

An abstract background graphic consisting of a grid of small, semi-transparent gray dots arranged in a wavy, undulating pattern across the middle of the slide. Interspersed among these gray dots are several larger, solid-colored dots: a cluster of green dots on the left, a single red dot near the center, and a cluster of green dots on the right.

ENABLING REAL-TIME RECONSTRUCTION FOR HIGH INTRINSIC RESOLUTION SPECT SYSTEMS

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CONTEXT

CdZnTe Detectors



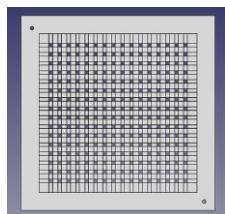
- Compactness
- Spatial Resolution : 0.3 mm
- Energetic resolution: 2.5 % at 140keV

High resolution Readout modules

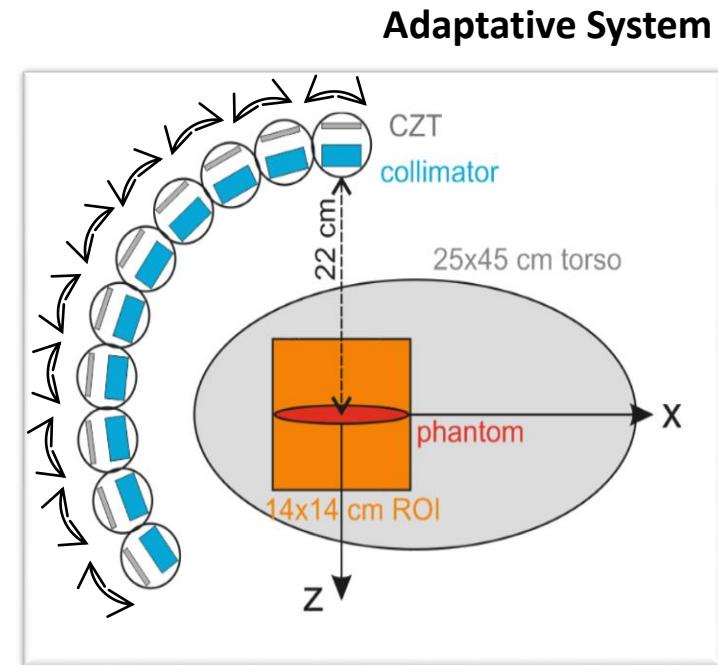


- 3D Positioning
- $128 \times 128 \times 8$ detecting voxels per module
- Four $40 \times 40 \times 5$ mm modules per head

Parallel holes collimator



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



Adaptation of head position
during the examination

→ Real-time Computing

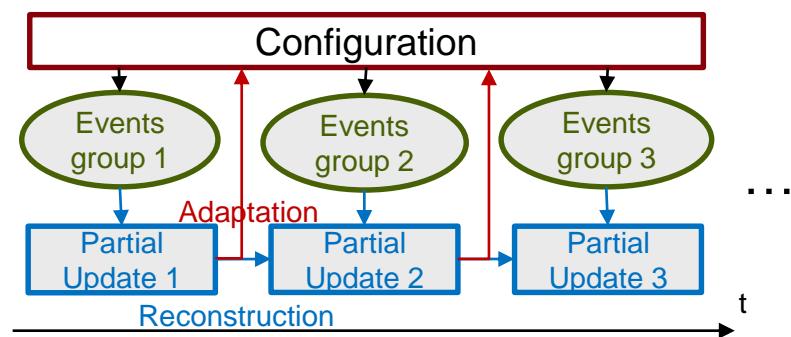
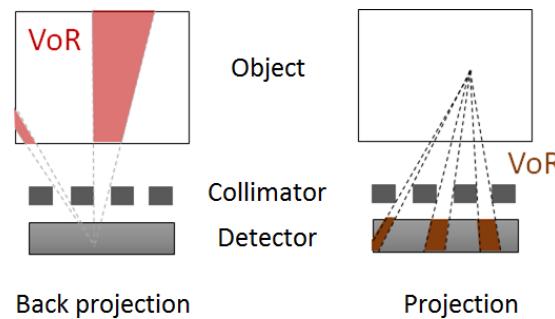
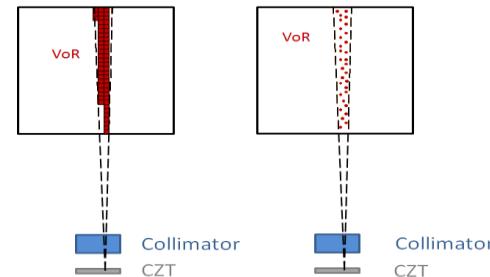
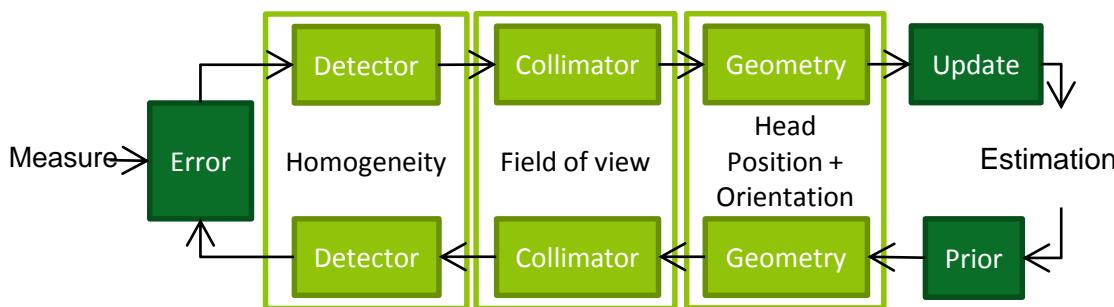
IMPLEMENTATION TECHNIQUES FOR MLEM RECONSTRUCTION

- Exact implementation techniques

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

- Non-exact implementation techniques

- Monte-Carlo Back projections
- Partial updates



Parallel computing

THANK YOU FOR YOUR ATTENTION



ENABLING REAL-TIME RECONSTRUCTION FOR HIGH RESOLUTION SPECT SYSTEMS

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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 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 work on a cardiac system with 10 detecting heads based on high resolution readout modules. Modules can rotate on themselves according to 20 fixed angles.

CdZnTe Detectors	High resolution Readout modules	Parallel holes collimator
- Compactness : - Spatial Resolution : 0.3 mm - Energy resolution : 2.5 % at 140keV	- 3D Positioning : 128x128x128 pixels per head - Resolution : 1mm x 1mm x 5mm - Modules per head : 20	- Height : 20 mm - Distance between detector and source : 15 mm - Step : 2.5 mm - Step width : 1 mm - RFOV : 150mm - Accuracy : 2 x 10°

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 :

$$M = \mathbb{R}^n \cdot O$$

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.

III. Algorithms

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

- 1: Decomposition of the model
- 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

The model can be split into three sub-models :

- Detector response (D):
- Collimator selection (C):
- Geometrical configuration (G):

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

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

Homogeneity correction for each detection bin

$$M_m = D(m) \cdot C_m \cdot G_m(a) \cdot O_a$$

Image of G_m transformation

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

On-the-fly calculation of equations of lines delimiting volumes of response of the collimator

For each measurement :

For each voxel :

(a) All projections of the emitting object
 (b) Full mode MLEM reconstruction
 (c) Reconstruction on 50k events

Ray-tracing makes the reconstruction possible in an acceptable time (~50 seconds).

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.

Plot showing the decrease in precision and computation time depending on the number of drawings per detection (bin selection)

Monte-Carlo reconstruction (50 iterations) using Monte-Carlo single slice and multi-slice algorithms

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 prior 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.

Partial update with different numbers of events per group (total of 10k events)

Reduction of accuracy depending of the size of the group of events

Configuration

Events group 1
 Events group 2
 Events group 3
 ...

Partial Update 1
 Adaptation
 Partial Update 2
 Partial Update 3
 ...

IV. Conclusion

- Fast processing :
- List-mode
- On-the-fly processing
- Parallel computing :
- Monte-Carlo computations
- 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. Montemont, S. Lus, O. Monier, S. Stanchina, and L. Verger, "Design and Evaluation of CZT Detectors Using Sub-10 nm Positioning for SPECT," IEEE Transactions on Nuclear Science, vol. 61, no. 5, pp. 2550-2556, Oct. 2014.
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Poster session 1