Explainability of Deep Learning Models for Melanoma Segmentation: A New Perspective from Compound Loss Functions

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Introduction

Melanoma is one of the deadliest forms of skin cancer in the USA, with a survival rate of 23% for delayed diagnosis; however, an early detection could extend the survival rate up to 99%. Many efforts have been dedicated to the implementation of end-to-end automated artificial intelligence systems to early detect the presence of melanoma. In this study, we investigate a series of loss functions that have been used for medical image analysis with deep learning models, from an aspect of explainability. We propose weighted compound loss (WCL) functions to improve the prediction accuracy of a U-Net based deep learning model for Melanoma segmentation.

Hypothesis

The fusion of different loss functions with non-equative weights will not only improve the performance of deep learning algorithms for Melanoma segmentation, but also better capture important features that echoes with the explainability of the predicted outputs.

Methods

We used the ISIC2016 dataset, which contains 900 dermoscopic lesion images with the corresponding binary segmentation masks.

We evaluated four popular loss functions for deep learning based medical image segmentation tasks, including binary cross entropy(BCE), dice loss, Jaccard loss, and focal loss. The experiments were conducted with the use of a lighter version of the U-Net architecture, and a series of different configurations of weights {λ1, λ2, λ3, λ4} for the WCL function.

Experimental performance was quantified with evaluation metrics used for segmentation tasks, including: mean Intersection over Union(IoU) and F1-score.

Results

Table 1 showed increment in the performance of the segmentation task with our proposed WCL functions. The best performance was achieved by leveraging the merits of three loss functions with different weighted representation.

Qualitatively, the segmentation output produced with models trained using WCL seems visually more similar to the ground truth as it is shown in Figure 1. In addition, the saliency map showed the presence of more important image features as the model uses WCL3 during training.

Conclusion

Experimental results supported the hypothesis that WCL function improves the performance of deep learning algorithms for Melanoma segmentation task. It also better captures representative features that echo with "visual explanations" for decisions from U-Net based segmentation models.

Keywords

Artificial Intelligence/Machine Learning; Imaging Research