Bridging the Resource Gap: An Open-Source Python Implementation of FLAIRSEG 2.0 for Rapid Tumor and Multiple Sclerosis Lesion Segmentation in Low Resource Settings

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Introduction

FLAIRSEG 2.0 is an automated low-compute brain tumor and multiple sclerosis (MS) lesion characterization tool whose core functionality operates entirely offline, making it ideal for low resource settings and adept for global deployment.

Aim

To develop, deploy, and validate an open-source low-compute medical imaging segmentation tool for brain tumor and MS lesion characterization.

Background

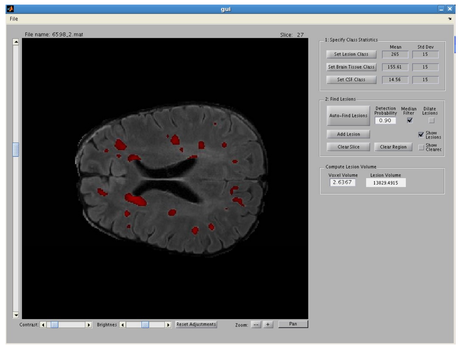


Figure 1: Legacy FLAIRSEG interface showing post-segmentation axial slice

FLAIRSEG 2.0 classifies each voxel as lesion, non-lesion brain tissue, or cerebrospinal fluid (CSF), estimating the probability that voxel v belongs to class c given its FLAIR intensity I, $Pr(v = c \mid I)$.

A prior MATLAB-developed version of FLAIRSEG was reverse-engineered, functionally expanded, and implemented in Python, replicating core functionality while featuring new and improved tools and usability.

Methodology

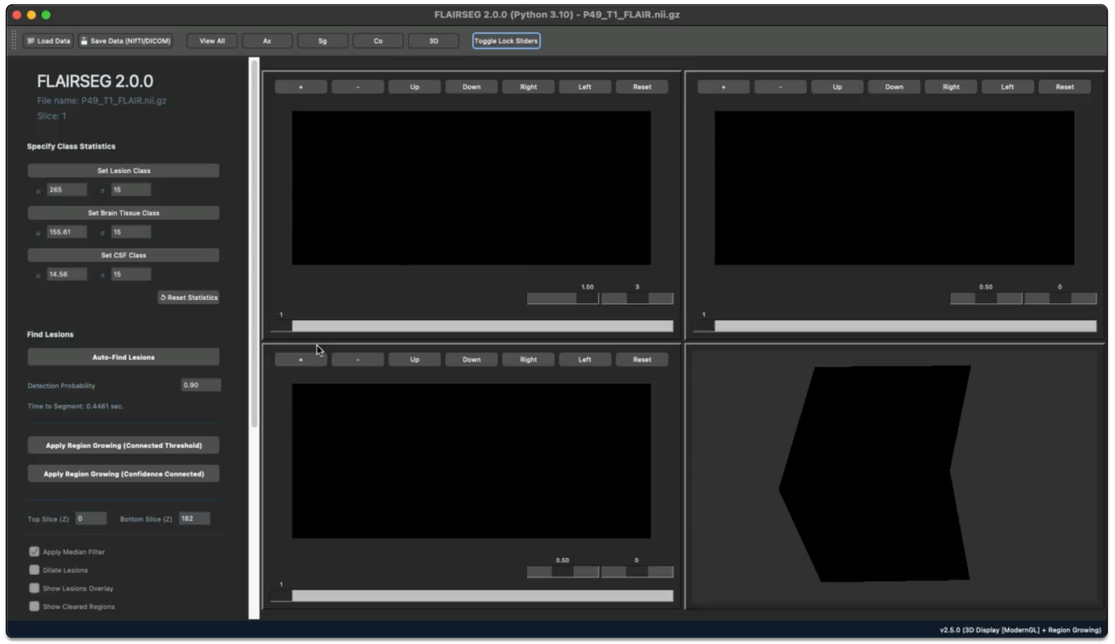


Figure 2: Video demonstrating FLAIRSEG 2.0 and functionality (Automatic Segmentation; Region selection; Draw/Erase Features; 3D View; Zoom in/out functionality; Z-axis slice selection)

This Python re-implementation emphasizes user interaction and flexible parameter adjustment while preserving the core probabilistic segmentation algorithm.

20 cases from publicly-available **2024 MSLesSeg** and **Pretreat-MetsToBrain-Masks** databases were used to evaluate FLAIRSEG 2.0 (10 cases each)

- T2-FLAIR images were segmented using FLAIRSEG 2.0. Masks were automatically generated and saved. Minimal postprocessing was performed for each mask.
- Spatial overlap of 5 segmentation maps per case were evaluated against ground truth. DICE volumetric assessment of tumor and MS lesion cases were done.
- Average segmentation time was recorded.

Results

Segmentation masks show **strong spatial alignment (DSC > 0.95) with ground truth masks** in both brain tumor and MS lesion datasets.

- The mean DSC for brain tumor segmentation was 0.97 ± 0.01, with average segmentation time was 0.72 ± 0.02 seconds.
- The mean DSC for MS lesion segmentation was 0.99 ± 0.02, average segmentation was 0.63 ± 0.13 seconds.

FLAIRSEG 2.0 Python implementation, **improves the original MATLAB tool's core functionality while enhancing the speed and accuracy of segmentation.**

	Average DSC	Average Time (seconds)
Brain Tumor Case 1	0.96 +/- 0.00	0.73 +/- 0.01
Brain Tumor Case 2	0.97+/- 0.00	0.72 +/- 0.01
Brain Tumor Case 3	0.99 +/- 0.00	0.71 +/- 0.01
Brain Tumor Case 4	0.99 +/- 0.00	0.72 +/- 0.01
Brain Tumor Case 5	0.97 +/- 0.00	0.71 +/- 0.00
Brain Tumor Case 6	0.98 +/- 0.00	0.74 +/- 0.01
Brain Tumor Case 7	0.98 +/- 0.00	0.74 +/- 0.01
Brain Tumor Case 8	0.97 +/- 0.00	0.74 +/- 0.01
Brain Tumor Case 9	0.97 +/- 0.00	0.74 +/- 0.01
Brain Tumor Case 10	0.96 +/- 0.02	0.73 +/- 0.01
	Average DSC	**Average Time (seconds)**
MS Lesion Case 1	1.00 +/- 0.00	0.70 +/- 0.02
MS Lesion Case 2	0.99 +/- 0.00	0.71 +/- 0.02
MS Lesion Case 3	0.99 +/- 0.00	0.69 +/- 0.03
MS Lesion Case 4	0.99 +/- 0.01	0.70 +/- 0.01
MS Lesion Case 5	1.00 +/- 0.00	0.68 +/- 0.01
MS Lesion Case 6	1.00 +/- 0.00	0.68 +/- 0.01
MS Lesion Case 7	1.00 +/- 0.00	0.70 +/- 0.02
MS Lesion Case 8	1.00 +/- 0.00	0.71 +/- 0.03
MS Lesion Case 9	1.00 +/- 0.00	0.69 +/- 0.01
MS Lesion Case 10	0.97 +/- 0.01	0.71 +/- 0.02

Table 1: Average DSC and segmentation time (seconds) (+/- standard deviation) across 10 MS lesion and 10 brain tumor cases;

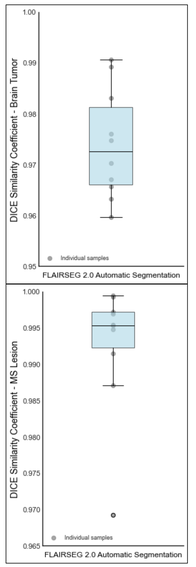


Figure 3: Box plot showing average DSC across 10 brain tumor cases (top); Box plot showing average DSC across 10 MS lesion cases (back);

Conclusion

We present an open-source, vendor-neutral, and low-compute solution for tumor and MS lesion segmentation. This initiative extends advanced neuroimaging capabilities to researchers and clinicians across resource-limited settings to promote equitable access to reliable neuroimaging analysis.

This makes FLAIRSEG 2.0 ideal for applicability in low-resource settings and adept for global deployment.

Contact Information

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