Abstract: Light-weight Semantic Segmentation and Labelling of Vertebrae in 3D-CT Scans

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In order to facilitate early diagnosis and prevention of osteoporosis and degenerative diseases of the spine, automated opportunistic screening in routine 3D-CT scans can be implemented to assist radiologists in clinical practice. The resource limited clinical setting demands for solutions that emphasise accuracy and robustness while oftentimes being limited by computational resources. The VerSe19 and '20 challenges aim at addressing the task of spine CT analysis but most proposed methods require multiple-stages and are computationally complex. In contrast to prior work for vertebrae segmentation and labelling, we design a light-weight deep learning alternative: a 3D DeepLab [1]. Our proposed patch-based segmentation method comprises a modified MobileNetV2 backbone, Atrous Spatial Pyramid Pooling and a small segmentation head with a single skip connection. To fit our model to this specific task and improve efficiency and accuracy, we have further optimised the network architecture by applying the compound scaling idea of the EfficientNet. Our model was trained and evaluated on the public VerSe19 dataset sampled to isotropic 1.5 mm spacing and is compared to results of the nnUNet as baseline method. Our method yields a multi-label Dice score of 73±17 % and a binary Dice score of 86±5 %. In comparison, the nnUNet scored a multi-label Dice score of 81±14 % and a binary Dice score of 90±4 %. The Centre-Mass-Distances of each vertebra over each scan are 2.7±2.2 Voxel and 1.9±2.0 Voxel, respectively. However, the inference time of our method is an order of magnitude faster due to the reduced amount of trainable parameters, namely 1.2 M parameters for our method and 32.2 M parameters for the nnUNet. The segmentation outcome of our method can be further employed for down-stream tasks such as detection of fractured vertebrae and degenerative diseases in the context of opportunistic spine assessment. We believe that our memory and time efficient segmentation algorithm is a promising alternative to already existing algorithms and helps facilitate the application of opportunistic screening for osteoporosis and other degenerative deformities of the spine. Code available at: `github.com/multimodallearning/vertebrae-segmentation-classification`.

References

1. Hempe H, Yilmaz EB, Meyer C, Heinrich MP. Opportunistic CT screening for degenerative deformities and osteoporotic fractures with 3D DeepLab. Medical Imaging 2022: Image Processing. SPIE, 2022.

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