World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:17, No:04, 2023

Image Segmentation with Deep Learning of Prostate Cancer Bone Metastases on Computed Tomography

Authors : Joseph M. Rich, Vinay A. Duddalwar, Assad A. Oberai

Abstract : Prostate adenocarcinoma is the most common cancer in males, with osseous metastases as the commonest site of metastatic prostate carcinoma (mPC). Treatment monitoring is based on the evaluation and characterization of lesions on multiple imaging studies, including Computed Tomography (CT). Monitoring of the osseous disease burden, including follow-up of lesions and identification and characterization of new lesions, is a laborious task for radiologists. Deep learning algorithms are increasingly used to perform tasks such as identification and segmentation for osseous metastatic disease and provide accurate information regarding metastatic burden. Here, nnUNet was used to produce a model which can segment CT scan images of prostate adenocarcinoma vertebral bone metastatic lesions. nnUNet is an open-source Python package that adds optimizations to deep learning-based UNet architecture but has not been extensively combined with transfer learning techniques due to the absence of a readily available functionality of this method. The IRB-approved study data set includes imaging studies from patients with mPC who were enrolled in clinical trials at the University of Southern California (USC) Health Science Campus and Los Angeles County (LAC)/USC medical center. Manual segmentation of metastatic lesions was completed by an expert radiologist Dr. Vinay Duddalwar (20+ years in radiology and oncologic imaging), to serve as ground truths for the automated segmentation. Despite nnUNet's success on some medical segmentation tasks, it only produced an average Dice Similarity Coefficient (DSC) of 0.31 on the USC dataset. DSC results fell in a bimodal distribution, with most scores falling either over 0.66 (reasonably accurate) or at 0 (no lesion detected). Applying more aggressive data augmentation techniques dropped the DSC to 0.15, and reducing the number of epochs reduced the DSC to below 0.1. Datasets have been identified for transfer learning, which involve balancing between size and similarity of the dataset. Identified datasets include the Pancreas data from the Medical Segmentation Decathlon, Pelvic Reference Data, and CT volumes with multiple organ segmentations (CT-ORG). Some of the challenges of producing an accurate model from the USC dataset include small dataset size (115 images), 2D data (as nnUNet generally performs better on 3D data), and the limited amount of public data capturing annotated CT images of bone lesions. Optimizations and improvements will be made by applying transfer learning and generative methods, including incorporating generative adversarial networks and diffusion models in order to augment the dataset. Performance with different libraries, including MONAI and custom architectures with Pytorch, will be compared. In the future, molecular correlations will be tracked with radiologic features for the purpose of multimodal composite biomarker identification. Once validated, these models will be incorporated into evaluation workflows to optimize radiologist evaluation. Our work demonstrates the challenges of applying automated image segmentation to small medical datasets and lays a foundation for techniques to improve performance. As machine learning models become increasingly incorporated into the workflow of radiologists, these findings will help improve the speed and accuracy of vertebral metastatic lesions detection.

Keywords : deep learning, image segmentation, medicine, nnUNet, prostate carcinoma, radiomics
Conference Title : ICMLA 2023 : International Conference on Machine Learning and Applications
Conference Location : Boston, United States
Conference Dates : April 17-18, 2023