Improving spine segmentation in CT imaging using Convlutional LSTMs

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1 Introduction

Accurate automatic vertebrae segmentation in computed tomography (CT) is crucial for preoperative planning of scoliosis surgery [1]. Detailed 3D vertebrae model will result in accurate placement of pedicle screws or screw guides which minimizes the neurological and vascular ramification. However, automatic vertebrae segmentation remains challenging due to the high variation of patients' spinal anatomy, and noises caused by implants and CT scanners. Among the existing works, multi-stage model architecture achieved greatest segmentation performance, but they require more training parameters and longer training time [2]. The aim of the paper is to improve the performance of 2D model on 3D CT vertebrae segmentation by exploring spatial characteristics with ConvLSTM.

2 Methodology

In this paper, we proposed a deep learning approach for 3D CT vertebrae segmentation with a 2D Dense U-Net with ConvLSTM [3]. The proposed model integrates the advantage of 2D Dense U-Net with the spatial characteristics brought by ConvLSTM. Instead of simple concatenation of encoding layer and decoding layer, we employ ConvLSTM in the skipping layer to combine previous features with current features. A combination of the binary cross-entropy and dice loss was used as the loss function. We evaluate our method with Large Scale Vertebrae Segmentation Challenge (VerSe 19'and 20') dataset [4]. We conducted two experiments with ConvLSTM. The first experiment explored various loss functions and compound loss functions with the proposed model. The second experiment investigated the impact of ConvLSTM by experimenting with different numbers of ConvLSTM in the skipping connections.

3 Results & Discussion

Compound losses showed a superior performance compared to single loss functions while dice with focal Tversky loss achieves the greatest validation dice score coefficient. Our proposed model with such compound loss achieved 84.7% dice score coefficient in the validation dataset of VerSe 1920 which is comparable performance with 3D models in the existing works. With single ConvLSTM unit, the model converged faster while providing significant improvement in performance. Increasing the number of ConvLSTM improves the performance by 2% in validation dice score coefficient but increase the training time by 4 times.

References

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