PhD Fellowship on Dual Energy CBCT Reconstruction for Dose Computation in Radiotherapy

Thesis Location: Laboratory of Medical Information Processing (LaTIM), French Institute of Health and Medical Research (INSERM UMR 1101), Brest, France

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Period: 3 years, starting on October 2018

Context and Objectives:

The CT planning scan is an integral part of a radiotherapy treatment, performed for all patients few days prior to treatment allowing an optimization of the treatment plan and associated therapy efficiency. During the radiotherapy sessions, a cone beam CT (CBCT) scan is most frequently performed to principally ensure optimum patient positioning but also to potentially allow for the detection of anatomical changes during treatment and/or for motion management issues. Different aspects hamper the efficient use of CBCT within this context, such as low image quality, motion artefacts, image noise. In addition, depending on the frequency of the acquired CBCT (given that radiotherapy treatments typically involve 30-50 fractions), the dose to the patient may become significant and as such there is an increasing interest in working with low dose CBCT acquisitions without an associated compromise in the overall resulting image quality. On the other hand, iterative image reconstruction algorithms may allow to more accurately model measurement noise characteristics as well as some of the physics principles of the overall detection process. Furthermore, it has been recently shown that CBCT used in a dual energy (DE) mode may help improving the accuracy of patient dosimetry computations [1-2].

The aim of this thesis is to propose new iterative reconstruction algorithms dedicated to DE-CBCT including methods for the incorporation of low statistics noise modeling. The first stage will be to adapt existing CT algorithms such as MLTR [3] or IMPACT [4] for CBCT considering a low statistics environment including the use of the dual energy mode. Real data from the CBCT of a VARIAN TrueBeam Novalis within the radiotherapy department in Brest will be explored, while validation studies using simulated data produced with the GGEMS [5] software will be also included in the study. Within the same context of improving overall quality of low dose CBCT images new methods for the correction of scattered events based on the use of neural networks, such as CNN, will be proposed. Finally, the potential of using the CT planning scan as a priori information in the reconstruction of the subsequent CBCT images will be explored. An implementation using hybrid computer architectures such as graphical processing units (GPUs) will be explored due to the associated long computational tasks. All developments are expected to be integrated within the publicly available multimodality tomographic reconstruction platform, CASToR [6].

Education: The candidate must hold a Master degree in Physics or Computer Science. Experience on neural network and/or tomographic reconstruction programming would be appreciated but is not required

Scientific Interests: Tomographic reconstruction, numerical simulation

Programming Skills : C/C++, OpenCL (or CUDA)

Languages: English, French optional

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References:

[1] Vaniqui A. et al. Radiation Oncology (2017) 12:181
[2] Men K. et al. Physica Medica 36 (2017) 110-118
[3] Van Slambrouck K. and Nuyts J. Medical physics, 39(11), 7080-7093.
[4] De Man B. et al IEEE Trans. Med. Imaging 14(1), 132–137 (1995)
[5] Bert J et al. Phys Med Biol (2013) 58:5593-5611
[6] http://www.castor-project.org