Learning with Difference of Gaussian Features in the 3D Segmentation of Glioblastoma Brain Tumors

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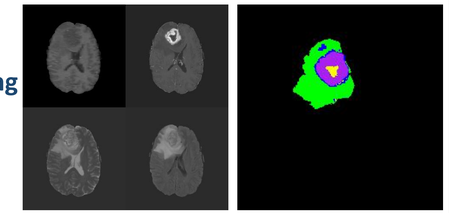
Overview

Glioblastoma (GBM) is an especially aggressive tumor that accounts for over 50% of brain tissue tumor cases. To better understand GBM's, we must first have easy access to their image data within MR scans, and this necessitates segmentation of the GBM region from the surrounding brain. Better yet, the GBM can also be classified into four sub-categories:

- necrosis
- edema
- non-enhancing
- enhancing.



Goals

Automatic Segmentation, if proven effective, will save a lot of human time in the segmentation step of GBM image processing, which will allow for highly efficient quantitative feature mining of these images. **Goals**:

- Find a feature space right for the data.
- Find the optimal ML algorithm to learn the data.
- Automatically detect and segment GBM.

Data

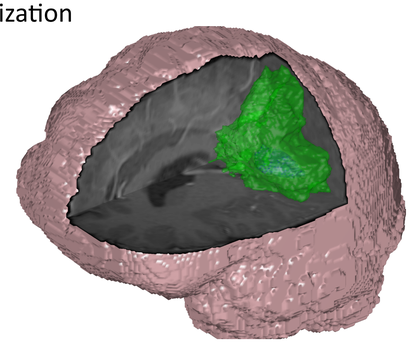
2015 MICCAI BRATS (Brain Tumor Segmentation):

- 220 High Grade Glioblastoma (HGG)
- 54 Low Grade Glioblastoma (LGG).

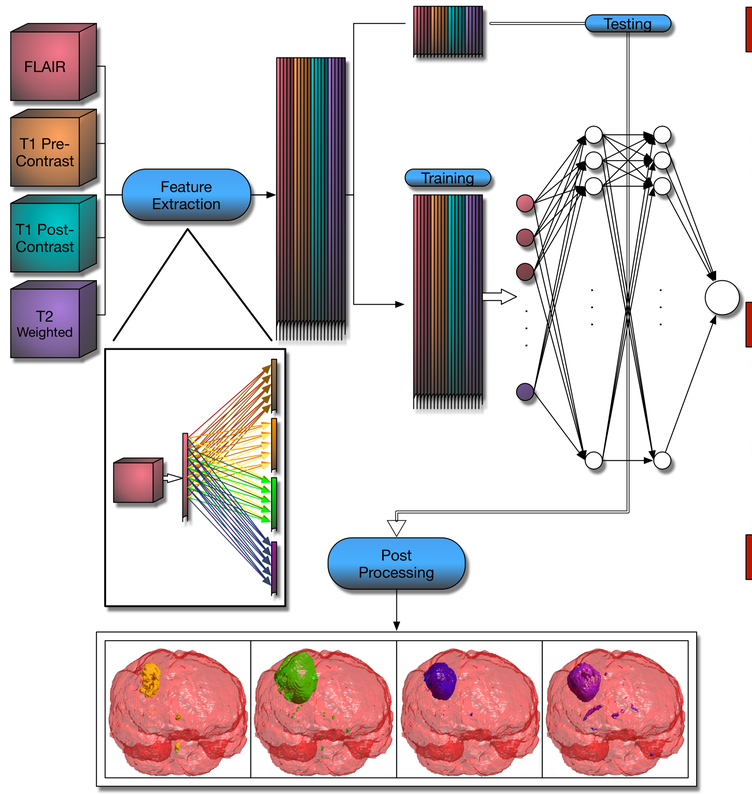
MR Modalities:

[FLAIR, T1 PRE-Contrast; T2 Weighted, T1 POST-Contrast]

Pre-processed: Skull-Stripped, Registration, Scale Normalization



Methodology



Feature Space

Data Problem: Each patient has millions of voxels of information but only a few hundred patients. Consider voxels Independently to increase n. (Bias ↑ Variance ↓)

$$\mathbf{X}\ (\in \mathbb{R}^{274 \times (Vox * Feat)}) \rightarrow \mathbf{y}\ (\in \{0,1\}^{274 \times Vox})$$

$$\mathbf{X}\ (\in \mathbb{R}^{(274 * Vox) \times Feat}) \rightarrow \mathbf{y}\ (\in \{0,1\}^{274 * Vox})$$

Convolution

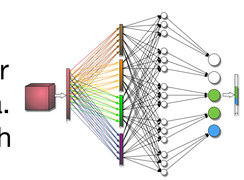
Convolution with filters to get features.

$$[f*g](t) = \int_0^t d\tau\, f(\tau)\, g(t-\tau)$$

Even though we consider each voxel completely independently, we still couple environmental information.

Neural Network

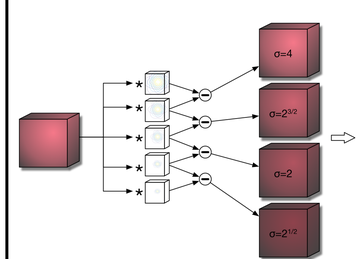
- 72 Input
- Binary Output
- 2 Hidden Layer
- 10 Neurons Ea.
- 4 Nets for Each Subregion

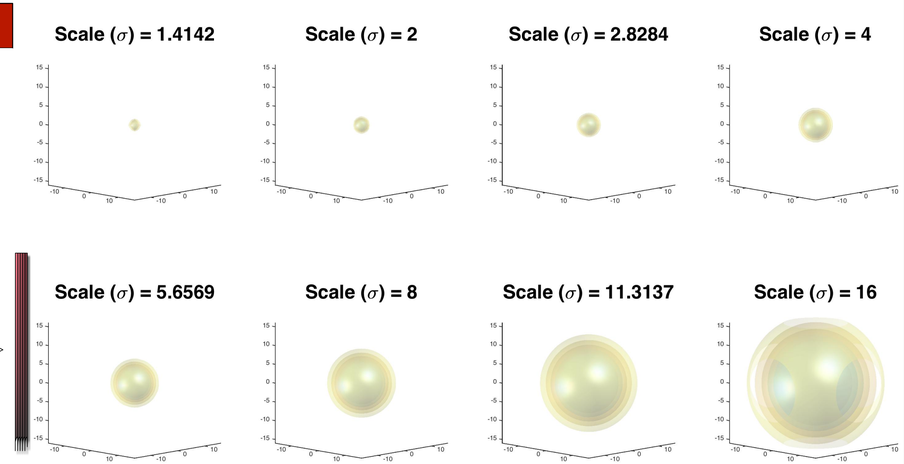


Difference of Gaussian

Robustness

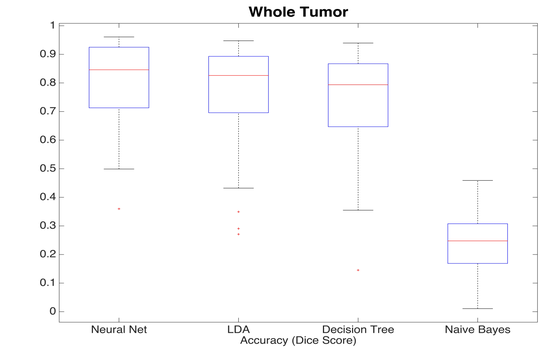
- Rotationally Invariant
- Easy to Calculate
- Proven Scale Space Exploration Efficiency



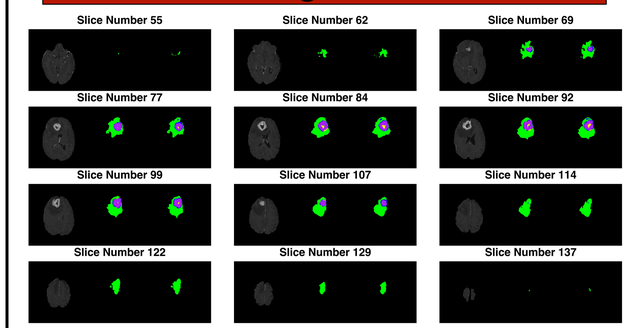


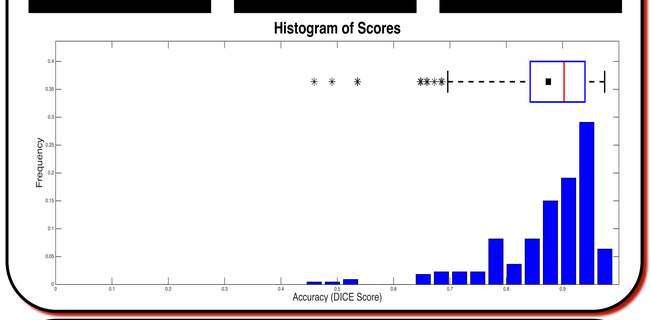
Results

Choosing Neural Network



GBM Segmentation





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