Ryerson University | Data Science & Analytics Graduate Studies

2018-2019 M.Sc. in Data Science and Analytics

Chest X-ray Segmentation utilizing Convolution Neural Networks (CNN)

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Objective

The objective is to analyze the Chest X-ray segmentation process using the improved Attention gate (AG) U-Net architecture

This model suppresses the irrelevant regions and saliently points out the useful features for the targeted relevant tasks

It takes less computational resources and learns automatically for the different sizes and shapes of the target chest's X-ray images

Attention Gate with U-Net increased the model's sensitivity and accuracy

The proposed architecture is analyzed by using two renowned chest x-rays data-sets: Montgomery County and Shenzhen Hospital

Background

With the help of the advancement of "Convolutional Neural Networks (CNN), it is possible to analyze the medical image segmentation and the outcome will be almost to the near-expert level performance

CNN model is an effective model for the image segmentation as it has the excessive representation power and the properties of filter sharing

Two CNN models are used very commonly in this sector, one is the "Fully Convolutional Network" (FCN) and the other one is the U-Net

These models can do the extraction of the region of interest (ROI) from the target organs which can be different sizes and shape and also do the dense prediction

It requires a lot of computational resources, parameters of the models and it repetitively extract the low-level features. To mitigate this general problem, attention gates (AG) is introduced

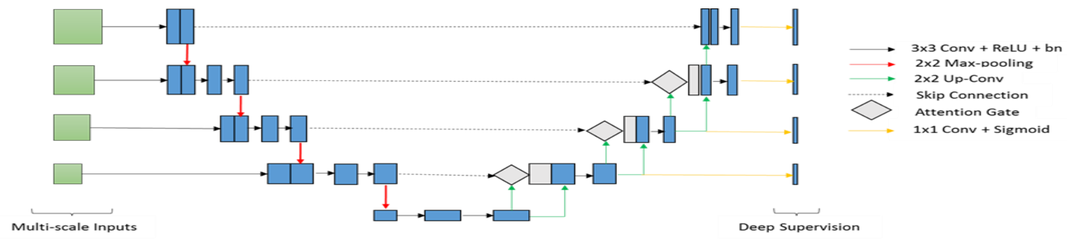
It follows the same standard training procedure as of FCN which can be trained from scratch and learns automatically to look after the target region without any extra supervision. The AG silently originate the soft regions on-the-fly and spot the main features

Being multi-model frameworks, it doesn't require large computational resources and parameters. Thus by suppressing the features from the non-relevant regions this model improves the overall sensitivity and helps for the dense label predictions.

Methodology

Fully Convolutional Network (FCN), especially U-Net architecture is very popular and robust for medical image segmentation tasks

Here, we implemented the improved attention U-Net architecture for lung segmentation images that eventually will help to determine the Pneumonia



The contracting path (Down-sampling) extracts the locality features and the expansive (Up-sampling) path is resample the image to map with the contextual information in this architecture

The local features with high resolution and the global features of low resolution are merged by using the skip connections procedure and thus achieves the significant outputs. During the forward and backward pass, this model filters the activations of the neuron

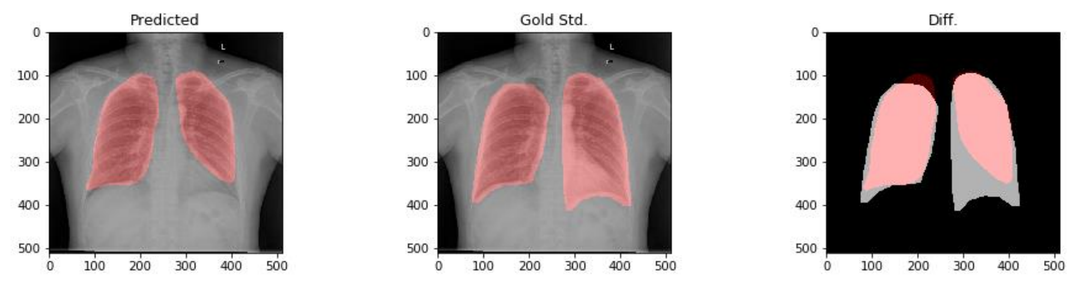
The network has the cascaded convolutions layers and non-linearity so there is the possibility to lose the spatial details. To overcome this issue, soft attention gates (AGs) have been used where the attention coefficient can spot the impotent regions and suppresses the irrelevant feature. Also, gating signal is used to determine the focus region for each pixel.

ReLU is used for intermediate maps transformation and the sigmoid activation function are applied to map each output. The use of deep-supervision, at each image scale, it is ensured that the intermediate feature-maps are semantically discriminative

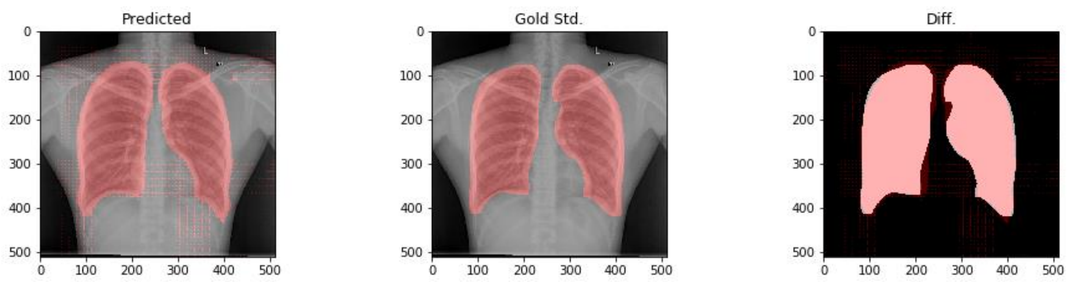
The combination of introducing the encoder layers with image pyramid (in front of each max-pooling layers) and the deep-supervision improve the segmentation accuracy and Dice Score Coefficient (DSC)

Results

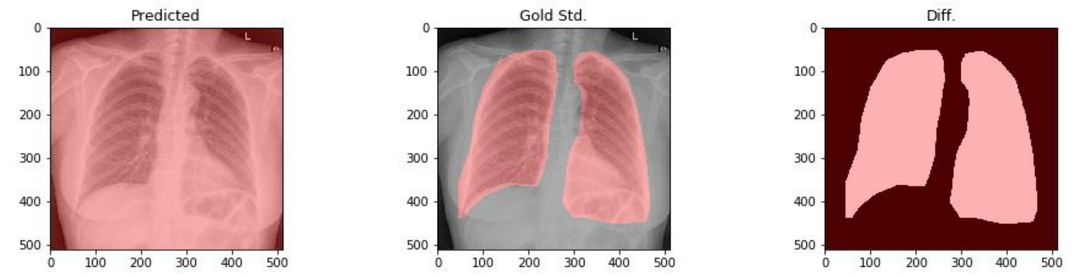
Model	Dice score coefficient (DSC)	Binary Accuracy
U-Net + Dice Loss	0.8959	0.9354
Attention U-Net + Dice Loss	0.9492	0.9706
Attention U-Net + Deep Supervision + Dice Loss	0.8732	0.9738
Attention U-Net + Deep Supervision + Multi-Input + Dice Loss	0.9025	0.9749



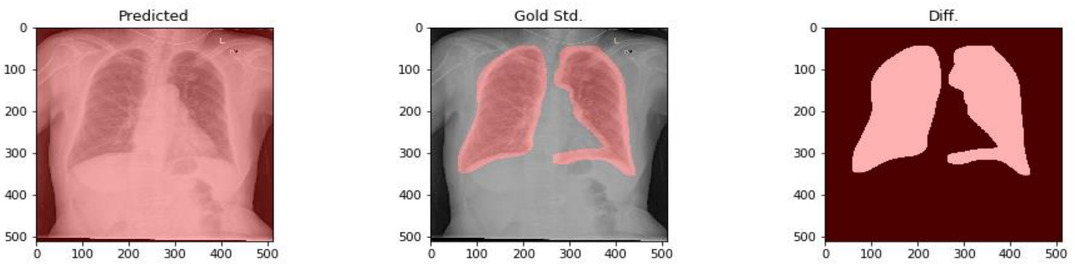
U-Net + Dice Loss



Attention U-Net + Dice Loss



Attention U-Net + Deep Supervision + Dice Loss



Attention U-Net + Deep Supervision + Multi-Input + Dice Loss

Conclusions

Our proposed Attention gate (AG) U-Net architecture for segmentation of chest x-ray images improve the dice coefficient scores, model's sensitivity, accuracy and efficiency

The suppression of irrelevant regions and features helped to limit the computational resources

The experiment shows the proposed model outperforms the existing U-Net architecture

By improving the computation resources along with epoch and batch sizes of the inputs the model's performance could be better

For future work, the proposed model's performance can be improved focusing on other loss functions, like Tversky loss function (TL) for the large datasets of different sizes and shapes of Chest X-Ray images using higher computational resources