Master internship 2021 in Lyon, France

Simulated CBCT images for training Deep Learning based segmentation methods in Head and Neck radiation therapy

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This work is a collaboration between researchers from CREATIS lab and the radiation therapy department of the Léon Bérard cancer center (Lyon, France). Funded by the Labex PRIMES.

Medical context.
CBCT images (cone-beam computed tomography) are conventionally used to guide radiation therapy treatment. For head and neck patient, daily adaptation of the treatment plan may be beneficial but required to be able to accurately contours organs and target volumes on CBCT images. However, even if the quality of those images has increased in the past years, it remains a challenging task [1], [2].

Scientific context.
Several methods have been proposed to contour such CBCT images with very different approaches such atlas based, adaptive filters, registration with CT, etc. More recently, several deep learning methods was proposed with, in general, improved results compared to previous methods. However, building a training dataset composed of reliably contoured CBCT images is very difficult. Alternatively, some authors tried to "improve" CBCT images by transforming them into a pseudoCT images (pCT). This strategy allows to train the neural networks on contoured CT, the inference being performed on the pCT. Several strategies are currently under investigation, and it is not clear which ones are better [3]–[6].

Project.
In this project, we propose an alternative approach consisting in generating a training dataset of simulated CBCT (sCBCT) from contoured CT [7], [8]. Conventional UNet deep learning approach would then be trained on sCBCT and inference could be done on CBCT images, without the need of pCT.

Objectives of the master internship.
1. Perform bibliographic review on segmentation methods for head and neck CBCT images, and on simulation methods of CBCT images
2. Participate to the creation of a large database of cases (CT, CBCT, contours, head and neck)
3. Investigate the current Monte Carlo (GATE) method to simulate CBCT
4. Investigate the current (nnUnet) method to segment images

Environment. The student will work in a multidisciplinary team composed of medical physicists, researchers and computer scientists of CREATIS laboratory and Leon-Bérard Cancer Center.

Expected skills and other information

- Expected skills: AI, medical physics, computer sciences, image processing
- Technical skills: Python, Gate
- English and French
- Expected start: early 2022
- Location: Lyon, Léon Bérard Cancer Center, France
- Send CV to: david.sarrut@creatis.insa-lyon.fr and MarieClaude.BISTON@lyon.unicancer.fr

[1] T. Taniguchi *et al.*, "Effect of computed tomography value error on dose calculation in adaptive radiotherapy with Elekta X-ray volume imaging cone beam computed tomography," *J. Appl. Clin. Med. Phys.*, vol. 22, no. 9, pp. 271–279, Sep. 2021, doi: 10.1002/acm2.13384.

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[3] S. W. Yoon *et al.*, "Initial Evaluation of a Novel Cone-Beam CT-Based Semi-Automated Online Adaptive Radiotherapy System for Head and Neck Cancer Treatment - A Timing and Automation Quality Study," *Cureus*, vol. 12, no. 8, p. e9660, Aug. 2020, doi: 10.7759/cureus.9660.

[4] M. Eckl *et al.*, "Evaluation of a cycle-generative adversarial network-based cone-beam CT to synthetic CT conversion algorithm for adaptive radiation therapy," *Phys. Medica PM Int. J. Devoted Appl. Phys. Med. Biol. Off. J. Ital. Assoc. Biomed. Phys. AIFB*, vol. 80, pp. 308–316, Dec. 2020, doi: 10.1016/j.ejmp.2020.11.007.

[5] X. Dai *et al.*, "Head-and-neck organs-at-risk auto-delineation using dual pyramid networks for CBCT-guided adaptive radiotherapy," *Phys. Med. Biol.*, vol. 66, no. 4, p. 045021, Feb. 2021, doi: 10.1088/1361-6560/abd953.

[6] W. Chen *et al.*, "Clinical Enhancement in AI-Based Post-processed Fast-Scan Low-Dose CBCT for Head and Neck Adaptive Radiotherapy," *Front. Artif. Intell.*, vol. 3, p. 614384, 2020, doi: 10.3389/frai.2020.614384.

[7] S. Jan *et al.*, "GATE V6: a major enhancement of the GATE simulation platform enabling modelling of CT and radiotherapy.," *Phys Med Biol*, vol. 56, no. 4, pp. 881–901, Feb. 2011, doi: 10.1088/0031-9155/56/4/001.

[8] D. Sarrut *et al.*, "A review of the use and potential of the GATE Monte Carlo simulation code for radiation therapy and dosimetry applications," *Med. Phys.*, vol. 41, no. 6Part1, p. 064301, Jun. 2014, doi: 10.1118/1.4871617.