Amsterdam UMC
Universitair Medische Centra

Master internship: Synthetic CT validation in online adaptive radiotherapy for bone metastases and breast treatment.

Start date: August – December 2022 (as soon as possible)
Duration: 24-39 ECTS
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Institution: Amsterdam UMC, location VUmc, department of radiotherapy

Introduction

Radiotherapy is the treatment of cancer using ionizing radiation. The treatment is designed based on imaging data of the patient (CT, MR) to provide an optimal, tailored treatment which is subsequently delivered in multiple fractions. The patients anatomy, tumour site and nearby critical organs, all delineated on the original imaging data, are considered in this process. To ensure proper radiation of the whole tumour when the patient is positioned at the linac (which always slightly differ from the positioning on the planning CT-scan), margins are used which enlarge the treatment volume. This happens at the cost of radiating healthy tissue causing possible harmful side effects. In radiotherapy, one of the main challenges is to minimize these margins whilst maintaining an adequate treatment for the tumour. One recently implemented method is to adapt the treatment plan to the daily anatomy visible on the cone beam CT-scan (CBCT) made prior to every daily treatment, which allows for use of smaller margins.

Project description

At our department, CBCT-based Online Daily Adaptive Radiotherapy (oART) is being used to treat patients with different types of tumours: bone metastases (FAST-METS trial), breast, bladder, and rectum. Currently, other treatment sites are being investigated to determine the feasibility and added-value of an oART procedure. This project will focus on bony metastases and breast treatment sites.

The adaptive software of the Ethos platform works as follows: The algorithm co-registers the planning CT (pCT) to a daily Cone-beam CT (CBCT) using a B-spline deformation model and Mattes ‘mutual information as cost function. The generated vector fields are used to propagate the HU-value for each voxel of the pCT to the CBCT, thereby creating a synthetic CT (sCT) for use in dose calculations. 'Influencer structures' are defined for each anatomical target area, which are used in subsequent structure-guided deformable registration to propagate the targets to the CBCT. Influencers are automatically delineated on the CBCT by segmentation algorithms, before contours were reviewed and adapted (if required) by the radiation oncologist. The target are automatically propagated using a structure guided deformable image registration. Next, an adapted treatment plan is optimized for the daily anatomy on the sCT and consequently can be used to treat the patient immediately.

For the adaptive workflow to provide clinically acceptable treatment, it is important that the created sCT is a good representation of the patient anatomy. Deviations in density values or anatomical errors can lead to differences in dose distributions and could potentially cause problems (under-treatment of the targets or higher dose to important healthy tissue). Currently, we are investigating methods to validate this sCT in order to develop a quantitative method that gives insight into possible issues. This requires knowledge and research regarding: HU-units/densities of the CBCT, pCT and sCT; influence of changes on dose distributions; metrics to determine registration accuracy (Mean average error, Jacobian determinant, vector length); deformable image registration.

The goal is for the student to develop and investigate different evaluation metrics for sCT quality. This should be tested retrospectively for several clinically treated patients using the current sCT algorithm.

Your profile

- Master-student Biomedical Technology and Physics, Biomedical engineering or any other master related to physics/technology in healthcare
- Communicative and independent
- Interested in the application of physics in Radiotherapy
- Able to understand and distinguish relevant literature within the scope of this project

What we offer

During this project you will be supervised by, and collaborate with researchers, physicians and clinical physicists who are involved in two clinical research projects at our department (FAST-METS and Breast-ART). AUMC-radiation oncology, both at location AMC and VUmc, is one of the biggest Dutch institutions to irradiated patients with cancer. Main clinical foci of the AUMC-Radiotherapy is image-guided adaptive radiotherapy, MRI-guided brachytherapy and advanced treatment planning based on scripting technique and Artificial Intelligence.

Our department is equipped with the most modern equipment and state of the art treatments. These are results based on the employment of a multidisciplinary team with clinicians, technicians and (research) physicists. Development and research is present at several levels, i.e. technical, physical, and clinical. Cooperation with physicist of other departments, e.g. RNG, is well developed and pleasant. This leads to seamless implementation of research to benefit patient treatments. The scientific personnel includes ~15 PhD students and multiple postdocs, providing an inspiring academic working environment.

Additionally, we also offer students an insight into clinical practise of radiotherapy and research. Students are encouraged to participate in research meetings and discover the clinical environment.

Additional info:

Fast delivery of IMRT to metastatic disease without planning CT simulation:

https://www.estro.org/Abstract?a=89e56a58-c330-ec11-b6e6-0022489bbbc0

Ethos adaptive therapy, Varian

https://www.varian.com/products/adaptive-therapy/ethos

Interested? Please send your CV, motivation and/or questions to k.j.nelissen@amsterdamumc.nl