

Castor image reconstruction results for a NEMA NU-4 PET phantom: GATE simulations

Davinder Siwal

Department of Physics, Central University of Kashmir, Main Campus, Tulumulla-191131, Ganderbal, Jammu and Kashmir

Email: dsiwal@cukashmir.ac.in

Positron Emission Tomography (PET) is a non-invasive technique to infer about spatial distribution of a localised radioisotope. Acting as spectators, high efficiency granular detectors can be arranged to capture the back-to-back emitted gamma-rays. Detected position vectors from the detector array are supplied to fast iterative algorithms for the image reconstruction. The objective of this research is to understand the fast iterative image reconstruction algorithms by means of open source software such as castor [1]. Castor is a highly customizable software based on C++ codes with a variety of imaging modalities such as; SPECT, PET, and X-ray CT options available for the image reconstruction. It has standard iterative reconstruction algorithms that can be utilized for the user implemented scanner geometry. In this connection, an animal PET scanner geometry is constructed in the GATE framework based on Lutetium–Yttrium Oxyorthosilicate (LYSO) crystal to simulated NEMA NU-4 phantom response [2]. A single PET module comprises of 24×24 LYSO bars having dimensions of $2 \text{ mm} \times 2 \text{ mm} \times 10 \text{ mm}$ which were experimentally coupled to 12×12 SiPM tile having 9 mm^2 as the pad area [2].

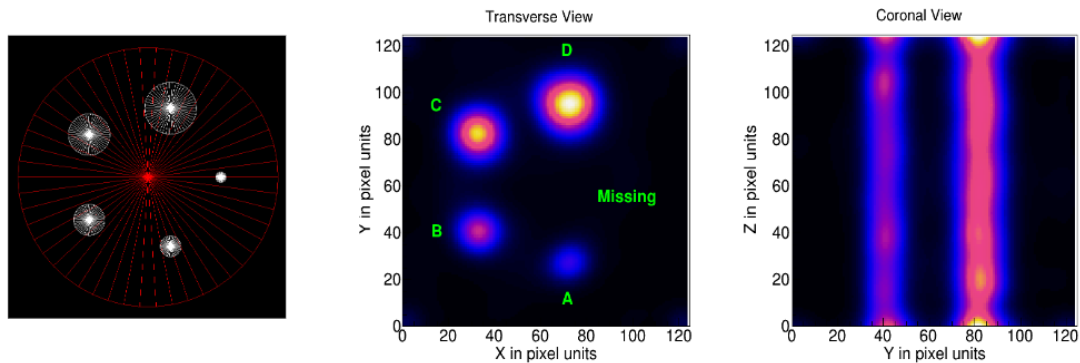


Figure : Left diagram shows the NEMA NU-4 phantom rods, middle represents the castor reconstructed image, and the right panel shows the phantom coronal view.

PET scanner is reconstructed in GATE by replicating 10 modules with 83 mm (50.3 mm) transaxial (axial) field of view. A phantom is generated with five cylinders of diameter 1 mm through 5 mm and 50 mm in length as shown in figure. They are filled with ^{19}F radioisotope with activity of $1.019 \text{ KBq}/\mu\text{L}$. Emitted photons were detected by the array within the energy (time) window of 250 keV to 650 keV (10 ns) [2]. The collected coincidence events were processed in castor software with MLEM algorithm and Gaussian colvolver of 2 mm (2 mm) transaxial (axial) resolution. Preliminary results of the reconstructed images are depicted in the figure. Obtained image resolution from A through D were

found to be ; 2.88 mm, 3.02 mm, 3.6 mm, 4.03 mm respectively. Notice that the 1 mm diameter image is missing as the minimum detection limit is governed by the crystal cross-section which is 2 mm x 2 mm, thus the image submerges into the background during the reconstruction procedure. The obtained results give confidence to implement MOBY computational phantom to further assess the castor performance.

References:

[1] T. Merlin *et al.*, CASToR: a generic data organization and processing code framework for multi-modal and multi-dimensional tomographic reconstruction”, **63 (18)** (2018) 185005

[2] M. Amirrashedi *et al.*, “NEMA NU4 2008 performance evaluation of Xtrim-PET: A prototype SiPM-based preclinical scanner”, Med. Phys. **46 (11)** (2019) 4816.

Author’s Comments : I would like to thank the organizers for the consideration of my abstract. I am aiming to develop a cheaper pre-clinical mammography instrument for the breast cancer detection within the Indian scenario and translate the efforts for the regular clinical usage. CASTOR is a highly flexible open software that can be utilized for the pre-clinical image resolution studies. The findings mentioned in the abstract is the first step to execute the vision.

Q.1 How the Castor image reconstruction procedure is better than filtered back projection and/or iterative reconstruction procedure(s)?

Author’s response : Castor uses the standard Maximum Likelihood Expectation Maximization (MLEM) or Ordered Subsets Expectation Maximization (OSEM) algorithms at the backend and both are based on the iterative reconstruction which compares the estimated projections with the measured data. Iterative algorithms provide better noise suppression, especially in low count rate situations as compared to filtered backprojection (FBP). Also, FBP is highly sensitive to the choice of filter kernel and suffers from streak artifacts. New advances in computing power with acceleration image processing techniques makes iterative reconstruction more feasible for clinical practice.

Q.2 Did you compare the similar data from the other modalities like SPECT, CT?

Author’s response : At present the PET geometry is reconstructed in OpenGATE software following the dimensions given in reference 2. I have compared the results with figure 7 of the same reference which is a near to match. I can’t compare the coincidence image resolution with SPECT camera because it is a single photon emission scanner whose resolution is governed by the collimator aperture size, whereas in PET it is decided by the crystal cross-section and time-of-flight window, thus the two have different mechanism of image broadening. It is also well established that CT image resolution is orders of magnitude better (lies in μm) than PET and SPECT (lies in mm) because of image segmentation mechanisms both on hardware and software level, thus the obtained image response can’t be compared.

Comment: Reference # 1 seems to be incomplete.

Author’s response : As concerned by the referees, the reference #1 is now corrected.