Abstract GDR MI2B/SFPM

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Multimodalities imaging PET/CT-MR for radiotherapy: study of positioning uncertainties

Purpose/Objective:
CT scan is considered as the reference imaging for radiotherapy treatment planning, giving high spatial resolution electronic density information need for dosimetry calculation without being affected by geometric distortions. Nevertheless, other images modalities, like PET or MR, may be useful for physicians to better discriminate soft tissues or to assess the possible local spread of a disease. Thus, tri-modality imaging for radiotherapy might be a powerful tool for determining precisely the different volumes of interest. In order to correctly visualize these volumes on all acquisitions, a multi-modal registration is necessary. As the greatest precision is required in radiotherapy, keeping patient in the same position during the entire tri-modality workflow would be benefit. The purpose of this study is to evaluate intrinsic positioning uncertainties associated with a PET/CT – MR solution and to evaluate its performance in a clinical used with 20 head and neck patients positioned according to radiotherapy modalities.

Material/Methods:
The PET/CT – MR solution is the association of a PET/CT (Discovery 710 GE) and a MR Imager (Optima MR450w GE) coupled with transfer table, Zephyr XL DIACOR, allowing patient transfer from one imager to the other by keeping the same positioning. The multi-modal registration is performed by means of the Integrated Registration software implemented on AW Server 3.2 (GE).
In the first way, the accuracy of the registration software and the transfer technique were evaluated. To evaluate the precision of the registration algorithm a digital phantom was used. Known rotations (0.2° to 5°) and translations (2mm to 22mm) were introduced and the corresponding modified images were registered with the non-transformed image.
Uncertainties in transfer table procedure from PET/CT to MRI, were estimated using ALARA's phantom. Images were acquired using the both acquisitions techniques. The rigid registration between CT and MR scans gives the rigid transformation matrix relative to positioning uncertainties. The operation was performed 10 times.
Finally, the evaluation of positioning uncertainties was performed on a cohort of 20 head and neck patients. Patients were transferred from one modality to another without getting up thanks to the use of the Zephyr XL transfer table. For each patient, multi-modal images were registered and the rigid transformation matrix was determined giving positioning uncertainties.

Results:
The evaluation of the registration algorithm results in maximum relative error of 12.8% for translation. The other relative errors obtained are between -1.7% and 5.4%. For rotation, the relative errors are between -14.6% and 33.2% when the rotation is inferior to 1.6° and between -4.1% and 5% for other rotations.
In a second part studying position of a physical phantom, uncertainties for translations of 3.7mm,

0.19mm and 4.3mm was obtained respectively for the left-right(L-R), antero-posterior(A-P) and superior-inferior(S-I). In the case of rotations, the uncertainties obtained were: 0.41° for the roll, 0.22° for the pitch and 0.58° the yaw. Details statistical results are presented in the Figure 1 &2 for translations and rotations.

Finally, for the study on patient, we obtained the highest uncertainty of 10.5mm in A-P direction. 9.8mm and 5.7mm were the uncertainties in translation for the S-I and L-R directions. In the case of rotations, all values obtained were inferior to 1°. Figures 3&4 present statistical results for the patient study.

Conclusion:

This study allowed us to show that uncertainties of patient positioning are ultimately affected by a set of factors affecting the overall workflow: the accuracy of the registration algorithm, the patient's movements, a different isocenter between the two devices. In order to complete this study, it would now be necessary to evaluate the registration carried out using anatomical landmarks defined by different specialists on each of the images.

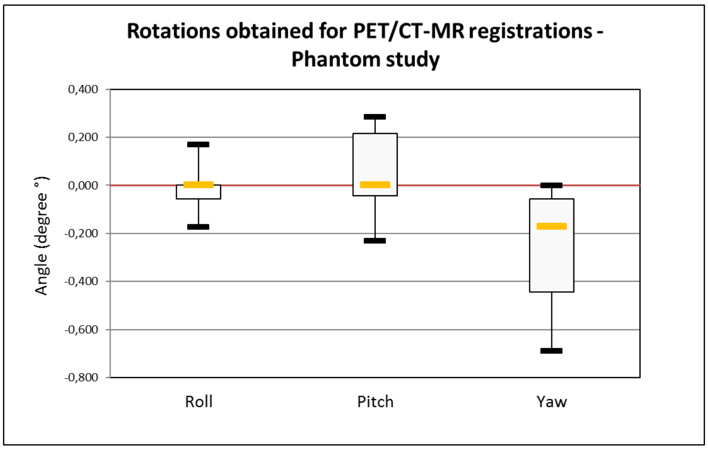

Figure 1: Box plots of the rotations obtained after CT-MR registration for the 10 tests on phantom – (the yellow bar indicates the value of the median)

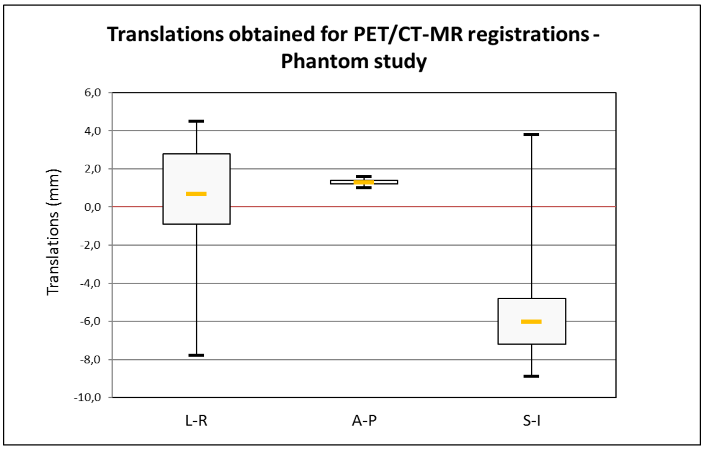

Figure 2: Box plots of the translations obtained after CT-MR registration for the 10 tests on phantom – (the yellow bar indicates the value of the median)

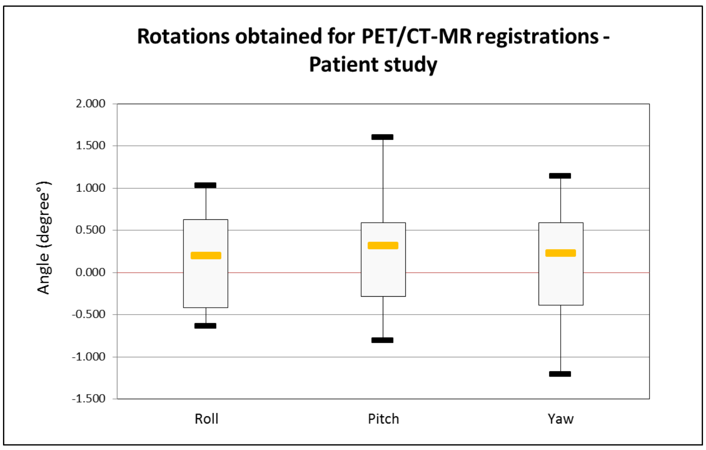

Figure 3: Box plots of the rotations obtained after CT-MR registration for the cohort of 20 patients – (the yellow bar indicates the value of the median)

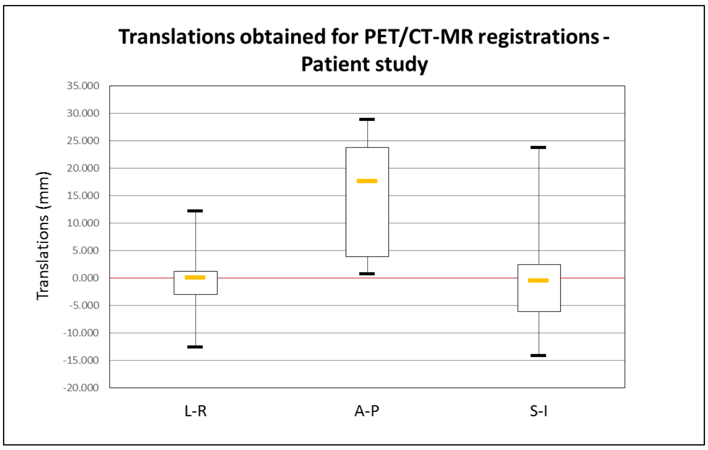

Figure 4: Box plots of the translations obtained after CT-MR registration for the cohort of 20 patients – (the yellow bar indicates the value of the median)