CASToR[1]: A Generic Data Organization and Processing Code Framework for Multi-Modal and Multi-Dimensional Tomographic Reconstruction

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Motivations for an unified tomographic image reconstruction platform

- Natural differences in the dataset acquisition / organization ...
  - ... lead to algorithms optimized for specific applications, with potential drawbacks:
    • Restricted use of methodologies however compatible with other sets of conditions
    • Difference in duplication of implementations
    • Possibly hardly tractable code development

- Additional drives for an unified platform:
  • Analogous components (projector, optimizer, ...) for PET/SPECT/CT tomographic reconstruction
  • Re-emergence of iterative reconstruction in CT[2]

General data file Description

- Generic Event structure for all type of data (modality/data mode)
- Reconstruction framework is Event-based
- PET/SPECT Event can be of “list-mode” type (i.e. single detected event) or histogram type (i.e. content of a histogram bin)
- Events must contain mandatory fields: timestamp, event value, geo localizer indices and optionally: TOF, scatter/random rate, norm factors, etc... (optional fields)

- System configuration file
  • Modality (PET / SPECT / CT)
  • Purpose (tracer dynamics, gated dataset)
  • Data format (list-mode/histogram)

Proposed solution

- Unified and generic data organization and processing code framework for multi-modal and multi-dimensional tomographic reconstruction.
- Analogous data organization for list-mode/histogram.
- Compromise between genericity and efficiency
- Focus on the modularity and extensibility of the platform

CASToR[3] Iterative framework

- Reconstruction parameters
  • Image dimensions
  • Number of iterations/subsets
  • Select reconstruction components
  • Components configuration parameters/variables

- PET/SPECT/CT datafile
  • Modality
  • Modality histogram/ist
  • Number of events
  • System name
  • Acquisition metadata
  • Enabled/Disabled corrections
  • Raw data

- Sensitivity (list-mode) / Blank scan (CT) generation

- Main loops of the iterative core algorithm
  • Geometry generation
    - Components Initialization
    - Sensitivity (list-mode) / Blank scan (CT) generation

- System geometry
  • PET / SPECT / CT Integrator
  • PET / SPECT / CT
  • PET / SPECT / CT

- Event
  • Sliced axial view
  • Sliced sagittal view
  • Sliced coronal view

- Projector
  • Sliced axial view
  • Sliced sagittal view
  • Sliced coronal view

- Optimizer
  • Spatial regularization
  • Image deformation
  • Dynamic Model
  • Generic classes

- Ex : Histogram reconstruction using different optimization algorithms

- Ex : List-mode 4D reconstruction without (left) and with (right) temporal regularization

Conclusions & Perspectives

- Proposed architecture handles histogram/list-mode multi-modal and multi-dimensional iterative reconstruction
- Simplified integration of new reconstruction features / methodologies, with limited duplication of implementations
- Good computing performances in its parallel execution (Unique call to the projector by event allowed a 1.5 to 2.75 increase speedup ratios on the test platform, as well as moderate cost of genericity)
- Proposed implementation will be soon available through an open-source software[1]

References