Image Reconstruction in Positron Emission Tomography

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Examples of clinical PET images

Advantages: high sensitivity to cancer
Problems: resolution, noise, attenuation, scatter, randoms
(Illustrated images lack proper treatment of those effects)
Whole-body PET study – Fully 3D reconstruction
PET data - classification of events

1) True event
2) Scatter event
3', 3'') Single events
3'+3'') Random event

==false coincidence lines
PET data - 2D vs. 3D scanner geometry

⇒ The larger the acceptance angle, the more (good and bad) events are accepted.
Fully 3D PET reconstruction flowchart

**Fully 3D data**
- Emision data

**3D image**
- Emission image

**4DAC, Scatter, Randoms,...**

**Forward-projection**

**Scatter, randoms estimation**

**Transmission data**

**Transmission reconstruction**

**Attenuation image**

**Fully 3D reconstruction**
Fast Fully 3D Reconstruction – WHY?

Modern emission tomography systems:

- Fast increase of **data sizes** (exceeding Moore’s law)
  → needed – reduction of computation demands of reconstruction

- Low counts per data bin – **noisy data**
  Data attenuation, scatter and contamination
  → needed – reconstruction techniques with better modeling

Conflicting demands
→ needed – **very fast reconstruction approaches**
Studied 3D PET reconstruction approaches

- 3D non-iterative analytical techniques (3DRP, 3D-FRP)
- 3D iterative techniques (3D RAMLA, ...)
- Rebinning (into non-oblique data) followed by multislice 2D or 2.5D iterative reconstruction
- List mode reconstruction
- Time-of-flight reconstruction
- Dynamic list mode reconstruction
Favorite tools

- **Fourier-based approaches**
  - Analytical reconstruction
  - Forward and back-projectors for attenuation correction and iterative reconstruction

- **Kaiser-Bessel window functions**
  - Image basis function
  - Interpolators
  - Display

- **Efficient grids**
  - Reconstruction
  - Display
Analytical 3D/2.5D reconstructions

3D-FRP

3DRP

FORE reconstruction
Allegro
Iterative approaches

2.5D recon

3D recon
**Fourier-based projection**

<table>
<thead>
<tr>
<th>Projection</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>No zeropadding</td>
<td>100% zeropadding</td>
</tr>
<tr>
<td>1% scale</td>
<td>0.5% scale</td>
</tr>
<tr>
<td>58 ms/view</td>
<td>96 ms/view</td>
</tr>
</tbody>
</table>
Fourier-based iterative reconstruction
The End