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Screen 04 - A Convolutional Neural Network for Automated Delineation and Classification of Metabolic Tumor Volume in Head and Neck Cancer

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Deep Learning based approaches for automated analysis of tomographic image data are drawing ever increasing attention in Radiology and Nuclear Medicine. With the advent of the new generation of PET scanners with massively enlarged axial field of view ("total body PET") the importance of integrating such approaches into clinical workflows will further increase. In the present study we report on our application of a convolutional neural network (CNN) for automated survival analysis in head and neck cancer (HNC): PET parameters such as metabolic tumor volume (MTV), total lesion glycolysis, and asphericity of the primary tumor are known to be prognostic of clinical outcome in HNC patients. Additionally including evaluation of lymph node metastases further increases the prognostic value of PET. However, accurate manual delineation and classification of all lesions is time consuming and incompatible with clinical routine. Our goal, therefore, was development and evaluation of an automated tool for MTV delineation/classification of primary tumor and lymph node metastases in HNC in PET.

Automated delineation of the HNC cancer lesions was per- formed with a residual 3D U-Net convolutional neural network (CNN). 698 FDG PET/CT scans from 3 different sites and 4 public databases were used for network training and testing. In these data, primary tumor and metastases were manually delineated (with assistance of semi-automatic tools) and accordingly labeled by an experienced physician. Performance of the trained network models was assessed by 5-fold cross validation using the Dice similarity coefficient for individual delineation tasks.

Additionally, survival analysis using univariate Cox regression was performed. Delineation of all malignant lesions with the trained U-Net model achieves a Dice coefficient of 0.866 when not discriminating between primary tumor and lymph nodes. Treating primary tumor and lymph node metastases as distinct classes yields Dice coefficients of 0.835 and 0.757 for the respective delineations. The univariate Cox analysis reveals that, both, manually as well as automatically derived total MTVs are highly prognostic with similar hazard ratios (HR) with respect to overall survival (HR=1.8; P<0.001 and HR=1.7; P<0.001, respectively). To the best of our knowledge, our work represents the first CNN model for successful MTV delineation and lesion classification in HNC. The network quickly performs usually satisfactory delineation and classification of primary tumor and lymph node metastases in HNC using FDG-PET data alone with only minimal sporadic manual corrections required. It is able to massively facilitate study data evaluation
in large patient groups and also does have clear potential for clinical application.

Primary author: Dr NIKULIN, Pavel (Helmholtz-Zentrum Dresden-Rossendorf, PET Center, Institute of Radiopharmaceutical Cancer Research)

Co-authors: Dr HOFHEINZ, Frank (Helmholtz-Center Dresden-Rossendorf, PET Center, Institute of Radiopharmaceutical Cancer Research); Dr MAUS, Jens (Helmholtz-Zentrum Dresden-Rossendorf, PET Center, Institute of Radiopharmaceutical Cancer Research); Dr CEGŁA, Paulina (Greater Poland Cancer Centre, Department of Nuclear Medicine); Dr FURTH, Christian (Charité –Universitätsmedizin Berlin, Klinik für Nuklearmedizin); Dr KAŹMIERSKA, Joanna (Greater Poland Cancer Centre, Radiotherapy Department II); Dr ROGASCH, Julian (Charité –Universitätsmedizin Berlin, Klinik für Nuklearmedizin); Ms HAJIYIANNI, Marina (Charité Universitätsmedizin Berlin, Department of Radiation Oncology and Radiotherapy); Prof. KOTZERKE, Jörg (Universitätsklinikum Carl Gustav Carus, Klinik und Poliklinik für Nuklearmedizin); Dr ZSCHAECK, Sebastian (Charité –Universitätsmedizin Berlin, Klinik für Radioonkologie und Strahlentherapie); Prof. VAN DEN HOFF, Jörg (Helmholtz-Zentrum Dresden-Rossendorf, PET Center, Institute of Radiopharmaceutical Cancer Research)

Presenter: Dr NIKULIN, Pavel (Helmholtz-Zentrum Dresden-Rossendorf, PET Center, Institute of Radiopharmaceutical Cancer Research)

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