CNN for Chronic Stroke Lesion Segmentation

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Abstract

Stroke is the 4th leading cause of death in the United States. Brain MRI scan is often used to identify the extent of stroke lesion. With computer vision and image processing techniques, we could automatically identify the lesion area instead of manually segmenting MRIs, which is time consuming and prone to subjective error. Previous work applied statistical machine learning methods to solve the problem, while suffering from complicated parameter tuning for different brain cases. Recently, deep learning networks have shown promising results on many visual recognition tasks. However, most of the methods are restricted to traditional 2D images, which are not suitable for the 3D MRI images. In this paper, we design an automatic lesion segmentation pipeline named Deep Lesion ConvNet segmentation pipeline by utilizing 3D convolutional neural network (CNN). Our method can produce stroke lesion mask without any parameter and threshold setting, based on mono-modality T1 images instead of multi-modalities.

1 Methods

Thirty participants with aphasia resulting from a single left-hemisphere stroke were recruited from three research laboratories. All participants were monolingual English speakers and were right handed, at least one-year post onset of stroke. The participants underwent imaging that included a standard T1-weighted 3D MPRAGE scan acquired in the sagittal plane with isotropic resolution of 1mm. The gold standard measure of manual tracing was generated using MRIcro on the 3D T1 volume in the native space.

(1) Preprocessing: T1 image was bias field corrected with AFNI, skull-stripped with improved ROBEX to reduce the errors induced by lesions close to the skull. Images were intensity normalized to have zero-mean and unit standard deviation to avoid different intensity scales.

(2) Construction of Deep Lesion ConvNet: A 3D 7-layer CNN which contains 5 convolutional layers and 2 fully connected layers was constructed. The input to the network is a patch of voxels, and the output is the softmax probability of the central voxel of that patch, indicating whether this voxel is lesion or not. Comparing with traditional 2D network, 3D network uses 3-dimensional convolutional filters. The network were trained on 20 randomly selected participants and tested on the remaining 10 participants.

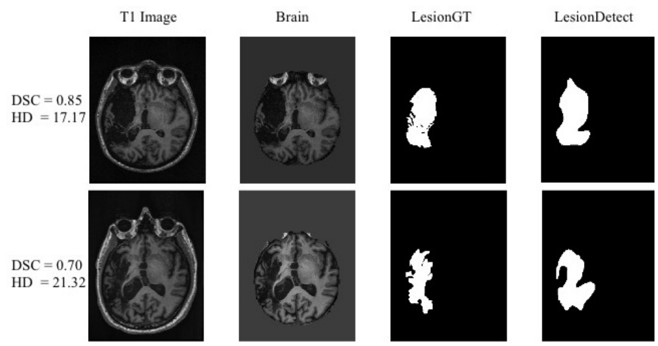

Figure 1: **Two examples produced by our pipeline. T1 image is the original T1 scan, Brain is the image after preprocessing, LesionGT is the lesion drawn by experts, LesionDetect is our prediction.**

(3) Postprocessing: Morphological operations were used to eliminate isolated small regions and smooth lesion edges to further improve the lesion identification.

Dice Similarity Coefficient (DSC) and Hausdorff Distance (HD) are used to evaluate the performance of the CNN model using manual drawn mask as ground truth.

2 Results

For the ten tested subjects, the average DSC is 0.78 and HD 18.75 mm. The detailed lesion volume and DSC, HD values are listed in Table 1. Figure 2 shows the results for two representative participants (top row is the subject with the highest DSC of 0.85 and bottom is the one with the lowest DSC of 0.70.

3 Conclusions

In summary we designed a very effective 3D CNN architecture for automatic lesion detection algorithm. One limitation is, part of CSF expansion was misclassified as lesion. Future work will focus on tackling these issues.