Factsheet for the Press (Physics)

ENHANCED 4D PET OPTIMIZATION BASED ON 4D CT MOTION MODELING

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Context: The image intensity in PET expresses the metabolic activity of tissues that in general correlates with tumour staging. The CT-PET hybrid scan permits to integrate in the radiotherapy treatment planning the PET functional imaging to the CT anatomical imaging, thus leading to a “correct” lesion delineation. The image quality in PET depends directly on the concentration of radioactive tracer in the patient and on the duration of the acquisition and is very sensitive to movements of the anatomical structures being imaged. Particularly, the issue of breathing motion during PET imaging generates considerable image quality loss due to blurring leading to uncertainties in determining size, localization and intensity of a moving lesion. Time resolved PET imaging (4D PET) is used to face this problem by generating PET volumes synchronised with patient’s respiration. The 4D PET acquisition modality generates a set of PET images representing the breathing cycle, where a PET image for each breathing phase is visualized. However, the advantages obtained in image quality are paid back by higher dose of radioactive tracer given to the patient and by considerably longer time and higher workload for 4D imaging acquisition and processing.

The context of the study is the 4D PET imaging optimization, in order to reduce the influence of motion on image quality by contemporary minimizing risks for patient and operators and computational efforts.

Purpose: The purpose of the study is to evaluate the performance of a novel strategy aiming at the optimization of 4D PET image quality in the hybrid scan CT-PET. The novel strategy permits to reduce the concentration of radioactive tracer delivered to the patient and the acquisition and data processing time of time resolved PET imaging, thus reaching values that are comparable to conventional static PET acquisition. The concept resides in using the time resolved information already obtained during the CT imaging stage. The proposed strategy reduces risks for the patients and implies lower workload for the operators, thus resulting in improved patient throughput.

Findings: Compared to state-of-the-art strategies for motion compensation in PET imaging, our approach has advantages. First, it does not require the adoption of specific technology and equipment aiming at breathing motion detection for synchronisation with PET imaging. By using the breathing phase information already measured during the 4D CT stage, we are able to:

- preserve 4D PET image quality while reducing the concentration of radioactive tracer to be delivered to the patient
- shorten the total acquisition time
- limit the influence of the uncertainties of time resolved imaging mainly related to irregular

breathing patterns

- reduce the workload for PET image acquisition and processing in 4D

Impact: The optimization strategy permits to obtain a set of time resolved PET images, representative of the radioactive tracer distribution during the breathing cycle, featuring enhanced image quality and obtained with lower risk for the patients and efforts for the operators. The resulting potentially increased patient throughput is expected to ease the systematic application of 4D PET imaging in lung cancer staging and in in-vivo dosimetric evaluation in particle therapy.

Indicative of a bigger trend in oncology? The oncological trends this research fits in is related to the always more important role played by anatomical and functional imaging for treatment planning and outcome evaluation in cancer patients. The research provides a contribution towards the optimisation of PET image quality obtained from moving anatomic and pathological structures, thus finding potential application for radiotherapy treatment planning and post-therapy staging in lung and liver cancer, which are particularly influenced by respiratory motion. Ultimately, the combination of optimised time resolved CT and PET imaging is put forward to represent a strategic technology for always more targeted therapy ensuring the highest therapeutic benefits for patients.

> *"The approach was tested on a digital 4D NCAT phantom and the results were promising."*
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> Prof Tinsu Pan, M.D. Anderson Cancer Center, The University of Texas, USA

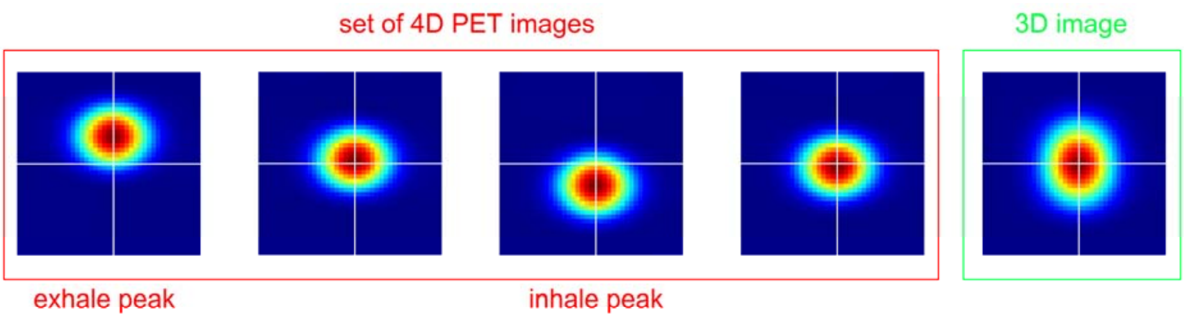

Figure 1. Simulation of a set of 4D PET images and the corresponding 3D image: the tumour motion representation on the 4D PET images and the blurring effects on the 3D image.

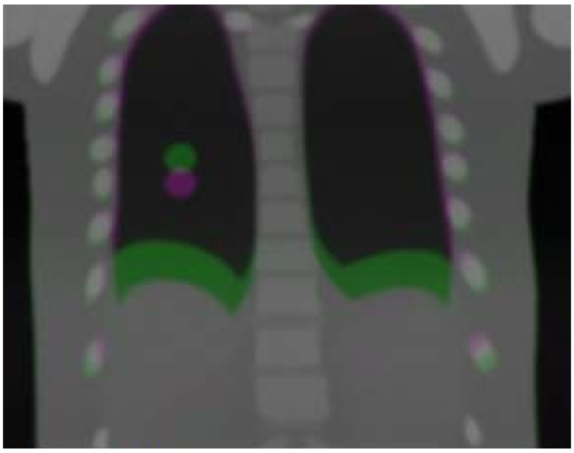

Figure 2. 4D CT simulation: tumour range of motion due to breathing (exhale and inhale peaks).