ICR The Institute of Cancer Research

PhD Project Proposal

Funder details

Studentship funded by: Biomedical Research Centre (BRC)

Project details

Project title: Development of automatic plan-of-the-day selection tools for radiation therapy of pelvic cancer

Supervisory team

Primary Supervisor: Professor Helen McNair

Associate Supervisor(s): Dr Shaista Hafeez and Dr Sarah Blackledge

Secondary Supervisor: Dr Emma Harris

Divisional affiliation

Primary Division: Radiotherapy and Imaging

Primary Team: Translational Therapeutic Radiography

Site: Sutton

Project background

Radiation is a common treatment for patients with pelvic cancers, such as bladder cancer and cervical cancer, that cannot receive surgery. Daily variation in bladder and rectal filling results in changes in size and position of the target tissues. Consequently, large radiotherapy fields must be employed, which impart high doses to surrounding normal tissues and increase the probability of side effects. Adaptive radiotherapy reduces dose to surrounding tissues whilst maintaining the dose to the target, thereby, reducing radiation related toxicities.

One adaptive strategy is 'online re-planning', where a new treatment plan is generated each day. However, this is only available on specialized systems (e.g., integrated magnetic resonance linac). Plan-of-the-day (POTD) selection (McDonald, 2013) is another adaptive strategy available on all standard treatment machines and involves (1) generating a library of plans in advance to account for anticipated anatomical variations (i.e., different bladder sizes) and (2) selecting the plan that best conforms to the patient's anatomy at the time of treatment as visualized on daily cone-beam CT (CBCT) imaging. Unfortunately, POTD selection is not widely implemented because it is **resource intensive**, **challenging** and **time-consuming.** The requirement of two specially trained radiographers to agree on the optimal plan is a significant resource issue because often one must be called from another treatment unit interrupting the patient workflow there. Furthermore, poor CBCT soft-tissue contrast makes it difficult to identify the target quickly and accurately, which causes errors not only in optimal plan selection, but also introduces motion-related errors associated with the increased time the patient is on the treatment couch. These factors not only decrease the efficacy of this adaptive strategy, but prevent its wide adoption, with not all centres employing adaptive radiotherapy for bladder cancer.

We will develop deep-learning based solutions that **fully automate POTD selection**. This will facilitate the **universal adoption of POTD selection** for pelvic cancers, thereby **increasing treatment efficacy** by ensuring target coverage and **reducing the likelihood and severity of radiation toxicities for patients treated at every centre.**

Project aims

- Develop a deep-learning (DL) based tool to automatically select the optimal plan from a pre-defined library of 3-4 plans (current clinical standard) quickly and accurately for bladder cancer patients. Once its utility in bladder cancer has been established, we also aim to train this tool for use in cervical cancer.

- Establish the dosimetric differences between (a) the plan chosen manually by radiographers at the time of treatment, (b) the optimal plan established off-line as part of a central review procedure, and (c) the plan chosen automatically using the tool developed in this project.

- Test the performance of the DL-based POTD selection tool developed in this project (trained on data from the HYBRID trial for bladder cancer patients and the GENIUS II study for cervical cancer patients) on prospectively acquired data for bladder and cervical cancer patients treated at the Royal Marsden Hospital (RMH).

- Expand the use of POTD selection tool to other modalities: Apply transfer learning techniques to facilitate automatic POTD selection on CT images acquired from the RadExact tomotherapy system at the RMH.

- Expand the use of POTD selection tool to specialised on-line replanning systems such as the MRL or Ethos system to determine if adaptation is necessary, or whether a pre-existing plan is suitable. This will involve the creation of a novel hybrid workflow whereby any plans generated on-line can be considered for use in subsequent fractions.
    - Build sufficient flexibility into the AI tool to select the best plan given a potentially dynamic library.
    - Establish the dosimetric differences between online replanning vs. optimal POD selection.

Research proposal

It is well established that POTD selection offers significant dosimetric benefit to patients compared with non-adaptive strategies (McDonald, 2013, Huddart 2021). However, previous studies have shown that observers fail to select the most optimal plan in 40% and 22% of cases for cervix and bladder cancers respectively (Gobeli et al 2018, Webster 2022). In the case of cervix cancer, several groups have developed POTD selection tools to aid observers in optimal plan selection (Langerak 2014, Zhang 2022). Although promising, these attempts aren't clinically appropriate either because of the amount of user intervention/interaction required, segmentation errors in cases of low CBCT image quality, and/or because of the failure to consider dose imparted to the organs at risk (OARs) when defining the optimal plan. There have been no attempts for automatic POTD selection for bladder cancer.

The relationship between patient anatomy, variable image quality, delivered dose, and optimal clinical goals is incredibly complex, yet must be considered simultaneously when selecting the most optimal plan. Rather than oversimplifying this to a segmentation problem, we propose a novel automatic POTD selection approach based on Deep-learning (DL) feature extraction.

For the sake of protecting intellectual property, we have decided to keep the specific details of the proposed DL pipeline out of the public domain. Further details will be available upon selection for interview

This project directly addresses an urgent clinical need, and provides an exciting opportunity to embark on the development of novel medical technology within the fields of radiation therapy and artificial intelligence.

Literature references

Huddart, R., Hafeez, S., Lewis, R., et al. (2021). Clinical Outcomes of a Randomized Trial of Adaptive Plan-of-the-Day Treatment in Patients Receiving Ultra-hypofractionated Weekly Radiation Therapy for Bladder Cancer. *International Journal of Radiation Oncology Biology Physics*, *110*(2), 412–424. https://doi.org/10.1016/j.ijrobp.2020.11.068

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Sauter D, Lodde G, Nensa F, et al.(2023) Deep learning in computational dermatopathology of melanoma: A technical systematic literature review. *Comput Biol Med*. 163:107083. 10.1016/j.compbiomed.2023.107083

van de Schoot, A., Schooneveldt, G., Wognum, S.,et al . (2013), SU-C-WAB-05: Automatic Bladder Segmentation On CBCT for Plan Selection During Cervical ART. *Med. Phys*., 40: 90-91. https://doi.org/10.1118/1.4813957

Webster A, McNair HA, Hansen VN, et al (2022) . Recognising the challenges of implementing multi-centre adaptive plan of the day radiotherapy. *Tech Innov Patient Support Radiat Oncol*.21:31-35. https://doi:10.1016/j.tipsro.2022.01.002

Zhang C, Lafond C, Barateau A, et al (2022). Automatic segmentation for plan-of-the-day selection in CBCT-guided adaptive radiation therapy of cervical cancer. *Phys Med Biol*.;67(24):10.1088/1361-6560/aca5e5. doi:10.1088/1361-6560/aca5e5

Candidate profile

Note: the ICR's standard minimum entry requirement is a relevant undergraduate Honours degree (First or 2:1).

Pre-requisite qualifications of applicants: BSc or equivalent in: physics, medical physics, engineering, computer science, or related field.

The applicant must alos have experience in programming (python preferred). Experience with using deep learning libraries such as pytorch and keras would be advantageous, but not required. Candidates must have a basic knowledge of statistical analysis techniques and have good written/oral communication.

Intended learning outcomes:

- Role of radiotherapy in treating cancer patients, including treatment planning and delivery
- Clinical radiology and imaging physics
- How to build, train, and test deep-learning networks using clinical imaging data.
- Database management, data governance, and good clinical practice
- Statistical techniques for identifying significant differences between POTD selection techniques, reporting accuracy/confidence of AI models, etc.
- Programming skills associated with image processing, dicom handling, and database management

Advertising details

Project suitable for a student with a background in:

- [ ] Biological Sciences
- [x] Physics or Engineering
- [ ] Chemistry
- [ ] Maths, Statistics or Epidemiology
- [x] Computer Science