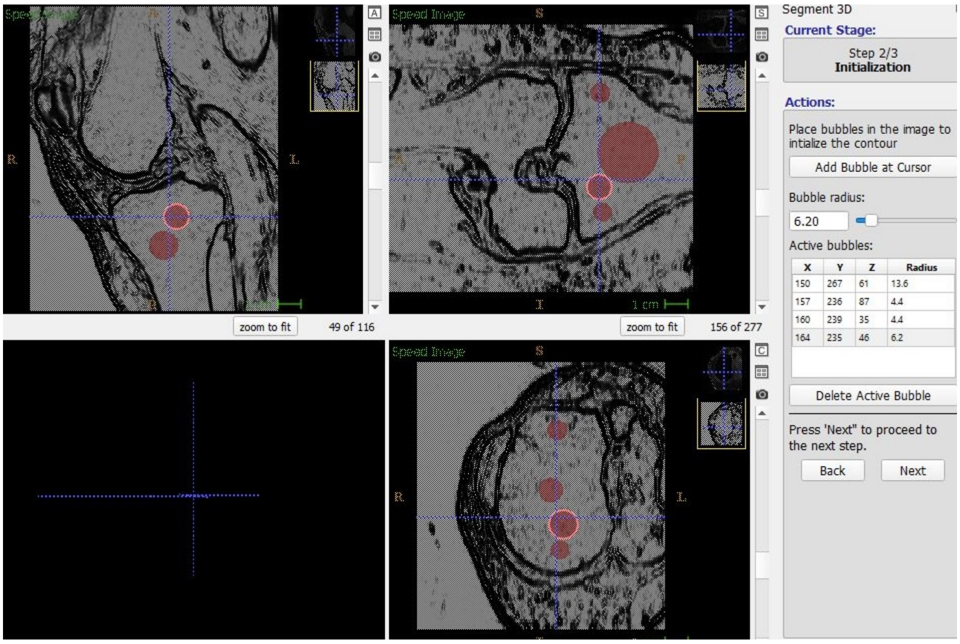

Figure 9: Addition of bubbles to initialize contour

the parameters. In some Pre-segmentation modes, the step size was increased (Classification) and reduced in some cases (Clustering). This precaution was taken to ensure that the bubbles do not outgrow the tibia.

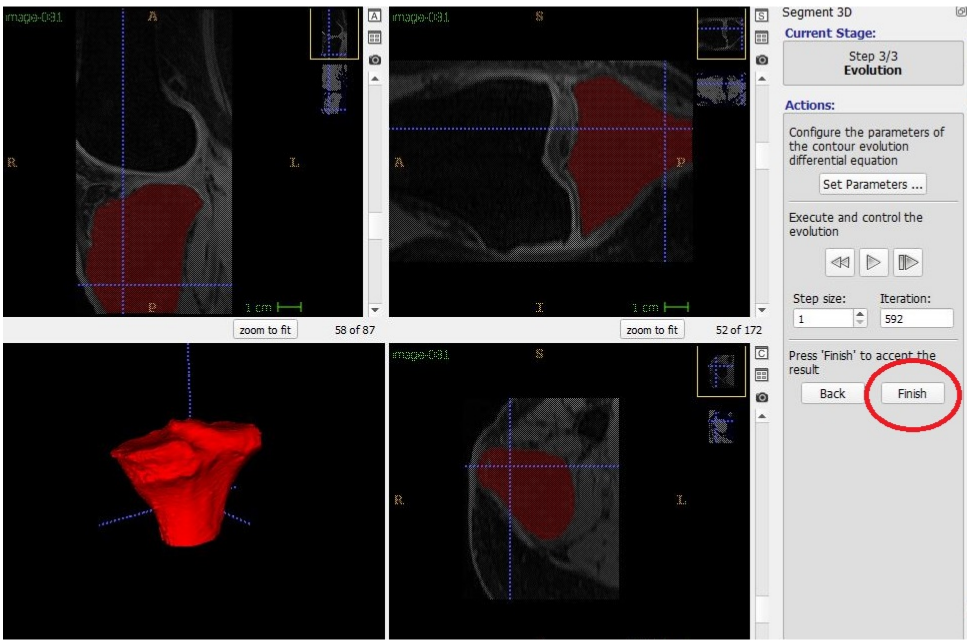

Figure 10: Configuration of set parameters

7. The final stage was to use the 'Finish' button to end the segmentation. Based on the segmentation results, further processing was done to improve the seg-

mentation results. In some cases, we had to manually remove wrongly segmented parts. Also we added some part to fill up holes in the segmented volume. This further processing was done using the 'brush' button on the 'Main Toolbar' (Figure 11).

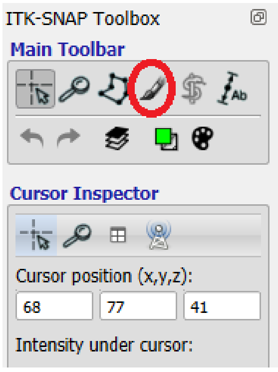

Figure 11: Further processing

8. Afterwards, the segmented volumes were saved as "seg1-classification", "seg2-clustering", "seg3-edge-attraction" using the 'Save Segmentation Image' option under 'Segmentation' in the menu bar (Figure 12).

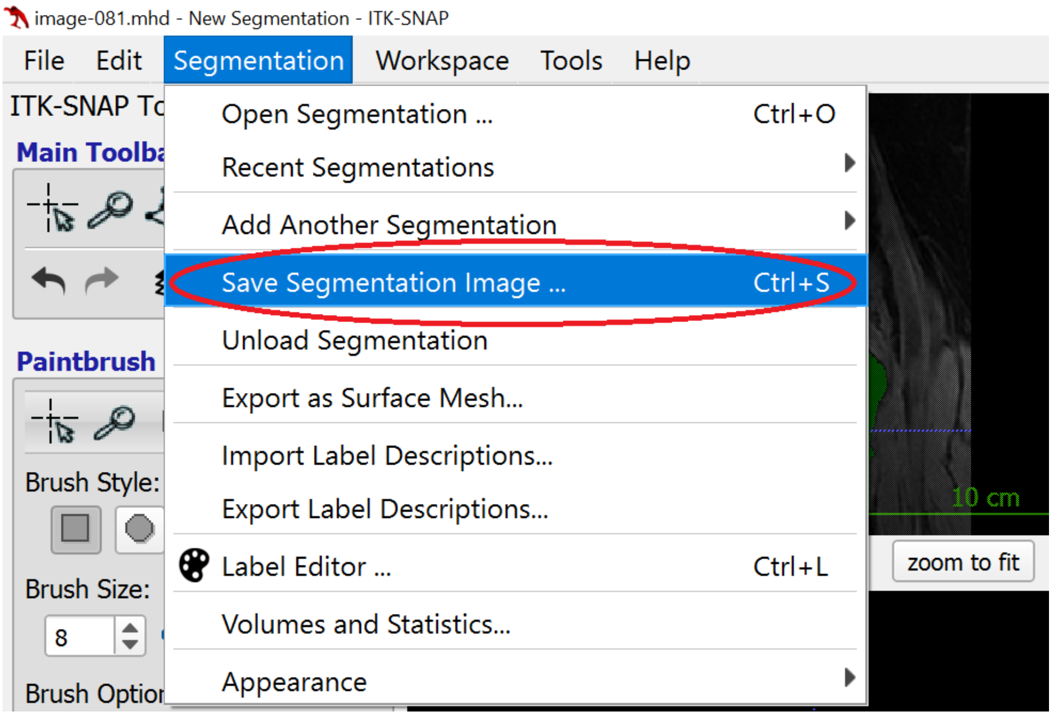

Figure 12: Saving segmented image

4 Dice Coefficient Computation

As a way to compare in between the various segmentation results, the dice coefficient was computed using the 3D slicer software version 4.8.0. The steps taken to compute the dice are explained below.

1. The 'DiceComputation' extension was installed using the 'Extension Manager'.
2. The 3 segmented images were loaded simultaneously to compute the dice coefficient.
3. In the first instance, seg2 and seg3 were loaded using 'Add data' under 'File' button. On 'Add data to scene' pop-up box, we converted the volume to label maps.(Figure 13 and Figure 14)

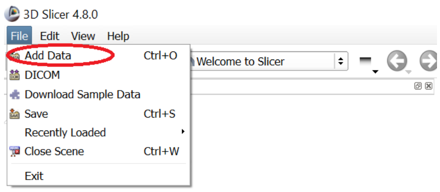

Figure 13: Loading files into 3D slicer

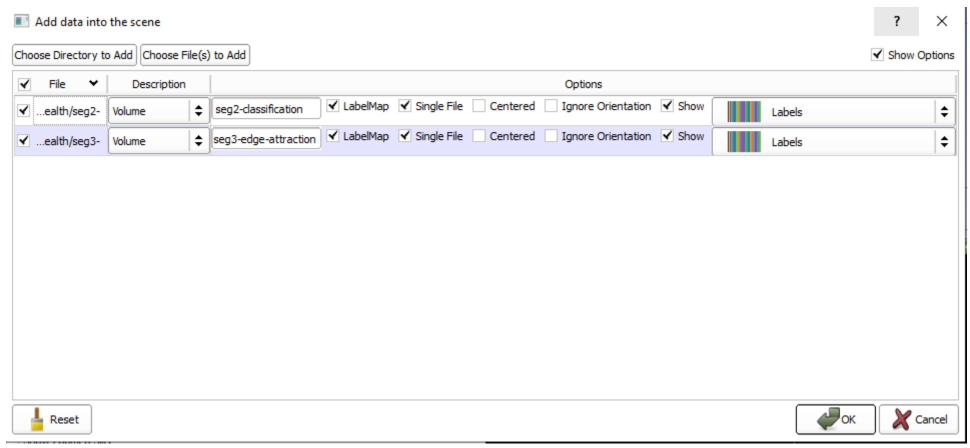

Figure 14: Conversion of volumes to label map

4. Using the 'Search Modules' button, the DiceComputation extension was used to compute the dice as shown in Figure 15.

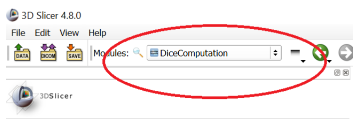

Figure 15: Navigation of the 'DiceComputation' extension

5. The dice coefficient computed for each pair from the 3 segmentation approaches are shown in Figure 17, Figure 18 and Figure 16. We can see that the segmentation results obtained using clustering and classification approaches are very similar due to the high dice score (0.99); however, when comparing the edge-based snakes with any of the other 2 methods, the similarity index drops to 0.96.

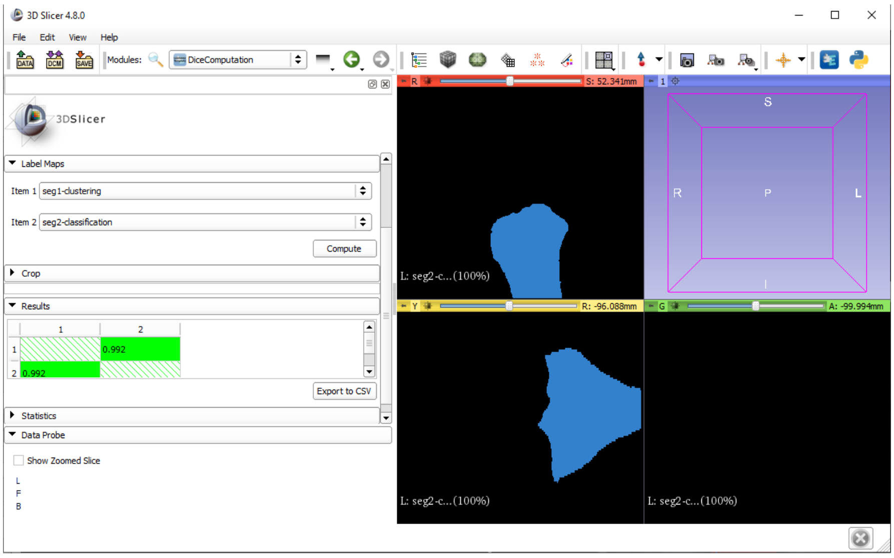

Figure 16: Dice computation for clustering and classification based approach

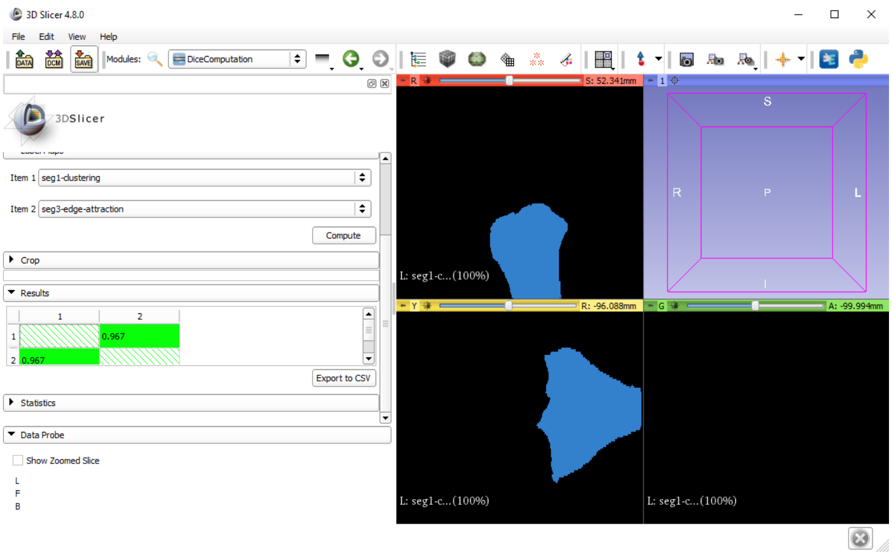

Figure 17: Dice computation for clustering and edge based approach

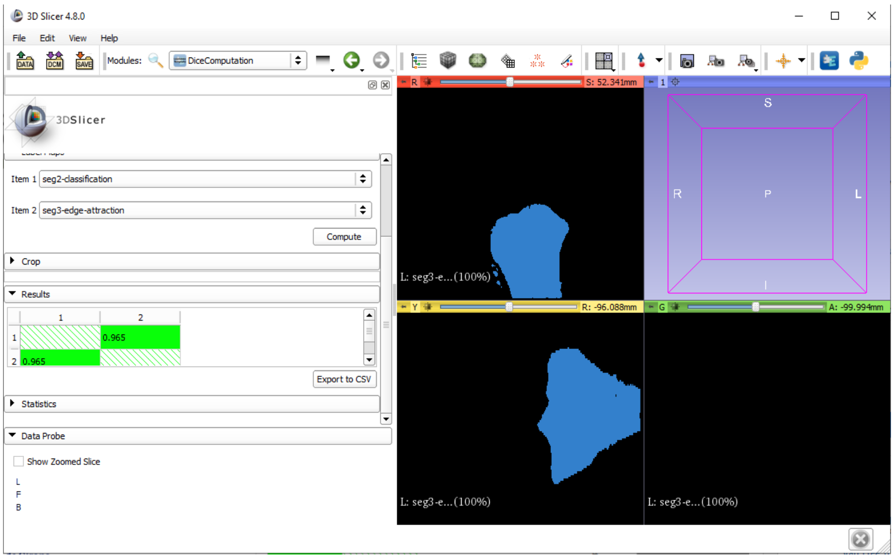

Figure 18: Dice computation for classification and edge based approach

5 Problems Encountered

During the implementation of this exercise, the problems encountered are as listed below:

- The number of bubbles to use and the precise position to place the bubbles to initialize the contour. Using too many bubbles slows down the segmentation process; however, using only one bubble may miss areas near the contours. Using a couple of them sparsely was a good balance.
- After the segmentation process finished, we often had to do some additional filling of holes or removing of protrusions.
- After installing the 'DiceComputation' extension, it was not obvious at first how to execute it until browsing around 3D Slicer's interface.

References

[1] Luis Ibáñez, Will Schroeder, Lydia Ng, and Josh Cates. The ITK software guide. http://www.itk.org. Accessed: 2018-10-20.

[2] Anita Khanna, Meenakshi Sood, and Swapna Devi. Us image segmentation based on expectation maximization and gabor filter. *International Journal of Modeling and Optimization*, 2(3):230, 2012.