PhD Thesis Title: Anatomically Informed Image Reconstruction for Time of Flight Positron Emission Tomography

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Abstract:

Positron emission tomography (PET) has an important role in disease diagnosis, drug development and patient management. PET images are accompanied with computed tomography (CT) or magnetic resonance (MR) to provide the complementary structural information. GE SIGNA PET/MR is the state-of-the-art clinical scanner that aims at combining time of flight-PET (TOF-PET) with anatomical and soft-tissue MR imaging. This work aims at modelling the mathematical and physical processes of TOF-PET data for the GE SIGNA PET/MR within an open-source software, software for tomographic image reconstruction (STIR). This work further examines the developments made to implement the acquisition model using typical (ordered subsets expectation maximisation (OSEM)) and advanced iterative algorithms (TOF-OSEM and TOF-kernelised expectation maximisation (TOF-KEM)).

TOF-PET improves conventional PET imaging as it localises the event along the line of response (LOR) within a small region with an uncertainty, which is calculated using the timing resolution of the detectors. It demonstrates robustness despite the presence of small errors, inconsistencies, or patient motion in the acquired data. The GE SIGNA PET/MR have a timing resolution of 390 ps. The aim of this work is to exploit TOF-PET and further include the anatomical information from MR images to facilitate robust PET reconstructions.

All the developments made in this thesis were compared with the vendor's reconstruction software (GE-toolbox). Real phantom and clinical datasets were used for the analysis. The calculated emission and data corrections using developments made in STIR were in excellent agreement with the GE-toolbox despite the absence of dead-time and decay effects within the current developments. Reconstructions using OSEM and TOF-OSEM algorithms demonstrated a good agreement with the GE-toolbox concerning quantitative, resolution and structural based analysis. TOF-KEM reconstructions demonstrated a slight improvement in quantification as compared to TOF-OSEM with STIR.

The thesis demonstrates the first instance of real data reconstruction for TOF-PET data using TOF-OSEM and TOF-KEM algorithms. The developments made in this thesis provide a platform to investigate the effects of a

novel reconstruction algorithm, TOF-KEM on the dose and scan time reduction using real clinical datasets.

References to author publications included in the thesis:

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