Report for exchange at the Frédéric Joliot Hospital (SHFJ) at CEA, Orsay, France
PET-MR data acquisition and management

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January 12, 2017

Summary

The purpose of the exchange was to become familiar with the data acquisition process with the GE PET-MR system and with the use of the respiratory tracking device currently utilized in the centre (that is a pressure belt), and to acquire patient data with MR sequences that could allow the detection of an MR navigator (as representative of the internal respiratory motion of the organs). Moreover, data acquired with the GE PET-MR scanner were meant to be used as test datasets for the utilization of a feature of the STIR code, that allows the user to unlist the listmode files into sinograms (after the recent addition of the scanner to the library).

Activities

Internal meeting

I attended an internal meeting of the PET/MR research group. I presented my work on PET data-driven respiratory gating and explained the benefits that would come from the use of MR data, to obtain a signal that is representative of internal respiratory motion (with the MR navigator sequence).

Data collection

During the days spent at the SHFJ center, I was able to collect 6 patients datasets, inclusive of PET raw data (listmode files, uncompressed directly on the console), MR data, pressure belt respiratory signal and related trigger files. No MR navigator was acquired during these acquisitions, as they were performed following research protocols that were not tailored for our study. These datasets have been used to test the functioning of the `list_lm_events` and `lm_to_projdata` utilities of STIR on the GE Signa PET listmode files, as we have recently added the definition of the scanner and of its new data format (HDF5 files) to the software. Both utilities proved to be successful and I was able to generate sinograms.

Phantom acquisition

I took part in the acquisition of a phantom, made up of parallelepiped shaped objects filled with water, with no activity. As we are interested in respiratory motion, that is assumed to occur mostly in the cranio-caudal (axial) direction, we generated artificial motion with the "table rocking" feature provided by the scanner, that allows to choose the frequency and amplitude of the shift of the table, that will then move backwards and forwards periodically. The belt signal was set to be a simulated respiratory periodic trace.

The purpose of this acquisition was to set up the appropriate MR sequence required to get the MR navigator signal. As the Region of Interest (ROI) required to get the navigator signal, we selected an area that included moving edges of the phantom. We set up the acquisition in order to acquire the navigator signal in certain points of the motion cycle, while in the remaining part of the scan duration an FRFSE sequence was acquired. Visualizing the profile of the navigator, we realised that this set-up generated a motion signal that is not practically usable, as the gaps between its acquisition (when the FRFSE is on) are too big and the related motion would remain unknown. Therefore the result of this test was that, to be able to acquire a navigator signal that could be reliably considered as representative of the patient respiratory motion, the MR navigator needs to be acquired continuously throughout the period of interest. This can be achieved by adding extra minutes either at the beginning or at the end of the series of MR sequences that are acquired for clinical purposes. The set-up of such a protocol needs to be finalised.

Volunteer acquisition

Additionally, a volunteer was acquired, with no PET activity, with a similar protocol as with the phantom. In this case, the belt signal was generated by the true respiratory motion of the volunteer. The ROI for the navigator was selected to be able to include the edge between the liver and the lungs. As with the phantom acquisition, the navigator signal was interrupted by the acquisition of the FRFSE sequences.

Data-driven respiratory signal extraction

The sinograms obtained by the unlisted PET data were utilised to obtain a data-driven respiratory signal, with the use of Principal Component Analysis [1]. Our method successfully generated good respiratory signals.

Results

The main results of the exchange have been:

- collection of patient data (PET, MR and pressure belt), that will be useful for future analysis as well;
- successful utilisation of STIR listmode utilities with GE Signa PET listmode files;
- phantom and volunteer acquisitions;
- attempt to include the MR navigator sequence within a normal protocol, the results showed it needs to be acquired on its own with the addition of a few extra minutes of MR acquisition;
- successful visualization of the acquired MR navigator signals (although the signals were not optimal for the above mentioned reasons);
- regarding PET data-driven respiratory gating: successful generation of respiratory signals using Principal Component Analysis on the sinograms obtained with the STIR `lm_to_projdata`;
- attempt to synchronize the belt signal with the PET data-driven signal: some issues remain with regards to the automation of this process, due to the lack of temporal information stored in the belt signal and

due to the presence of time offsets between the two sets of data. Work is ongoing in order to fix this problem

References

1. Thielemans K, Rathore S, Engbrant F, Razifar P, *Device-less gating for PET/CT using PCA*, IEEE Nuclear Science Symp. and Medical Imaging Conf. Record, pp. 3904–3910, 2011