Efficient outcomes-driven treatment planning using the Pinnacle system

Joe Deasy et al.

Thanks to
- Beth Pierburg, CMD
- Kevin Moore, PhD
- Rojano Kashani, PhD
- Jan Wilkins, PhD
- Aditya Apte, PhD
- Vanessa Clark, PhD
- Jeff Michalski, MD
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Outline
1. What are we trying to do?
2. What do we want to do: Prioritized prescription optimization (Clark et al.)
3. Tools at your disposal in Pinnacle
4. Constrained optimization in Pinnacle
5. Overlap-guided planning automation (Moore et al.)
6. Where are we now?

What are we trying to do?
- Achieve a high dose to the target
- Achieve low dose to the normal tissues
- But this is impossible!
So we…

• Make tradeoffs.
• But what are the treatment (physician) priorities?
• Usually there is a natural order:
  – Effective target coverage
  – Reduced dose to nearby critical normal structures
  – Minimal hotspots inside and outside target
  – Smoothed beam weights/low MUs

Potential answer: Priopt

• Prioritized prescription optimization
• Successively optimize easy-to-solve problems in order of clinical priority
• Advantages
  – Clear tradeoffs
  – Characterizable solution
  – Can be optimal
  – Automation potential
  – Competitive with clinical results (this work)

(slides courtesy Vanessa Clark; see Clark et al, ICR 2010)
Objectives
(based on physician preferences)

• Optimized in the following order:
  1. Maximize PTV D98 (Maximum PTV dose ≤ 75.6 Gy * 1.10)
  2. Minimize Rectum V65 & V40 (<17%, 35%)
  3. Minimize Bladder V65 & V40 (<25%, 50%)
  4. Minimize Normal Tissues mean & max dose
  5. Smoothing and minimize PTV mean dose

• Used mean-tail-dose instead of dose-volume objectives
  – Clark LAA 2008
  – Clark ICCR 2007

Prioritized planning within Pinnacle

Priopt vs. Pinnacle for one case

Pinnacle has...

• Typical DVH constraints
• gEUD objectives
• Constrained optimization
### Required planning objectives [3/3]

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### PriOpt, Step 1

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### PriOpt, Step 3 (last step)

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Slow!

Prostate objectives
Prostate PriOpt Step 3 (final step)

Issues

• Can be slow
• Automation (scripting) may be hampered by the need to keep the objective function from ‘blowing up’. That is, objectives shouldn’t be too far off what was available from earlier steps.

Where is the biology?

• In the prioritization!
• Relax target homogeneity constraints…
• …but protect target minimum dose requirements
• Use gEUD with relatively high a value for rectum and bladder (a = 5).
• We can use simple objective functions because of the constrained optimization framework.
Automated IMRT plan generation for prostate cancer

Rojano Kashani, Ph.D., Beth A. Pierburg, CMD, Deshan Yang, Ph.D., Kevin L. Moore, Ph.D.
Washington University School of Medicine
St. Louis, Missouri

Methods

- Autoplanning routines were created in the Philips Pinnacle treatment planning system using "scripts."
- The "scripts" are a set of internal commands stored as text files, which can be invoked on a new patient or plan.

Setting the initial objectives

- Target objectives
- Non-overlap structures
  Set maximum dose tolerances for the organ e.g. Femurs
- OARs overlapping or abutting the target
  The minimum achievable mean dose estimated e.g. Bladder and Rectum

Determination of objectives

Results

The automated solution showed overall improvements in quality relative to the clinically approved plan.

- The script also improved efficiency
  - Two cases required no additional optimizations
  - Remaining cases required minimal effort (10 min - 3 hours)

Future work will focus on improving the overlap model, and further improvements in the autoplanning script

Conclusions

- Constrained optimization (WUSTL, U Mich) reduces guesswork in treatment planning
- Current Pinnacle constrained optimization algorithm needs more development to become an efficient clinical tool.
- Other approaches (WUSTL, McNutt et al.) are leading to reliably good plans with reduced need for ‘tweaking’

Final remarks