CREATIS

CENTRE DE LUTTE CONTRE LE CANCER LEON BERARD

Post-Doctoral fellow proposal

24 months starting at the beginning of 2024

Head and Neck radiotherapy dose painting from mpMRI-based tumor habitat maps

Locations

In Lyon at the comprehensive cancer center Léon Berard in both diagnostic imaging and radiotherapy departments as well as on campus LyonTech-La Doua at CREATIS.

Partnership

This project, funded by the National Research Agency for 4 years from January 2023, is carried out in partnership with CREATIS, the radiology and radiotherapy departments of the Center Leon Berard and the company Therapanacea. An additional support will be bring by the LabEx PRIMES (https://primes.universite-lyon.fr/)

Scientific context

Cancer is the leading cause of mortality and morbidity globally. Radiation therapy is used in more than 50% of patients treated for cancer. Head and neck (HN) tumors have the sixth most frequent cancer prevalence and are often associated with poor outcomes and lifelong sequels. Radiation therapy is generally performed using intensity modulated techniques with photon beams. It is particularly challenging due to anatomical complexity and physiological functions associated with the organs at risk (OAR). At the same time, proton therapy has the potential to further reduce the toxicity of the treatment, but is much less accessible [1]. Treatment planning is routinely performed on CT imaging since accurate dose calculation requires the conversion of Hounsfield unit values (HU) of the CT to relative electron density (ED) or stopping power, for photons and protons beams, respectively. However, CT imaging fails to provide functional information regarding tumor infiltration. MR imaging (MRI) has the potential to improve efficiency of treatment due to its unique ability for better tissue visualization of organs at risk and tumor physiological characterization. Until now, the only way to calculate the dose on MRI is to generate a pseudo-CT or a synthetic CT via different methods such as bulk density assignment (BDM), atlas-based and deep learning (DL) methods [2]. In the literature, however, teams have sought to use proton density to calculate dose directly from MRI images [3].
In the Radiology Department of center Leon Berard, we have developed at 3.0T (Siemens Vida MR system) a MRI acquisition protocol including a specific coils setup and patient table to host the patient with the immobilizer mask. This protocol is running and aims to enroll 200 patients. It includes several MRI pulse sequences such as morphological acquisition for the OAR and target volume contouring, and other sequences for multiparametric quantitative MRI (mpq-MRI) purpose, including oxygenation mapping.

Objectives

This project aims to propose a dose distribution planning solution entirely based on MRI. Particularly, we will exploit the additional potential of mpq-MRI for dose calculation accounting for the spatial biology of the tumor [4]. Mpq-MRI is used to build a hydrogen concentration map for dose calculation and a tumor microenvironment map for dose painting. The proposed tumor microenvironment map is built from the multispectral information provided by oxygenation and diffusion mapping. It allows identifying tumor sub-regions such as necrosis, viable and proliferating tissue, and hypoxia region. Thus, the main objectives of this post-doc will be:

- To extract from the microenvironment maps of the Mpq-MRI hypoxic volumes on which a dose escalation will be performed [4-6];

- To perform CT/MRI registration and propagate the contours on the CT in order to perform a new treatment plan with photons using volumetric modulated arc therapy technique (VMAT). These plan will be compared to the clinical plans.
- To explore further the possibility of dose escalation by using protons rather than photons to perform the plans [7].
- To evaluate the accuracy of dose calculation on MRI images using the DAM method (or other available DL method at CLB) against dose calculation on the planning CT;
- To propose a new robust method for performing treatment planning directly on MRI imaging, based on the proton density.

Profile and skills of the candidate

- Physicist with a PhD thesis in medical physics.
- Knowledge about medical imaging and machine learning would be a plus.
- Good practice and knowledge of programming or prototyping softwares
- Willingness to get involved in the medical field and to work in an interdisciplinary environment
- Autonomy, dynamism
- Good oral and written level in English

Key words: Medical physics, Medical imaging, Dose painting, MRI Radiotherapy planning, Quantitative multi-parametric MRI, Head and Neck cancer

References:

[1] Hansen CR, Friborg J, Jensen K et al. NTCP model validation method for DAHANCA patient selection of protons versus photons in head and neck cancer radiotherapy. Acta Oncol. 2019 Oct;58(10):1410-1415. doi: 10.1080/0284186X.2019.1654129. Epub 2019 Aug 21.

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[3] Demol B, Viard R, Reynaert N. Monte Carlo calculation based on hydrogen composition of the tissue for MV photon radiotherapy. J Appl Clin Med Phys. 2015 Sep 8;16(5):117–130. doi: 10.1120/jacmp.v16i5.5586.

[4] Gouel P, Callonnec F, Obongo-Anga FR et al. Quantitative MRI to Characterize Hypoxic Tumors in Comparison to FMISO PET/CT for Radiotherapy in Oropharynx Cancers. Cancers (Basel). 2023 Mar 22;15(6):1918. doi: 10.3390/cancers15061918.

[5] Skjøtskift T, Evensen ME, Furre T et al. Dose painting for re-irradiation of head and neck cancer. Acta Oncol. 2018 Dec;57(12):1693-1699. doi: 10.1080/0284186X.2018.1512753. Epub 2018 Oct 3.

[6] Grönlund E, Almhagen E, Johansson S et al. Robust maximization of tumor control probability for radicality constrained radiotherapy dose painting by numbers of head and neck cancer. Phys Imaging Radiat Oncol. 2019 Dec 9;12:56-62. doi: 10.1016/j.phro.2019.11.004. eCollection 2019 Oct.

[7] Håkansson K, Smulders B, Specht L et al. Radiation dose-painting with protons vs. photons for head-and-neck cancer. Acta Oncol. 2020 May;59(5):525-533. doi: 10.1080/0284186X.2020.1714720. Epub 2020 Jan 21.

Applications:

Applications, with a detailed CV including publications list, and a personal letter highlighting the adequacy of the candidate's background and skills in relation to the proposed subject, should be sent to : olivier.beuf@creatis.insa-lyon.fr, MarieClaude.BISTON@lyon.unicancer.fr, vincent.gregoire@lyon.unicancer.fr et benjamin.leporq@creatis.insa-lyon.fr.