Start-up Deep Art Medicine is interested in developing and implementation of the artificial intelligence models as an innovative tool in radiology. Its task is to evaluate the results of different imaging methods across different types of modalities in radiology and radiotherapy. One of the main goals of our company is to develop models for prostate cancer detection. That's why we're convinced that Our image processing solution can provide a huge contribution to the topic EU4H-2022-PJ-01.

Diagnosis of prostate cancer is not only difficult for radiologists, but also for modern deep learning algorithms that rival human performance in medical image analysis. Even when using mp-MRI imaging modalities, automated prostate tumor delineation is commonly unable to detect the lesion. The ProstateX Challenge is the only publicly available dataset that includes mp-MRI sequence images for the detection/diagnosis of prostate cancer. Unfortunately, the lack of clinically validated ground truth images limits the potential to achieve optimal performance. A study by (Gunashekar et al., 2022) proposed CNN based method for the automatic prostate gland and the tumor lesions segmentation. The study included 112 mpMRI images with histologically confirmed primary prostate cancer. The deep learning model achieved a dice score of only 0.62 and 0.31 for the prostate and lesion segmentation. A study by (Coen de Vente et al., 2021) performed a Deep Learning Regression automatic model for Prostate Cancer Detection using ProstateX version two bp-MRI data. The model scored with low dice of 0.370 ±0.046, obtained using 5-fold cross-validation.

Data

In this study, multiple datasets from different institutes will be used to develop a robust and generalizable workflow for detection of prostate gland and tumour. The initial set of datasets comprises anatomical data from the pelvic area, including the prostate, significant prostatic tumor, and a specified segmentation mask created by medical specialists. For the delineation of the prostate (PTV), the following datasets will be considered: The SPIE-AAPM-NCI PROSTATEx Challenges (PROSTATEx) collection of 346 MR images together with PROSTATEx-2 of 162 MRI cases released, PROMISE12 challenge of 100 MRI scans and Prostate-MRI-US-Biopsy from a cancer imaging archive including 1151 MRI cases.

As previously stated, mp-MRI and bp-MRI may play an essential role in prostate cancer diagnosis by increasing the visibility and precision of prostatic tumor detection. Until today, the only publicly available data on prostate cancer detection/diagnosis is the ProstateX Challenge dataset, containing only 346 bp-MRI images. Despite the lack of available data, the detection models achieve only sub-optimal performance and have a limited level of generalizability. On May 1st, a new medical challenge called Artificial Intelligence & Radiologist at Prostate Cancer Detection in MRI (PI-CAI) will release a multivendor dataset of 1500 bp-MRI exams annotated by 16 radiology and urology experts, the largest data collection in the context of prostate cancer detection to date. Deep learning models are highly reliant on a large amount of data. As a result, the new PI-CAI dataset has the potential to greatly improve the current benchmark in prostate cancer diagnosis, provoking future research to investigate the feasibility.

Method

Acquiring target contours can be perceived as a segmentation problem. Some studies have proven that having a localization phase prior to the segmentation can result in more accurate results. The winners of the HEad and neCk TumOR (HECKTOR) 2021 segmentation challenge won the competition with the two-stage approach, where in the first step, the Region of the Interest was suggested, and then the final segmentation model was applied in this region. A study by (Ramazan Ozgur Dogan et al.) achieved optimal results with high accuracy in pancreas segmentation using a localization network and then a segmentation network.

For Prostate cancer detection (PCa), we propose a two-phase approach for automatic targets delineation, using the localization stage prior to the segmentation stage that produces the final binary mask of the targets.

We will employ two state-of-the-art object detection models (Mask RCNN and nnDetction) to detect and classify the targets (PTV and prostatic tumor) and compare the localization performance on the test dataset. We will assess the localization phase with the Free-response Receiver Operating Characteristic (FROC) curve that shows the detection sensitivity and number of false-positive predictions (FP). To make the two-phase approach feasible, we emphasize on high sensitivity at the cost of the FP predictions. In other words, if the prostatic tumor is not detected in the first phase, the second phase (segmentation model) will be unable to produce final segmentation. The model with better performance will be then used in the radiation dose prediction workflow.

The second phase aims to output the final segmentation of the targets applied to the ROI suggested by the detection model. Similarly, we will compare the segmentation performance of the modified 3D variant of the U-Net architecture and “no new U-Net” (nnU-Net) that has demonstrated state-of-the-art results in multiple medical segmentation challenges.