Dose Calculation on CBCT Datasets

Elekta System

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Elekta Synergy - XVI

Cone-Beam CT for IGRT

- Field of View (FOV)
  Sup-Inf: 12 and 26 cm
  Axial: 27 to 50 cm
- Selectable mAs and kV
- Scatter correction in software
- Single Bowtie Filter
- No scatter rejection grid

Tolerance on Electron Density

Limiting Relative Dose Error to 2%

Based on Effective Depth Inhomogeneity Correction

~5%  ~3%

Kiby et al. PMB, 47: p.1445-92, 2002
**Dose Calculation on CBCT Images**

**Key Requirements for Accurate Dose Calculation**

- Image Geometric Integrity
  - Scale
  - No distortion
  - Skin-line
- Reproducible CBCT numbers
- Accurate CBCT numbers

**Impact of Residual Artifacts**

**Result:** 99.8% within 2% dose diff. and 3 mm DTOA

**CBCT Image Artifacts**

**Three Categories:**

- **System**
  - Panel and tube calibration
  - Post reconstruction processing
- **Technique**
  - kVp, FOV, Panel Offset, Bowtie filter, Grid, Pre-reconstruction processing
- **Patient**
  - Size, prosthesis, intra-scan organ motion and truncation

**Inter-System CBCT# Variation**

CBCT # from 4 Systems: Same phantom and imaging technique
Inter-System CBCT# Variation

CBCT # from 6 Systems: Same phantom and imaging technique

Potential Solutions:
- CBCT-to-ED table per machine
- Flood field calibration
  - Adjust the amount of water to compensate for tube output variation
- Post-Processing algorithm
  - User-defined linear CBCT number conversion

All these solutions require periodical QA!!!!

Inter-Technique CBCT# Variation

Variation in FOV, kVp, mAs and filter

Change in kVp
(100 to 120 kVp)

About 500 HU variation
Inter-Technique CBCT# Variation

Variation in FOV, kVp, mAs and filter

Change in Sup-Inf FOV (12 to 25 cm):
About 70 HU variation

Ritcher et al., Radiation Oncology, 3:42, 2008

Inter-Technique CBCT# Variation

CBCT-to-ED table per technique or per anatomic site

Dose on CT and CBCT for a pelvis patient

Using a technique-based CBCT-to-ED table
20 cm diameter phantom for pelvis!

Ritcher et al., Radiation Oncology, 3:42, 2008

Inter-Technique CBCT# Variation

CBCT-to-ED table per technique or per anatomic site

Dose on CT and CBCT for a pelvis patient

Using an anatomic-site-based CBCT-to-ED table

Ritcher et al., Radiation Oncology, 3:42, 2008
**Inter-Technique CBCT# Variation**

Summary:

- Dose accuracy within 2% is achievable
  - Multiple fields are more forgiving

- CBCT-to-ED table per technique and anatomic sites
  - Require maintenance
  - Risk of mismatch

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**Inter-Patient CBCT# Variation**

Some cases:

<table>
<thead>
<tr>
<th>Physiological motion</th>
<th>Prosthesis</th>
<th>Truncation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Streaking</td>
<td>- Photon starvation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Streaking</td>
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</tr>
<tr>
<td></td>
<td>- Shift in CBCT #</td>
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</tbody>
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**Conclusion**

Accurate dose calculation on CBCT is possible

- Inter-system CBCT# variation

- CBCT-to-ED table per technique and anatomic sites

- Periodical QA required