PHOTON ATTENUATION CORRECTION IN WHOLE-BODY PET/MRI USING TISSUE CLASSIFICATION

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ABSTRACT

A challenge for hybrid PET/MRI imaging is the determination of the photon attenuation map to correct the acquired PET data. Segmentation of adapted MRI sequence data in four tissue classes (background, lungs, fat, and soft tissue) is proposed and evaluated using data from 35 PET/CT whole-body oncological examinations as well as two PET/CT and MRI examinations from the same patients. When reconstructing with the segmented attenuation map, small differences in tumor uptake were observed mainly for osseous lesions, but did not change the clinical interpretation in any case. The method appears to be viable for clinical use.

Index Terms— Positron Emission Tomography, Magnetic Resonance, Attenuation Correction

1. INTRODUCTION

PET/MRI hybrid scanners can provide significant advantages for imaging many pathological conditions [1]. However, a chief technical challenge for its diagnostic accuracy is the determination of attenuation maps which can be used to correct the attenuation suffered by 511 keV photons in PET. For a broad commercial use, it is necessary to have methods which are robust, accurate and economically viable.

Based on the experience from standalone PET scanners and PET/CT scanners, it was hypothesized that tissue segmentation based on acquired MRI data could provide a suitable solution, without the need of additional hardware.

2. METHODS

CT data from 35 oncological PET/CT examinations acquired without iodinated CT contrast media were segmented into 4 classes: background, lungs, fat, and soft tissue, with the cortical bone being included in the soft tissue class. A segmented attenuation map was created by assigning an attenuation factor of 0 cm^{-1} to background, 0.018 cm^{-1} to the lungs, 0.086 cm^{-1} to adipose tissue and 0.1 cm^{-1} to soft tissue.

The tumor uptake in the PET images reconstructed using the segmented and the original CT data was compared, and both reconstructions were interpreted by a physician blinded to the way the attenuation correction had been performed.

Moreover, MRI sequences which could allow the proposed segmentation were investigated. PET/CT and MRI data from 2 patients were non-rigidly registered with the algorithm reported in [2] and the MRI data used to perform attenuation correction of the PET data.

3. RESULTS

Segmentation of the attenuation map in PET/CT data had a variable effect depending on the location of the tumor. For tumors located in the neck and lung, the average uptake change was below 4%. In osseous tumors, the segmented attenuation map resulted in an average decrease of the observed uptake by 8%. The maximum observed difference in uptake was 13% for a lesion in the pelvic bone. There were no differences in the clinical interpretations for all of the patients between both reconstructions.

Regarding the combined PET/CT and MRI acquisitions, a two-point Dixon MRI sequence was found to be adequate as input for the segmentation. The Dixon data provide the separation between fat and water, whereas air and lung could be identified by analyzing the local intensity. The two patients undergoing both PET/CT and MRI examinations had mediastinal and bihilar lymph node metastases, which showed uptake changes below 5% by using the MRI-based attenuation map as compared to the CT-based attenuation map.

4. DISCUSSION

MRI-based tissue classification appears as a viable way of determining the attenuation map in combined PET/MRI scanners. The largest errors of such a segmented attenuation map appeared for osseous lesions, due to the absence of a bone class in the proposed approach. Bones were excluded because of their very low and unspecific MR signal in most sequences, which could lead to an error-prone segmentation. The absence of bones in the model makes MRI-based attenuation correction can be compared to radionuclide

based attenuation, which also showed less uptake for osseous lesions as compared to CT-based attenuation correction [3].

The differences in the reconstructed PET images resulting from the tissue classification were small. For comparison, the effects of using CT contrast media have been reported to be higher [4], as well as the reproducibility from FDG oncological PET acquisitions [5]. Moreover, the reported differences should be constant throughout several examinations, making the method suitable for follow-up examinations where even small changes could be of clinical relevance.

This work did not address related problems for MRI-based attenuation correction such as limited field of view in MRI [6] or geometric distortions. These issues are still to be solved for a broad clinical use of this approach.

5. CONCLUSIONS

MRI-based tissue classification has potential for attenuation correction of PET data. Small differences in tumor uptake were observed when using MRI-based attenuation correction as compared to CT-based attenuation correction mainly for osseous lesions, but did not change the clinical interpretation in any case.

6. REFERENCES

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