Planning-CT less adaptive radiotherapy for Head-and-Neck Cancer on conventional Linacs

Intensity-modulated radiation therapy techniques such as volumetric modulated arc therapy (VMAT) have become the standard treatment for head-an-neck (HN) tumors. Thanks to these techniques, highly conformal dose distributions with steep dose gradients are obtained which is beneficial for both ensuring sufficient planning target volume coverage and sparing the multiple surrounding organs at risk (OAR). However, anatomical changes are common during HN cancer radiotherapy and may introduce large dose variations. As they can significantly affect the dose distribution, such changes should be at least monitored during VMAT treatment course to find surrogate to decide on whom to reply.

Several Image-Guided Radiation Therapy (IGRT) devices providing 3-dimensional imaging for accurate patients' positioning and control anatomical changes are available on Linacs. Among them, the most frequently available is 3D-kV Cone-Beam Computed Tomography (CBCT). Using CBCT images, it is possible to perform adaptive radiotherapy (ART). The aim of "offline" ART is to compute the dose distribution using the "3D image of the day" and to decide whether it is necessary to perform a new plan based on a new simulation CT scan of the patient. However, CBCT images suffer from low soft-tissue contrast and a restricted field of view compared to Computed Tomography (CT) imaging modality. Hence, it is impossible to perform accurate contouring of the OARs and target volumes, particularly for HN cancer, where accurate contouring of targets requires the use of contrast-enhanced CT. In addition, auto-segmentation algorithms generally show poor performances on CBCT images. Furthermore, accurate dose calculation requires knowledge of tissues' electronic density (ED) (correlated to the Hounsfield units (HU) of the CT scanner) which is not easily achievable using CBCT images. To perform dose calculation on CBCT images, different methods based on density assignment (DAM), CBCT-HU to ED calibration curves, or deformable image registration (DIR) of planning CT images into daily CBCT have been evaluated. However, to date, none of these methods has shown sufficient accuracy to carry out a new dose plan calculation, and patients exhibiting anatomical changes still have to go through a new simulation CT.

More promising, research activities now focus on developing and evaluating deep learning methods to correct CBCTs and generate synthetic CTs (sCT). We thus propose to assess the performances of a new DL model developed by Therapanacea Company (Paris, France) trained with CT images to generate sCT from CBCTs. Based on those unique new algorithm, the goal of this PhD is to develop ad-hoc off-line adaptive therapy strategies for HN cancer patients. Among the different steps, the recruited PhD student will have 1) to compare the image quality; 2) evaluate the dosimetric accuracy against previously described methods (CBCT-HU to ED curve, DAM, DIR) ; 3) evaluate the performances of an AI-based segmentation method, also developed by Therapanacea society, for automatic contouring of lymph nodes and organs at risk directly on generated sCT; 4) perform dose accumulation in order to define thresholds for replanning 5) define new CBCT-only + auto-planning-based adaptive strategies with session-cumulated delivered dose. The overall approach will be performed in a clinical environment with real-life patient images and treatment plans.

The PhD will be conducted in the CREATIS lab, team "tomoradio", located in the radiation therapy department of the Léon Bérard cancer center, Lyon, France, in partnership with Therapanacea Company.

Applicant profile: Medical physicist, data analysis

Location: Léon Bérard center, radiation therapy department, CREATIS lab, Lyon, France

Length: 3 years starting in September 2023

Contact: Please send your CV and application letter by email to:

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Applications will be gathered until end of May 2023. Interviews will be conducted by videoconference or in Lyon depending on availability.