



ENABLING REAL-TIME RECONSTRUCTION FOR HIGH INTRINSIC RESOLUTION SPECT SYSTEMS

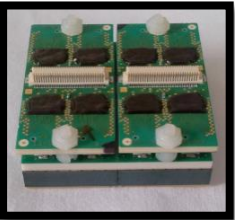
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CdZnTe Detectors



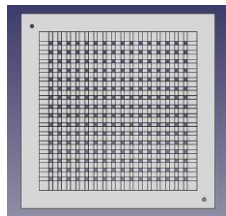
- Compactness
- Spatial Resolution : 0.3 mm
- Energetic resolution: 2.5 % at 140keV

High resolution Readout modules



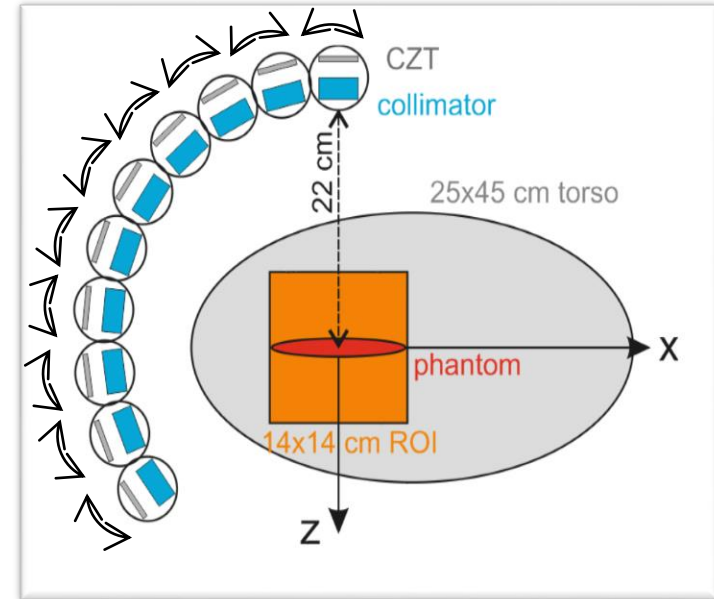
- 3D Positioning
- $128 \times 128 \times 8$ detecting voxels per module
- Four $40 \times 40 \times 5$ mm modules per head

Parallel holes collimator



- Height : 20 mm
- Collimator to detector distance : 15 mm
- Step : 2.5 mm
- Septa width : 1 mm

Adaptative System



Adaptation of head position during the examination

→ **Real-time Computing**

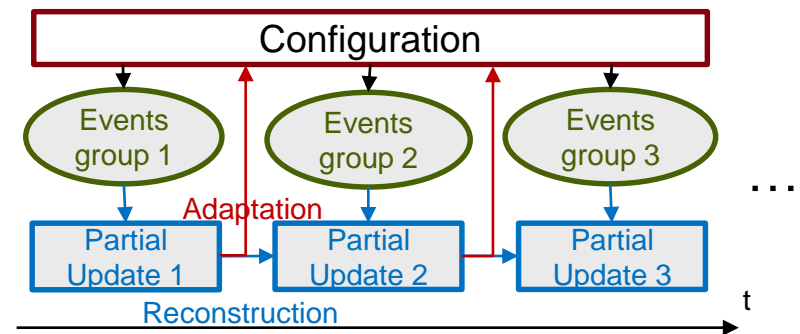
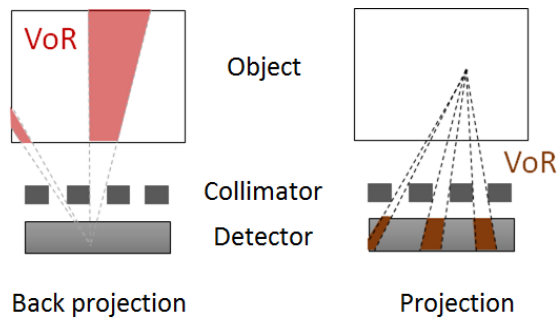
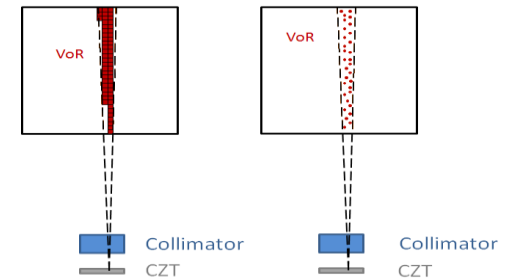
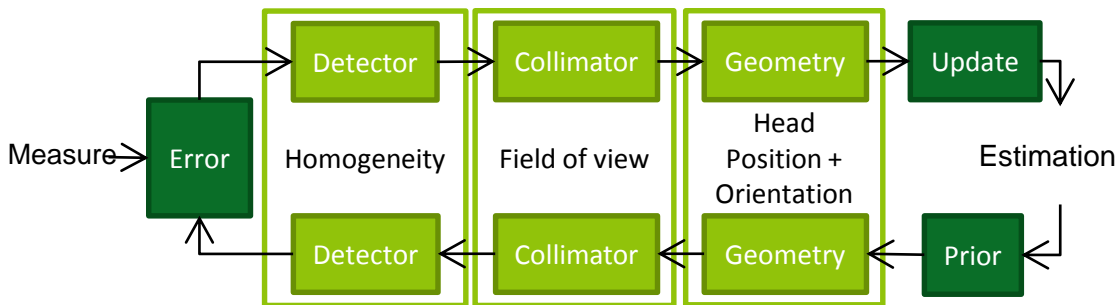
IMPLEMENTATION TECHNIQUES FOR MLEM RECONSTRUCTION

- Exact implementation techniques

- Decomposition of the model
- List-mode processing
- Ray-tracing

- Non-exact implementation techniques

- Monte-Carlo Back projections
- Partial updates



Parallel computing

- Poster session 1

ENABLING REAL-TIME RECONSTRUCTION FOR HIGH RESOLUTION SPECT SYSTEMS

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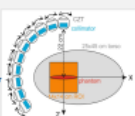
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I. Introduction

Adapting the field of view of the SPECT system to the emitting object during the acquisition can improve the trade-off between sensitivity and spatial resolution. A flexible nowadays configuration for cardiac imaging can empower such adaptations. However, adapting acquisition parameters during examination requires real-time computing to determine the area where to focus on using resulting estimations. Real-time computing on this complex flexible configuration requires implementation of acceleration techniques for MLEM algorithm.

II. Context

Compactness of CZT detectors enables flexible systems that can be adapted to patient morphology or examination kind. We worked on a cardiac system with 10 detecting heads based on high resolution readout modules. Modules can rotate on themselves according to 20 fixed angles.



Using such system, with high resolution detection modules, we face the complexity of the model to compute real-time reconstruction used to adapt geometrical configuration:

$$M = R \cdot O$$

Detection space (DSM) Model Object (64x64x64)

R is a huge matrix containing probabilities to get a measurement knowing a place of interaction. Computing and storing of this huge model is problematic.

CZT Detector	High resolution readout modules	Parallel holes collimator
<ul style="list-style-type: none"> Compactness Spatial Resolution: 0.3 mm Energetic resolution: 2.5 % at 140keV 	<ul style="list-style-type: none"> 3D Positioning 120 x 120 x 6 detecting heads per module Four 40 x 40 x 5 mm module per head 	<ul style="list-style-type: none"> Height: 20 mm Collimator to detector distance: 15 mm Step: 2.5 mm Slits width: 1 mm ROP: 150mm : 8mm Sensitivity: 2×10^{-4}

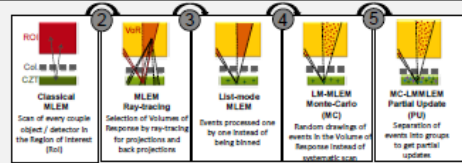
III. Algorithms

Some implementation techniques from MLEM algorithms are used without any change on the final result to enhance real-time computing:

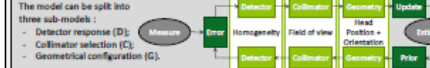
- 1: Classical MLEM
- 2: On-the-fly processing
- 3: List mode processing

Others adaptations enable trade-off between speed and reliability, and empower parallel computing:

- 4: Monte-Carlo drawings
- 5: Partial updates



1. Decomposition of the model



For all couples (detection bin/object bin) (m/a) :

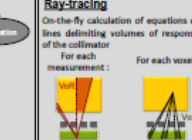
$$M_{m,a} = D_{m,m} \cdot C_{m,a} \cdot G_{a,m} \cdot O_a$$

Homogeneity correction for each detecting bin

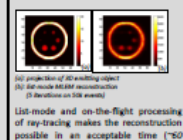
$$M_{m,a} = D'(m) \cdot C_{m,a}(x) \cdot O_a$$

Image of a by $G_{a,m}$ transformation

2. On-the-fly computing of Ray-tracing

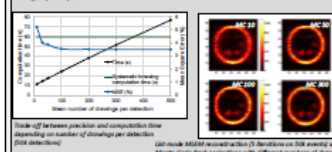


3. List-mode



4. Monte-Carlo

Back projection through collimator using enough Monte-Carlo drawings makes the computation faster than systematic scan without degrading image quality.

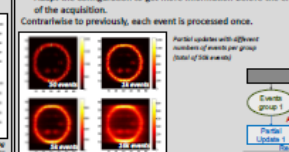


5. Partial Update

A partial update gives an intermediate estimation of emitting object in a few seconds. This partial update is used to:

- Get a priori for the next partial update.
- Adapt the configuration to get more information before the end of the acquisition.

Contrarily to previously, each event is processed once.



IV. Conclusion

- List processing.
- List-mode.
- On-the-fly processing.
- Parallel computing.
- Monte-Carlo back projections.
- Partial updates avoid making many iterations.
- Real-time adaptation.
- Adaptations on configuration from partial updates from 2.5k events every 0.8 seconds.

References

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 [3] G. Montémont, S. Liu, O. Monnet, S. Stanchina, and L. Verger, "Studying Spatial Resolution of CZT Detectors Using Sub-Pixel Positioning for SPECT," IEEE Transactions on Nuclear Science, vol. 61, no. 5, pp. 2566-2568, Oct. 2014.
 [4] H. M. Danek, T. White, and L. C. Park, "List-mode Backdoor," Opt Soc Am A Opt Image Sci Vis, vol. 14, no. 11, pp. 2814-2823, Nov. 1997.
 [5] H. M. Hudson and R. S. Leahy, "Accelerated image reconstruction using ordered subsets of projection data," IEEE Transactions on Medical Imaging, vol. 13, no. 4, pp. 801-809, Dec. 1994.