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Towards auto selection of beam angles and photon energies in mixed energy IMRT

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INTRODUCTION

Beam angle optimization is a computationally intensive optimization problem. For mixed photon energy IMRT plans, adding energy as an extra degree of freedom to this problem would double the complexity. In general, beam angles and corresponding energy are often selected manually for mixed photon energies IMRT plans. Owing to simultaneous optimization of beam angles and corresponding intensities for both energies, the current problem poses a nonlinear problem with double the complexity [1]. Oftentimes, this leads to a trial-and-error process. In this work, a simple "target-to-OARs dose ratio" heuristic approach is proposed for selection of beam angles and corresponding photon energy for mixed photon IMRT. In order to validate our approach, we have applied this to two cases: a left chestwall and a right chestwall case.

AIM

The aim of this work was to propose a unique dosimetric score-based optimization method for auto-selection of photon energy and corresponding beam angles in mixed energy IMRT.

METHOD

The approach first uses a linear objective function to solve mixed photon fluence optimization problem with 5-degree angular resolution, which results in 90 candidate beams for 6 MV and 18 MV. The candidate beams are ranked based on a metric called "target-to-organs at risks dosimetric ratio", defined as mean dose to PTV divided by summation of mean dose to all OARs. Owing to a global solution to this linear objective function, the direction and energy of given beam is reflected by its metric value. We tested our approach on a left-chestwall (LCW) and a right-chestwall (RCW) IMRT cases. For each case, two sets of plans were created with the same dosimetric objectives and total number of beams: a plan with a combination of manual selection of beam angles and photon energy by an experienced planner, and a second plan with selection of beam angles and energies based on proposed method.

RESULTS

Target-to-OARs dose ratio was computed for each candidate beam and corresponding photon energy post simultaneous optimization of mixed photon energy beams using a linear programming model (Figure 1). Based on this metric, the angles with high ratio (blue dots) were selected as top ranked candidate beams from both 6 and 18 MV photon beam energies.

Figures 2 and 3 demonstrates the DVH comparison between the manual and auto-selection techniques for a right chestwall and a left chestwall case, respectively. In both cases, the dosimetrically ranked plan demonstrated a large reduction in dose to important organs such as contralateral lung, spinal cord and esophagus **(Figure 2 and 3).** In comparison to manual approach, auto-selection spared a large volume of heart for right chestwall case, it slightly reduced doses to heart for a left chestwall case. In both cases, the auto-selection approach increased dose to thyroid and ipsilateral lung **(Figure 2 and 3)**; the dose to PTV and unspecified tissue was comparable between the proposed approach and manual plan.

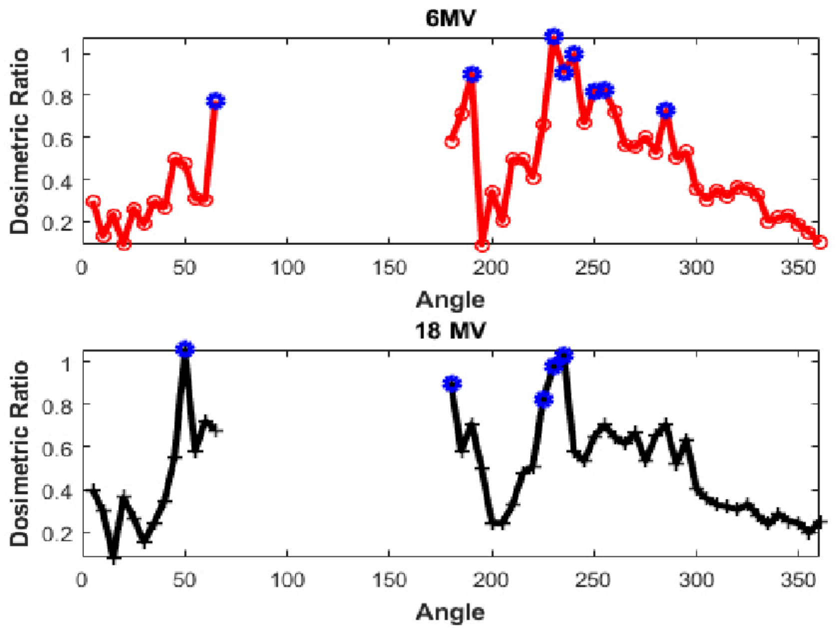

Figure 1. The plot of target-to-OARs dosimetric ratio with respect to the gantry angle for right chestwall case. The blue dots in the figure indicate highly ranked beams from the respective dosimetric ratio plots. Angles from 70 to 180 going from contra-lateral side were excluded in optimization.

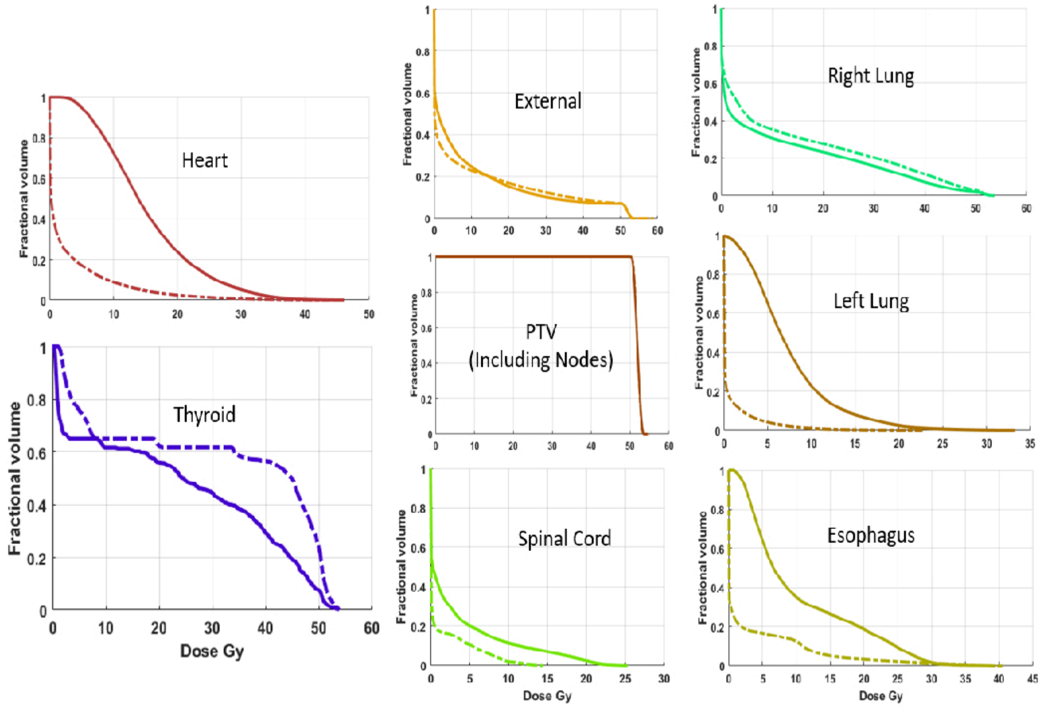

Figure 2. DVH comparison between auto-selection approach (dash-dot) and manual plan (solid) for a right chestwall case for PTV and major organs at risks

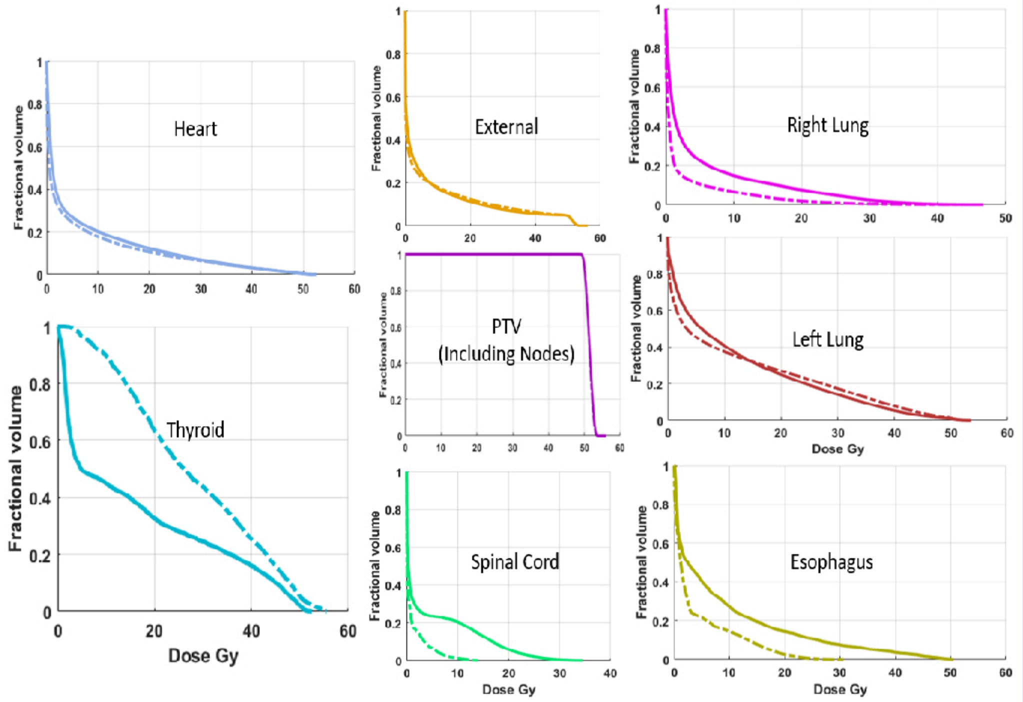

Figure 3. DVH comparison between auto-selection approach (dash-dot) and manual plan (solid) for a left chestwall case for PTV and major organs at risks.

CONCLUSIONS

- In both cases, the doses to planning target volume (PTV) and unspecified normal tissue were comparable between manual vs DR method..
- The auto-selection method reduced mean dose to heart (RCW:2.8Gy vs. 15.3Gy; LCW: 5.7Gy vs. 6.8Gy), esophagus (RCW: 3.1Gy vs. 10.4Gy; LCW: 3.74Gy vs. 8.28Gy), contralateral lung (RCW: 0.7Gy vs. 7.54Gy; LCW: 2.0Gy vs. 4.6Gy), and spinal cord (RCW: 1.1Gy vs. 3.2Gy; LCW: 1.0Gy vs. 4.3Gy)
- The auto-selection method, however, slightly increased doses to ipsilateral lung (RCW:12.6Gy vs. 10.2Gy; LCW:12.2Gy vs. 12.1Gy).
- The results obtained from the preliminary study suggest that the proposed approach is promising in improving the plan quality without compromising the target coverage while reducing dose to organs at risks.

REFERENCES

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CONTACT INFORMATION

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