Brain Tumor Segmentation Using MASK R-CNN

Bishal Paul (id: 17-35836-3), Gupta,Rajan Das (id: 18-36304-1), Jui, Saha Pritha (id: 17-35507-3), Zubaer Hossain Asif (id: 18-36248-1)

[a]*Department of Computer Sciences, American International University-Bangladesh*

Abstract

Brain MRI segmentation is an important task in many clinical applications. Various approaches for brain analysis rely on accurate segmentation of anatomical regions. Quantitative analysis of brain MRI has been used extensively for the characterization of brain disorders such as Alzheimer's disease, epilepsy, schizophrenia, multiple sclerosis (MS), cancer, and infectious and degenerative diseases. Manual Segmentation requires outlining structures slice-by-slice, and is not only expensive and tedious but also inaccurate due to human error. Not only that, segmentation is extremely time-consuming and initial hours of brain tumor and strokes are crucial to diagnosing. Therefore, there is a need for automated segmentation methods to provide accuracy close to that of expert ratters' with high consistency. We propose to create a Deep Learning based Brain Segmentation web application that would fully automate the process of Brain Segmentation to help in solving out those cases which are generally missed by the human eye and save time.

Keywords: Deep learning, Segmentation, Object detection, NN, Mask R-CNN

1. Introduction

Brain tumor is a lethal disease affecting millions of people around the globe and has a high mortality rate. Brain tumor represents a cluster of abnormal cells that grows and multiply uncontrollably within normal brain cells and causes to damage the nervous system that controls different functions in the human body. Early identification and segmentation of brain tumor helps to increase the survival chances of the patient and also saves them from complex surgical processes. Moreover, the precise segmentation of brain tumors facilitates the surgeon for better clinical development and cure. Manual detection and segmentation of brain tumors is slow and suffer from a high error rate. Thus, the demand for effective computer-aided brain tumor segmentation techniques has increased considerably in recent times. However, accurate brain tumor segmentation is still a challenge because of its structural complexity such as variations in location, size, shape, and overlapping tumor boundaries with normal brain tissues, etc.

***I*n this Paper, we propose an automated method to increase the robustness of brain tumor segmentation by employing the Mask R-CNN model. Here are the contributions to our work:**

- Accurate localization and segmentation of brain tumor using the region proposal network and pixel-to-pixel accurate segmentation.
- A rigorous quantitative and qualitative comparison of the presented and latest techniques was performed on two online available datasets to exhibit the efficacy of our method.
- To the best of our knowledge, it is the first time Mask- R-CNN has been employed for brain tumor segmentation.
- The proposed technique is robust to variations in size, shape, location, and overlapping tumor boundaries with normal brain tissues in the presence of MRI artifacts such as noise, bias field effect, and different acquisition angles.

2. Proposed Method

Preprocessing

The MRI images produced from different MRI machines often include certain artifacts such as noise, bias field, or intensity inhomogeneity, which must be corrected to improve the segmentation results. In the preprocessing step, we applied the level set method for bias field correction and median filter to reduce the noise to get the enhanced image.

Tumor localization and segmentation using Mask RCNN

For segmentation, our target is to automatically localize and segment the brain tumor from a complex background without requiring any manual intervention. We aim to predict either tumor or non-tumor regions in the given MRI images using the Mask RCNN.

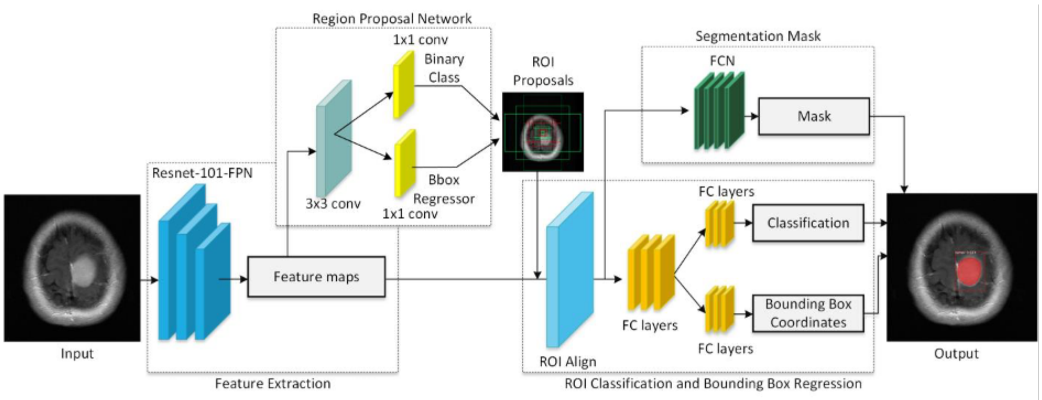

Figure 1: Mask R-CNN Model

The proposed framework (as shown in Fig. 1) consists of the following steps,

- feature extraction,
- region proposal network (RPN),
- region of interest (ROI) classifier and bounding box regressor (BBR), and
- segmentation.
- The detailed description of each step is discussed below.

Segmentation Mask

The segmentation network takes positive ROI identified by the ROI classifier as input and returns a segmentation mask of 28×28 represented by floating numbers that contains more information over binary masks. The GT masks are scaled down to 28×28 to measure the loss with the predicted mask during the training stage. However, during the inference, the predicted mask is scaled up to match the dimensions of the ROI bounding box and which provides the final output mask.

3. Dataset

The presented approach is evaluated on two online available datasets, Brain Tumor Figshare (BTF) Dataset and Brain Tumor Kaggle (BTK) Dataset that are diverse in terms of structural complexity, acquisition angle, devices, noise, and bias field-effect, etc. BTF dataset contains 3064 real MRI images of size 512×512 obtained from 233 subjects. BTK dataset contains 155 MRI images of size 845×845. Both datasets contain T1-weighted MRI images that are contrast- enhanced. The GT mask against each MRI image is created using the VGG Image Annotator tool. We employed the precision, recall, accuracy, dice score (DSC), and IoU to evaluate the proposed method.

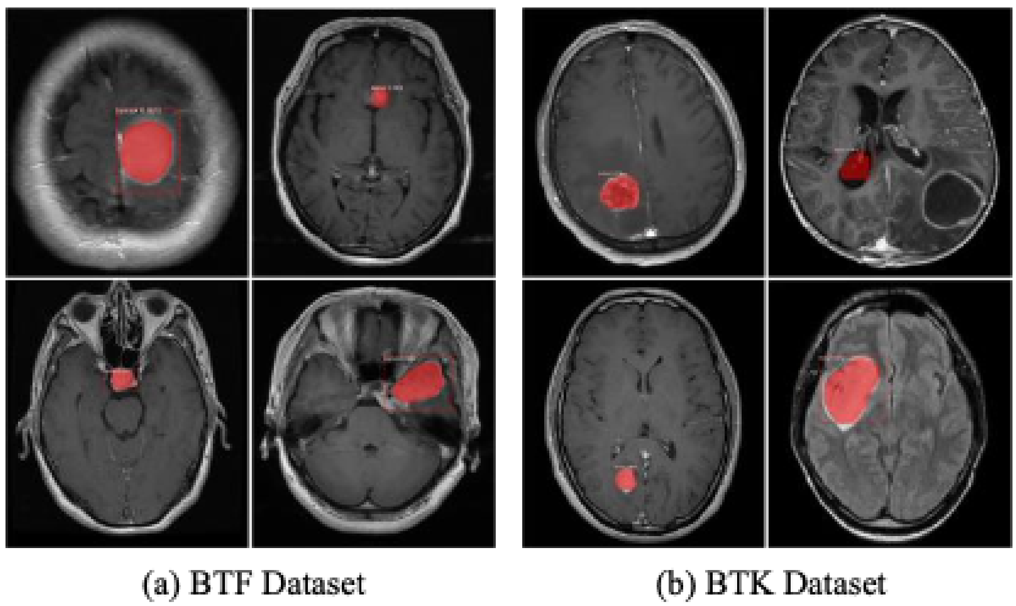

Figure 2: Visualization of Tumor Segmentation Results in MRI Images

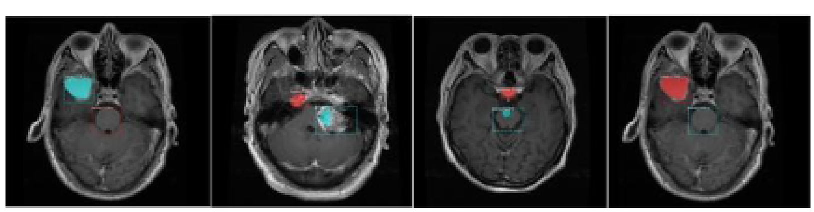

Figure 3: Example Images of Inaccurately Localized Brain Tumor.

4. Experiments and Results

We have implemented the model using Keras and TensorFlow libraries with ResNet-101, and FPN for feature extraction. We initialized the model using pre-trained weights obtained from the COCO dataset and employed transfer learning to fine-tune the model on MRI datasets for tumor segmentation. For experimentation, we used the 70-30 ratio that is randomly splitted into training (70 percent) and test (30 percent) sets.

Table 1 Comparison of the Proposed Approach with other RCNN Methods.

Methods	accuracy	mAP	dice	sensitivity
RCNN	0.92	0.91	0.87	0.95
Faster-RCNN	0.94	0.94	0.91	0.94
Proposed (Mask RCNN)	0.95	0.94	0.95	0.95

5. Discussion

This section provides a discussion of the results obtained after performing three different experiments. In our first experiment, we analyzed the performance of our technique on the BTF dataset and BTK dataset. Fig. 2 shows some of the high-scoring results of the segmented brain tumor obtained by applying the Mask RCNN. The proposed method can accurately localize the brain tumor with an average precision of 0.952 on the BTF dataset and 0.948 on the BTK dataset from the healthy tissues despite discontinuous or blurry boundaries and artifacts in MR images such as noise, bias field effect, and acquisition angle. Moreover, our method can precisely segment the brain tumor by overcoming the challenges of variations in location, shape, and size.

To further understand the performance of our method, we have drawn a boxplot for evaluation metrics on both datasets (Fig. 3). The boxplot represents the spread of results into four quartiles, median, and an outlier. Our method has achieved an average accuracy of 95.1 percent over the BTF dataset and 94.6 percent over the BTK dataset. Our method fails to accurately

6. Conclusion

In this letter, we have introduced a Mask RCNN model for the precise segmentation of brain tumor from the MRI images. We showed the significance of Mask RCNN for brain tumor segmentation. Mask RCNN can compute deep features with effective representation of brain tumor regions over existing systems. The results illustrate that the proposed method precisely delineates the tumor region and serves as an effective automated tool for diagnostic purposes. We plan to extend our work by performing the classification of different classes of brain tumor.

References

[1] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Addison-Wesley, Reading, Massachusetts, 1993.

[2] Brain tumor dataset,
$https://figshare.com/articles/brain_tumor_dataset/$1512427.

[3] Brain MRI Images for Brain Tumor Detection,
`https://www.kaggle.com/navoneel/brain-mri-images-for-brain-tumor-detection`