Contouring Strategies for Adaptive Radiotherapy

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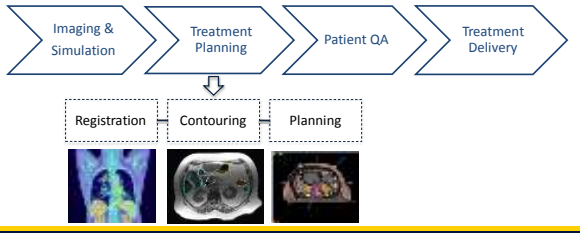
Disclosures

- Consultant - ViewRay Inc.

Radiotherapy Workflow

Radiotherapy Workflow



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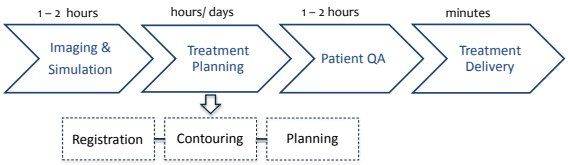
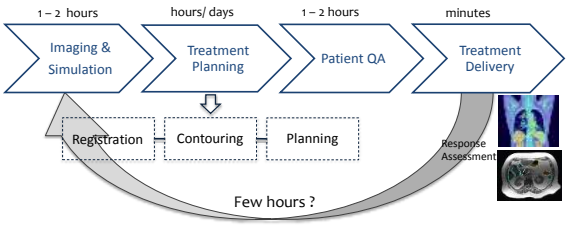
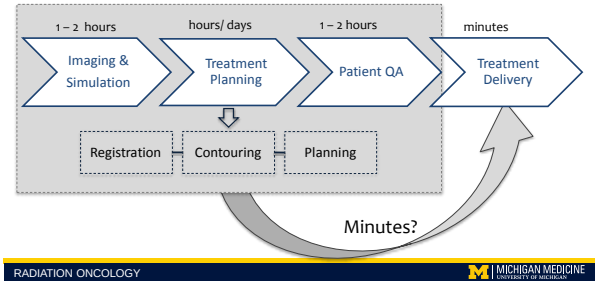


- Each step of this process may take several minutes to several hours.
- The overall process is still on the order of days to weeks in most standard cases.
- A large portion of that time goes to contouring (and re-contouring)

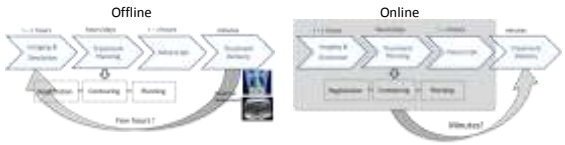
Adaptive Radiotherapy Workflow - Offline



Adaptive Radiotherapy Workflow - Online



How can we achieve this?



- How we achieve this, depends on the time-frame
  - Online has unique time restrictions
  - Adaptive indications that require more extensive imaging studies – offline
  - Adaptive indications that need immediate correction - online

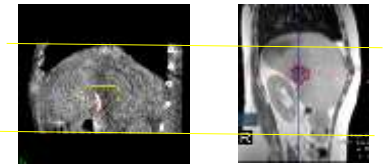
Imaging requirements

- Improvement in quality of on-board imaging:
  - Sufficiently high quality for contour delineation

Bin Cai, Washington University, St. Louis

Electron density for dose calculation

- Large field of view
  - Encompass all regions where contouring is required
  - Allow for inclusion of patient's external surface for dose calculation



Electron density for dose calculation

- Electron density maps can be generated using different techniques
  - Deforming the CT from simulation
  - Generation of electron density maps directly from MR
    - Various techniques available optimized for specific use case
    - Sometimes requires additional sequences
  - Bulk density overrides of the structures
  - Direct calculation on the daily image with the understanding of HU uncertainties (CBCT)

All methods have some level of uncertainty, and the impact on dose calculation should be understood for each clinical scenario

Electron density for dose calculation

- Deforming the electron density map from planning CT to image of the day
  - Any errors in deformation can result in errors in electron density map in that region as well

Electron density for dose calculation

- Manual correction to contours in regions where uncertainty is an issue.

Contouring Time

- Factors contributing to the overall contouring time:
  - Most contouring is manual
  - Significant involvement from the physician, which increases wait times
- Use auto-segmentation (atlases, deformable registration, deep learning)
  - Not fully characterized, requiring manual evaluation and intervention

~ 140 abstracts

Contouring Time

Phase I trial of stereotactic MR-guided online adaptive radiation therapy (SMART) for the treatment of oligometastatic or unresectable primary malignancies of the abdomen

- Reported contouring times for 97 online adaptive fractions for abdominal SBRT
- Contours were generated manually
- Contouring time ranged from 2 min to 24 min with a median of 9 minutes.

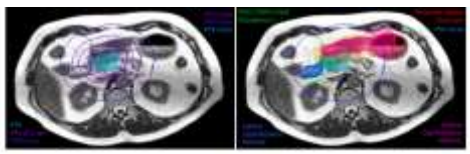
Contouring Time

- Timing study of each step of the adaptive process for 3 fractions on a single patient
- Contouring is the longest step

contouring time:
18 min (1st fx)
11 min (2nd fx)
9 min (3rd fx)

Contouring Accuracy

- Contouring:
  - Accuracy
    - How extensive the contours need to be?
    - How accurate?

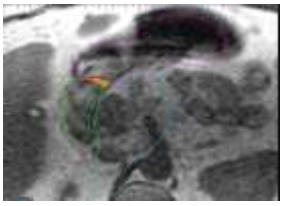


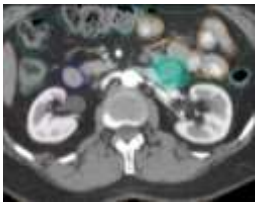
Contouring Accuracy

- Dosimetric accuracy

Contouring Accuracy

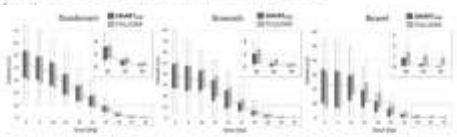
Focus on what matters





Contouring Accuracy

Fast and robust online adaptive planning in stereotactic MR-guided adaptive radiation therapy (SMART) for pancreatic cancer.



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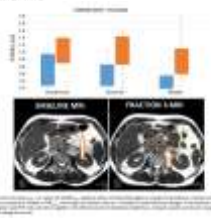
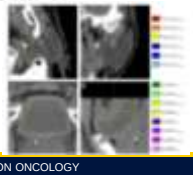
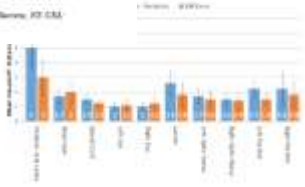


Contouring Accuracy

Deformable image registration and interobserver variation in contour propagation for radiation therapy planning

Adam C. Riegel,[1,2*] Jeffrey D. Antone,[1] Honglai Zhang,[1,2] Prachi Jain,[1] Jagdeep Rainge,[1] Anthony Rea,[1] Angelo M. Bergamo,[1] Ajay Kapur,[1,2] and Louis Potters[1,2]
*Department of Radiation Medicine,[1] Northwell Health, Lake Success, NY, USA; Hofstra Northwell School of Medicine,[2] Hempstead, NY, USA
*ariegel@northwell.edu





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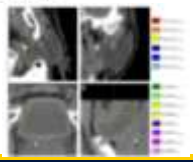
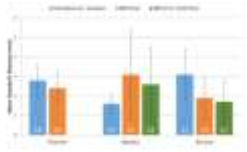
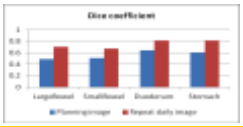




Contouring Accuracy

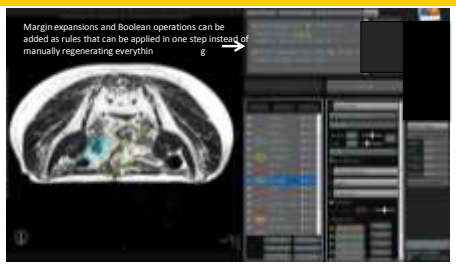
- What happens to the anatomy during the treatment fraction?
- Henke et al (MR in RT Symposium, Ann Arbor, June 2016)
  - Repeat images at 45 – 60 minutes after the initial image
  - Evaluated the contours and compared the magnitude of change to the changes observed in between fractions



Contouring Time

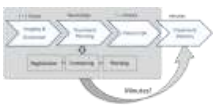
- Contour operations
  - PTV generation
  - Optimization structures
  - Evaluation structure
- Need clear and specific guidelines on how to re-define these after the contour changes.
- Prone to errors, require automation

Contouring Time



Discussion

- Clinical implementation of online and offline adaptive radiotherapy has been limited by the extensive resources required
- Contouring continues to be the most time-consuming part of the process
- Automation and utilization of resources other than the physician, can help expedite the process
- Understanding the necessary level of accuracy, is critical in moving the clinical implementation of online and offline adaptation forward.



Acknowledgements

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