Brain Tumor Segmentation Using Convolutional Neural Networks

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Introduction

Brain magnetic resonance (MR) images are extensively analyzed in oncology clinics for diagnosis, treatment planning and post-treatment tumor surveillance. The structural and spatial variations, as well as intensity inhomogeneity across an MR image make this problem very challenging. We propose a machine learning based automatic brain tumor segmentation system, namely the Mask Region-based Convolutional Neural Network (R-CNN). Mask R-CNN is a general framework for object detection and semantic segmentation, which has been successfully applied to the segmentation of natural images [1]. This paper explores its application to MR images for the purpose of accurate tumor delineation.

Materials and Methods

The MR image dataset from the 2018 Brain Tumor Segmentation (BraTS) challenge, which consists of 285 glioma patient images, was used to train the Mask R-CNN model. Mask R-CNN architecture derives a mask, bounding box, and label for every region of interest within the image by minimizing a multifaceted objective function. We used 90% of the BraTS data for network training, 5% for validation and 5% for testing. Due to the high computational requirements of training the Mask R-CNN model, Rowan University's High Performance Computer (HPC) was used to conduct most of these experiments. The model was trained using 4 NVIDIA Tesla K20m GPUs, and multithreading techniques were employed to accelerate the process of loading the data into memory.

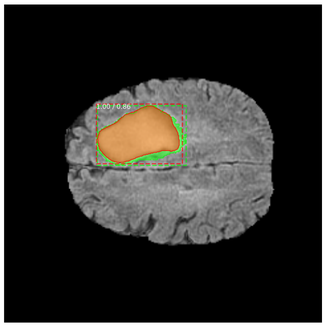

Figure 1: Mask R-CNN applied to a FLAIR image. The ground truth region is in green, and the predicted region is in red.

Results

The Dice coefficient was used to quantify the performance of Mask R-CNN. The Dice coefficient ranges between 0 (no overlap) and 1 (perfect overlap) and measures the overlap between the predicted and ground truth regions. On the test data, which contained about 600 images, the average Dice Coefficient was 0.75. An example output from Mask R-CNN is shown in Fig. 1.

Conclusion

Precise and timely segmentation of brain MR images is essential for surgical treatment planning, radiation therapy, and monitoring tumor growth/shrinkage after treatment delivery. Mask R-CNN was able to segment MR images much faster than the manual process adopted by physicians and achieved good accuracy. This work considered FLAIR sequences only. In the future, we plan to consider all MR modalities (T1, T1C, and T2).

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References

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