Deep learning-based segmentation for pneumothorax identification in chest radiograph: Application of tensor dimensionality reduction method

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Abstract

Background: The massive quantities of medical data accumulating from patients and populations hold the prospect of becoming an engine for precision medicine. The advanced analytics in statistical science has been established to efficiently extract the crucial health-related information from high dimension data. In this research, we use the tensor-based dimensionality reduction method, TensorProjection Layer (TPL) which reduces the input into smaller tensors by projection, in identifying pneumothorax disease in chest x-rays with UXception Net.

Methods: Ten-thousand chest x-ray and lung mask images of pneumothorax and healthy participants were acquired from the Society for Imaging Informatics in Medicine. The UXeption Net is used to segment pneumothorax regions in chest x-ray, and TensorProjection Layer is assigned for image dimension reduction. Firstly, we examine the model performance as the TPL replacing zero, one and all max-pooling layers in UXception. Secondly, we apply TPL as a data preprocessing step and discuss the utility in deep learning-based segmentation. The experiments were

conducted with Python 3.8 and run on one Quadro RTX 8000 GPU.

Results: Compare to the typical UXception Net, the computation time for one max-pooling replaced with TPL reduced from 6.42 to 3.81 hours. With all max-pooling replaced, the computation time increased to 9.58 hours due to the increasing trainable parameters, however, it provides the most stable training process. Using TPL as image preprocessing step, there was little improvement or no difference in validation accuracy and sensitivity.

Conclusions: This research suggests evidence of advancing deep learning in medicine by applying the statistical dimension reduction method as a regular image data downsampling step. Adequately used, the model with TensorProjection transformation performs significantly reduced computation time with similar segmentation results. From the statistical prospect, incorporating deep learning and dimension reduction methods can be practical and improve efficiency in clinical diagnosis.

Keywords: TensorProjection layer, pneumothorax, segmentation.