Online Adaptive Radiotherapy for Prostate Cancer: Clinical Implementation and Initial Experience

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Supports from Siemens OCS and Prowess Inc

Inter-fractional variation:

Head & Neck: Daily Variation

- Tumor of the day
- Cord and Tumor from planning CT
- Five days
Bladder: unpredictable inter-fraction change

Prostate: unpredictable inter-fraction change

On-line ART

Prostate daily maximum overlap rate
20 prostate cases

Histogram of Daily Prostate MOR

Frequency

Daily Prostate MOR (%)

Re-planning
Repositioning

Frequency of online re-planning

- Prostate (3 mm PTV margin):
  - Repositioning: 50-70% of fractions
  - Replanning: 25-40% of fractions

Online Replanning frequency increases with smaller PTV margin
**Online Adaptive replanning**

A full-scope re-optimization with available systems is too slow to be practical.

Need fast replanning methods!

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**Online ART**

- Image Acquisition via CT-on Rails
  - 0.5 min
- Contour generation (auto segmentation with manual editing)
- Segment Aperture Morphing (SAM) & Segment Weight Optimization (SWO)
  - 2 min
- Dose/DVH evaluation and comparison
  - 1 min
- ART plan transferring & QA verification with software
  - 2 min
- Delivery and documentation
  - 8-12 min for prostate, comparable to current repositioning!!!

Implemented in RealArt by Prowess Inc.

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**Rapid contour delineation/ modification**

**Software:**
- auto segmentation
- drag and drop planning contours
- interpolate contours for skipped images

**Hardware:**
- user-friendly interactive Grip pen display (Cintiq 21UX, Wacom).

- Decimating/Interpolating slices
- Dropping contours from planning CT
- Drawing tablet and pen
- Moving in Sagittal/Coronal view

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**Fast plan modification:**

**Segment Aperture Morphing**

- Implemented in RealART, Prowess Inc.
Software tools for QA prior and after delivery: verifying MU#, plan data transferring and actual delivery

Prostate case (2 fractions)

Planning CT

CT of Fr#1
Moderate Deformation
Overlap: 85%

CT of Fr#2
Large Deformation
Overlap: 74%

Prostate (2 fractions)

Moderate Deformation
Overlap: 0.85

Large Deformation
Overlap: 0.74

PTV margin: 0 mm

Planning contour (pink) overlaid on daily CT
Clinical case: prostate cancer

Rectum

Projected reduction in rectal bleeding

Clinical case: bladder cancer, Fx#1
Initial Clinical Experience

The online replanning has been used on 12 prostate cancer cases and one bladder cancer case so far.

The online replanning process, eliminating the need to shift the patient, can be performed within the similar or slightly longer time frame required for the current IGRT repositioning and fits into the routine clinical workflow.
Inter-fractional motion: pancreas

Online Adaptive Replanning
- ART allows smaller (3mm) PTV margin, compared to repositioning with typical 10 mm margin

Adaptive v.s. Repositioning
- Duodenum 10 cases

Dosimetric Impact of RT delivery technologies on pancreas RT

<table>
<thead>
<tr>
<th>Structure</th>
<th>Online-ART gating</th>
<th>IGRT gating</th>
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<th>No IGRT no gating</th>
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<tr>
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</tbody>
</table>

Average of 5 patients
Summary

- The current standard of IGRT (repositioning) can not address volume change, deformation and rotation.
- Methods have been developed to perform online fast replanning.
- Online replanning can address translational and rotational shifts and deformation, eliminating repositioning.
- The online replanning allows smaller PTV margins.
- The online replanning enables "image-plan-treat", the future of RT practice, particularly important for hypofractionations, SBRT.