Breast Cancer Segmentation using nnU-net

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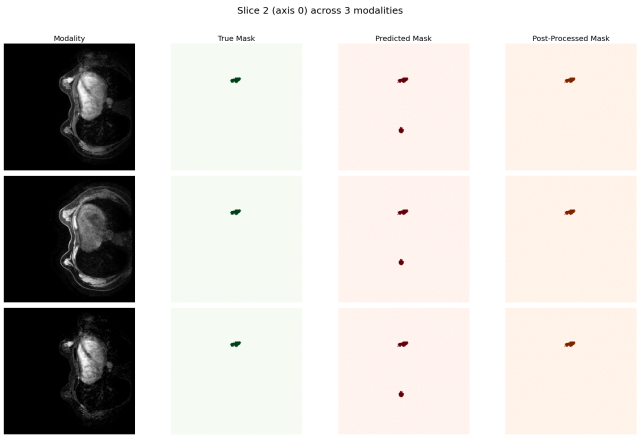
Breast cancer is one of the many abnormalities that has caused most deaths among women across the world. For early diagnosis and treatment planning, accurate tumor segmentation is necessary. Manually annotating the scans is time-consuming and introduces variability across experts, delimiting the scalability in clinical practice. The main goal of this project is to address such problems by developing an automated segmentation system based on deep learning for segmenting breast tumors from 3D MRI volumetric scans using the publicly available BreastDM dataset.

I have used the nnU-net framework, which dynamically adapts to the dataset fed to it, thus handling data of varying characteristics and complexities. I have leveraged the preprocessing, training, and inference from this pipeline. The preprocessing methods include cropping, resampling, configuration selection, and Z-score Normalization. This is done to ensure that the GPU is optimized. The training is done in mini-batches, using SGD with Nesterov momentum, combined loss, and on-the-fly data augmentation to promote generalization. The selected configuration (3D full res) dynamically adapts to my data, modifying the number of pooling operations, width and depth of architecture, and batch size, considering the memory. I developed a post-processing script that will refine the raw predicted labels by removing the small disconnected components (mostly false positives).



Model	DSC(%)	IoU(%)	PPV(%)
3D U-Net (Paper)	66.5	75.1	83.3
3D V-Net	65.6	74.2	77.1
3D DenseSeg	67.0	74.9	84.1
3D nnU-Net	**86.9**	**80.5**	**87.6**

The first figure (left) visualizes a slice of all three modalities of a patient's sample along with its ground truth mask, raw predicted mask, and post-processed mask. The second figure (right) is the table demonstrating comparison with baseline models reported in the BreastDM research paper, which shows that this model outperformed the baseline models by a large margin.

This system has many real-world applications. It eliminates the manual segmentation task and hence can be used by experts to save time and eradicate inter-observer variability. The system could also be integrated into PACS, where the MRI scans get automatically segmented once stored inside the archive. An application could be developed where the image of any modality or from any dataset can be uploaded, and segmentation could be generated, provided the model is trained across various datasets. Apart from implementation, I gained strong foundational learning in machine learning, deep learning, and multiple methods that can be used for automating manual medical labour.