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MBChB MRCP FRCR MSc PhD

The algorithms will employ machine-learning techniques to enhance feature recognition and the delineation of healthy and diseased tissues. The algorithms developed could then be applied to next generation radiotherapy treatment systems in line with the programme of the Centre for the Clinical Application of Particles at Imperial. <Need a comment on Why Maxeler here.>

Variation of the tumour position from day to day (due to breathing, changes of the filling of hollow organs and peristaltic or more complex changes of the anatomy of patients) is a major challenge in radiotherapy delivery. If not corrected or compensated for, these variations cause imprecise delivery of the irradiation dose with increased doses to the normal tissue and decreased doses to the tumour.

Image-guided radiotherapy (IGRT) detects the tumour position immediately prior to treatment and allows for the adaptation of RT if the target position changes compared with the planned situation. This more precise delivery of radiation will decrease safety margins, reduce doses to normal tissue and decrease the risk of toxicity, and may allow a safe increase in the radiation dose to improve local tumour control and survival (improvement of the therapeutic ratio).

Kilovoltage cone-beam computed tomography (CBCT) is currently state-of-the-art technology for IGRT. The principles of CBCT-based IGRT are as follows: a flat-panel detector and a kilovolt radiation source are integrated into a linear accelerator. Via rotation of the linac gantry around the patient, multiple projection radiographs are acquired immediately before a RT fraction with acquisition times of 40 seconds to two minutes. The radiographs are reconstructed with a back-projection algorithm to a volumetric image. This CBCT verification image is registered to the reference planning CT data set, preferably by means of automatic image registration, for calculation of the target position relative to the planned reference position.

Changes of the target position exceeding a pre-defined threshold are then corrected online prior to the start of RT. The positioning error is determined in six degrees of freedom while the possibility for correction of rotational errors in addition to translations depends on the specific treatment table.1,2 Imaging, reconstruction and position correction requires about five minutes with the currently commercially available systems.3 This process adds additional “on-table” time to the treatment pathway, requires manual input for the acquisition of CBCT images and matching to the reference planning CT scan (currently a bony match). In addition, the quality of CBCT images are inferior to diagnostic images and interpretation of variations in soft tissue structures is problematic.

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The studentship would be undertaken in the radiotherapy department at Charing Cross Hospital (Imperial) with access to offline cone beam CT verification images taken during a treatment course. The student would be supported by the Imperial departments of physics, bioinformatics, and imaging. The student would be supervised by a Clinical Oncologist, medical physicist, and the Departments of Bioinformatics and Physics. The industry partner would provide support for data processing and improvement of image quality.

Key objectives would be:

* To reduce treatment delivery time that is prolonged with on-board imaging by improving image acquisition and processing time – this would reduce uncertainties in patient position and organ motion that is more pronounced with longer treatment times
* To automate image processing from on-board imaging and develop machine learning algorithms to reduce image acquisition time and reduce patient time on the treatment couch (?industry partner can help with this)
* To improve the quality of ‘on-line’ imaging (by reducing artifact and noise) to allow use of these images for (i) better soft-tissue matching to reference CT images) (ii) replanning as part of an adaptive radiotherapy programme that responds to changes in patient contour, position, etc ((?industry partner can help with this)
* To adapt the above algorithms developed during the PhD for next generation accelerator/detector systems

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1. Meyer J, Wilbert J, Baier K, et al., Positioning accuracy of conebeam computed tomography in combination with a HexaPOD robot treatment table, Int J Radiat Oncol Biol Phys, 2007;67(4):1220–8.

2. Wilbert J, Baier K, Richter A, et al., Influence of continuous table motion on patient breathing patterns, Int J Radiat Oncol Biol Phys, 2010;77(2):622–9.

3. Thilmann C, Nill S, Tucking T, Hoss A, et al., Correction of patient positioning errors based on in-line cone beam CTs: clinical implementation and first experiences, Radiat Oncol, 2006;1:16.

# Unused in 1.3

This project will generate publications and a thesis on the development of next generation on-treatment verification with CBCT with improved image verification in terms of reducing acquisition time and better image quality for radiotherapy delivery. This will reduce treatment cost be reducing the “on-table” time required for image acquisition and verification. This may improve the accuracy of treatment delivery by automating the matching process and the quality of CBCT images. Furthermore, CBCT images obtained with this new technology may allow for better soft-tissue matching rather than using bony matching as a surrogate.

The new technology developed from this project also has the potential to:

* Be developed for commercial use in collaboration with an industry partner
* Open further opportunities for proposals on that require an industrial partner or close collaboration with medical physicists or radiobiologists;
* Develop further studies looking at radiobiological effects of adaptive radiotherapy planning in collaboration with radiobiologists through the Centre’s and Imperial’s activities in the clinical application of particle accelerators
* Develop in parallel with the CCAP’s programme on the development of novel particle accelerator technology to provide the image verification that would be necessary for next generation particle accelerators