

Introduction

Image segmentation is very common and useful when handling medical images. When we segment a medical image, such as ones done via Magnetic Resonance Imaging (MRI), we often want to separate distinct structures and then visualize them in 3D within applications [1].

The goal for this project was to successfully segment a fetal brain scan (fetal scan) using the algorithms provided by the program Slicer. To better understand the hurdles that arose when segmenting a fetal scan, it is worthwhile to first look at the segmentation of an adult brain scan. This will allow us to see the straightforward nature of a brain segmentation when a high quality, high resolution volume with distinct structures is available. After examining the adult brain scan, attention will be moved to the segmentation of the fetal scan, where we'll first look at the algorithms used and methods followed. Finally the outcomes and issues of the segmentations of the fetal scans and their corresponding algorithms will be discussed.

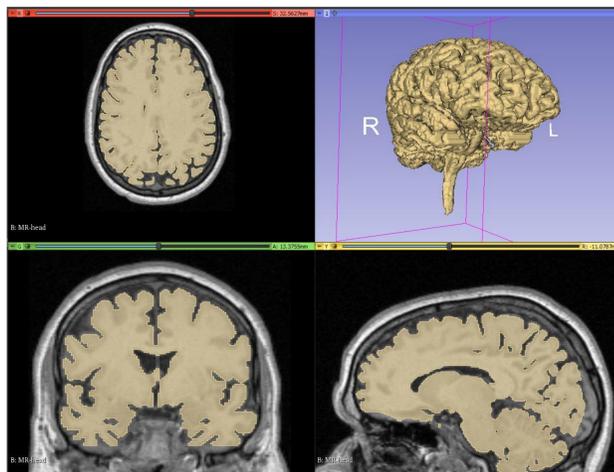


Figure 1

Segmentation Task 1

The first task was to create a segment of the high resolution volume. Since the volume had well defined structures and sufficient contrast between them, the algorithm *Local Threshold* was chosen. With this algorithm, a threshold range is chosen and running the algorithm will fill the areas of the volume within that range [2]. The range chosen was 58.58 - 116.72. One specific feature of *Local Threshold* is that when the algorithm is initialized (Using CTRL-Click) only regions connected to the point clicked on will be filled. The final segment can be seen in Figure 1.

Segmentation Tasks 2 & 3

Three different approaches were attempted while segmenting the fetal brain scan. On the first attempt, the same approach as the initial segmentation was used. After deciding on a valid threshold range of 869.92 - 1825.87, the algorithm was initialized to create the segment of the fetal brain. After it had finished, the resulting segment had extensive unwanted structures. This resulted in significant cleaning to be done – the *Scissors* tool was used. After the unwanted sections had been removed, the segment in Figure 2 remained.

For the second segmentation, the same algorithm with the same range was used, however, the Oversampling Factor was increased to 7. It is important to note that increasing the Oversampling Factor will also increase memory usage [3]. This resulted in the segmentation in Figure 3.

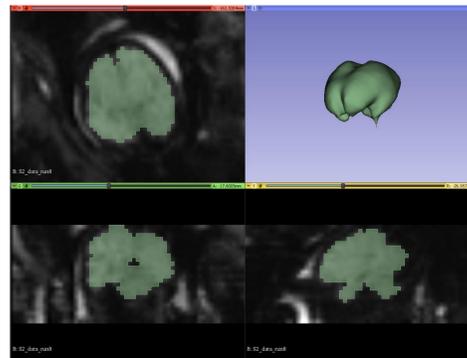


Figure 2

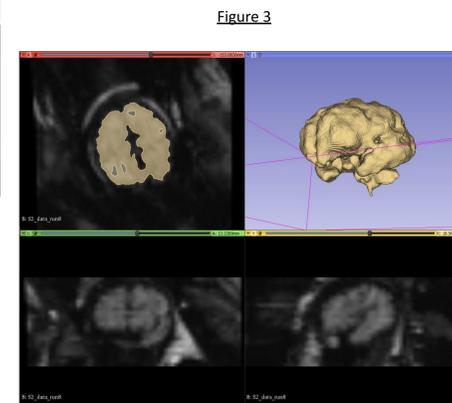


Figure 3

Segmentation Task 4

The last segmentation task was done by keeping the Oversampling Factor at 7 and using *Grow from Seeds*, a type of Grow Cut algorithm [4]. It was started by using the *Paint* tool to place our scribbles, each their own segment. These scribbles are to differentiate the foreground from the background. Two different background scribbles were used, one to indicate the high intensity background (4a - Red), and the other for low intensity (4a - Yellow). The third scribble was used to target the brain (4a - Green), which acted as the foreground. These scribbles were done on every 4th slice, for each of the three views. Once the algorithm was initialized, the fully segmented image showing all segments (Figure 4a) was output. The foreground segment only, showing the 3D view of the brain can be seen in Figure 4b.

Discussion

When observing the segmentation of the high-resolution scan, we see that it is very detailed and has a well-defined structure, it also required minimal cleaning after the algorithm was finished. Comparing this to the first fetal scan segmentation where the oversampling factor was set to 1, the vast difference in detail between the two segmentations can be seen. In addition, extensive cleaning was required to eliminate additional structures that were inadvertently added to the fetal brain segment from Figure 2.

After completing the first fetal segmentation using *Local Threshold*, it became clear that due to the ambiguous boundary between the edge of the brain and the high intensity structure surrounding it (See figure 3) additional sections of the scan were being included in the segment. Not only that, but regardless of whichever algorithm was used, there was not nearly enough detail due to the resolution of the volume compared to the segmentation pixels - see the segmentation overlay in Figure 2.

By updating the Oversampling Factor, a setting of the master volume, we were able to increase the resolution of the scan [3]. This made the segmentation pixels appear smaller in comparison to the scan, allowing for greater detail. While this allowed for greater detail, it did not help the leakage. The leakage occurs due to ambiguous boundaries and structures are merged when trying to achieve high detail.

To remedy this issue, the algorithm *Grow From Seeds* was chosen. This allowed us to explicitly declare boundary structures before the algorithm ran [4]. This resulted in the segmentation in Figure 4b, where there is superior detail to the first fetal segmentation (Figure 2), and less cleaning was needed than the second fetal segmentation (Figure 3), resulting in less time spent on the segmentation. One of the few drawback of the *GrowCut* algorithm is the upfront work needed to declare the boundaries.

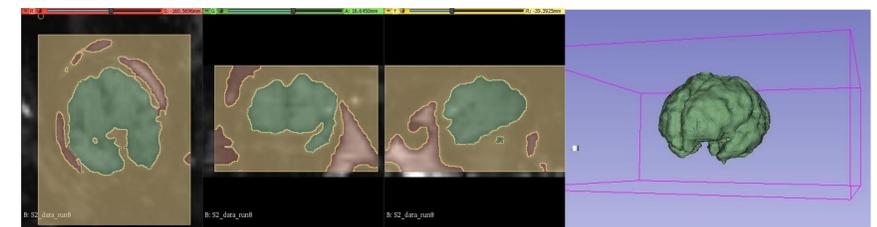


Figure 4a

Figure 4b

Acknowledgments

I would like to acknowledge the help of my supervisor Dr. Roy Eagleson, as well as members of our research group, specifically co-supervisor Dr. Sandrine De Ribaupierre.

Contact

Connor Burgess
Department Of Electrical And Computer Engineering
cburges6@uwo.ca

Please contact for an in-depth write up of the project.

References

1. Slicer Community, *Image Segmentation*, 2020, Accessed on: Aug. 19, 2021. https://slicer.readthedocs.io/en/latest/user_guide/image_segmentation.html
2. Cs. Pinter, A. Lasso, G. Fichtinger, "Polymorph segmentation representation for medical image computing", *Computer Methods and Programs in Biomedicine*, Volume 171, p19-26, 2019
3. Csaba Pinter, Andras Lasso, Kyle Sunderland, *Segmentations*, Sept. 22, 2017, Accessed on: Aug. 17, 2021. https://slicer.readthedocs.io/en/latest/user_guide/modules/segmentations.html
4. Harini Veeraraghavan, Jim Miller, *GrowCutSegmentation*, Oct. 25, 2010, Accessed on: Aug. 19, 2021. <https://www.slicer.org/wiki/Modules:GrowCutSegmentation-Documentation-3.6>