Experience and Innovations in Image-guided Radiation Therapy

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Database of Anatomy Models

CT

CT/PET

MR

Specific Patient

Additional Data

Contouring

$\sum; \Delta$

Optimization

Calc’n

IMRT Beam Patterns

$\delta$

IGRT Adjustments
How and when do we respond to these changes?

Temporal Scales of Adaptive Radiation Therapy

**Off-line**
- Auto-segmentation
- Deformation
- Inverse planning
- Dose accumulation
- Response assessment
- PET/MR/CT

**On-line**
- MV/kV CT, online planning
- Dose accumulation
- Rapid QA
- Monitoring
- Deformation
- Seed detection

**Real-time**
- kV Fluoro, MR-RT
- Ultrasound
- Robotic needles/couches
- Motion tracking
- Gating
- Control
- Prediction

**Therapeutic Intent**
(Prescribed Dose and Constraints)

**Image-based Information To Inform Adaptation**
(Geometry, Biology)

**Adaptive Intervention**
(External Beam, Brachytherapy)
Methods - Deformation Vector Fields (5 wks)

Planning (pre-treatment)

Week 1

Week 2

Week 3

Week 4

Week 5

30 Patients

Methods - Dose Accumulation via DVF

Weekly geometry / Planned dose

Planning geometry / Deformed dose

Deform to planning geometry

Delivered

30 Patients

On-line Planning for Ca Cervix - Summary

- Automated weekly replan strategy ensured target coverage with small (3mm) PTV margins
  - Without re-planning, 9 patients received < 45 Gy to 98% of CTV volume (none did with re-planning)
- Further gains in OAR sparing possible through adaptation, but require a more explicit approach
  - This study computed re-plans each week with no user interaction
Summary

• Image-guidance for correction of bony anatomy and soft-target position is possible and is routine.

• Significant opportunities for innovation in adaptation to changes in patient anatomy.

• Many technical innovations possible to increase the precision and accuracy of RT delivery.

  – Software, Processes, Devices and Contrast Agents
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