Automatic Planning Results Using a Novel Dose Prediction Tool

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Deciding on the underlying technology

Compared trade-offs between various techniques

<table>
<thead>
<tr>
<th>Knowledge-based</th>
<th>Multi-criteria optimization</th>
<th>Progressive Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Minimal user input required</td>
<td>• Provides trade-off analysis with interactive graphical interface</td>
<td>• Minimal user input</td>
</tr>
<tr>
<td>• Adapts to planning trade-offs</td>
<td>• BUT</td>
<td>• Adaptable to protocol changes</td>
</tr>
<tr>
<td>• Dependent on a knowledge base</td>
<td>• BUT</td>
<td>• No knowledge-based required</td>
</tr>
<tr>
<td>• Not flexible to inter-physician variability</td>
<td>• BUT</td>
<td>• Dosimetric drivers not limited to DVH parameters</td>
</tr>
<tr>
<td>• Affected by variations in contouring</td>
<td>• BUT</td>
<td>• No on-the-fly trade-off analysis</td>
</tr>
<tr>
<td>• Does not address new knowledge or toxicity endpoints</td>
<td>• BUT</td>
<td>• No historical information</td>
</tr>
</tbody>
</table>

Progressive optimization algorithm

Drives target coverage and sparing to the limits

<table>
<thead>
<tr>
<th>Auto-Planning achieves these results…</th>
<th>… by mimicking the experienced planner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input-data (Dose, Treatment Techniques)</td>
<td>Optimization</td>
</tr>
<tr>
<td>Multiple IMRT optimizations</td>
<td>Add Target objectives</td>
</tr>
<tr>
<td>Add/modify objectives</td>
<td>Add hot/cold spot objectives</td>
</tr>
<tr>
<td>Improve OAR sparing</td>
<td>Dose uniformity to target</td>
</tr>
</tbody>
</table>
Auto-Planning ROIs

Progressive optimization algorithm
Drives target coverage and sparing to the limits

Even with generic inputs, Auto-Planning pushes beyond what was requested

Progressive optimization algorithm
Validated Through Peer-Reviewed Research
Auto-Planning at the Pinnacle³ Plan Challenge
Better results than the median at a fraction of the time

Plan Challenge commissioned by Philips in 2013 through ROR
Blue bars indicate submitted scores by users generating manual plans
Yellow triangle indicates score achieved by Auto-Planning – well above the mean score

Can we improve Auto-Planning results with patient-specific, personalized, inputs?

PlanIQ Feasibility
Providing achievable sparing goals

Clinical Goals Feasibility
- Distinguish between achievable and unachievable clinical goals
- Efficiently modify clinical goals prior to the planning process

Feasibility OutTM
- Patient specific dosimetry for targets and OAR with feasibility bands
- Optimizes treatment plan goals
PlanIQ Feasibility
Providing achievable sparing goals
- A proprietary, algorithm-based, dose falloff calculation
- Targets are assigned uniform prescription doses, with no reference to any particular beam arrangement
- A benchmark 3D dose built outside the targets is estimated using a series of energy specific dose spread calculations
- This benchmark dose is used to produce the "best possible sparing" FDVH for an OAR

PlanIQ Feasibility
Benchmark dose calculation and comparison to goals
- In the top left are the target doses
- Target doses are used to generate PlanIQ Benchmark Dose in the middle image above
- PlanIQ Benchmark dose is overlaid on OARs to give FDVH on the right above
- On the left are the goals from the protocol and information on how feasible the goals are

PlanIQ Feasibility
Personalizing planning objectives
- Drill down report on achievability for each individual structure
  - Red: impossible without sacrificing tumor coverage (also described as "FDVH(0)"
  - Orange: difficult to achieve (FDVH(0.1))
  - Yellow: challenging
  - Green: easy
  - Gray dotted line: represents a "feasibility number" in this case it chosen 0.22 – can be set to any value via "slider bar"
PlanIQ was created to improve the quality of the planning process. The program accelerates the IMRT planning process by providing a feasibility tool that drives target coverage and critical structure sparing. Sun Nuclear Corporation's PlanIQ both provides a feasibility tool that accelerates the IMRT planning process by optimizing target coverage and critical structure sparing. Sun Nuclear's PlanIQ feasibility also includes a progressive optimization algorithm that drives target coverage and sparing to the limits.

Progressive optimization algorithm

Drives target coverage and sparing to the limits

- Use feasibility number of 0.22 as goal – Auto-Planning designed to push down
- If the protocol number is lower than this, use the protocol number
- If neither goal is not close to achievable – remove it if possible (submandible_R)

PlanIQ were Auto-Body plans in planning. In planning, one can be obtained while minimizing the amount of target coverage and normal tissue sparing. When used in conjunction, a good plan in terms of the treatment plan through novel scorecards. Quality of the plan and evaluates the quality of making recommendations to improve the quality and consistency, but validate the quality benefit in tools that not only improve plan this considered, there is significant potential techniques such as IMRT or VMAT. The quality consuming process when using planning planning is to provide optimal coverage while minimizing dose to normal tissue structures. One of the primary goals of radiation treatment planning is to provide optimal coverage while minimizing dose to normal tissue structures. When used in conjunction, a good plan in terms of the treatment plan through novel scorecards. Quality of the plan and evaluates the quality of making recommendations to improve the quality and consistency, but validate the quality benefit in tools that not only improve plan this considered, there is significant potential techniques such as IMRT or VMAT. The quality consuming process when using planning planning is to provide optimal coverage while minimizing dose to normal tissue structures. One of the primary goals of radiation treatment planning is to provide optimal coverage while minimizing dose to normal tissue structures.

Methods and Materials

Purpose

1. Texas Oncology, San Antonio, TX

Introduction

3 Auto-Planning designed to push down

Progressive optimization algorithm

Drives target coverage and sparing to the limits

- Use feasibility number of 0.22 as goal – Auto-Planning designed to push down
- If the protocol number is lower than this, use the protocol number
- If neither goal is not close to achievable – remove it if possible (submandible_R)
Feasibility driven results
Drives target coverage and sparing to the limits

- Auto Planning still places many structures below feasibility numbers, e.g., SpinalCord, Brainstem, Parotid_L, Esophagus_Up.
- Other structures (Larynx, Pharynx, Oral Cavity) are well within protocol guidelines, but not matching feasibility.
- Great results, but can we make them better?

Progressive optimization algorithm
Drives target coverage and sparing to the limits

- Feasibility DVHs have a curvature that is not reflected in a mean DVH goal.
- Add hint points to Auto-Planning to have it drive down to reflect curvature.
- Use feasibility information to drive priorities and what is asked of Auto-Planning.

Feasibility Aiding Clinical Decision Making

- Add Max DVH Points to reflect FDVH curvature.
- Change priorities based on Feasibility.
- Remove structures that have no chance of being spared, e.g., in this case Submandible_R already removed.
Average results over 10 cases

<table>
<thead>
<tr>
<th>Location</th>
<th>Cases Not Feasible to Spare</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAROTID_R</td>
<td>3</td>
</tr>
<tr>
<td>PAROTID_L</td>
<td>1</td>
</tr>
<tr>
<td>SUBMANDIBULA_L</td>
<td>7</td>
</tr>
<tr>
<td>SUBMANDIBULA_R</td>
<td>5</td>
</tr>
<tr>
<td>LARYNX</td>
<td>1</td>
</tr>
</tbody>
</table>

- Used NRG-002 HN Protocol for analysis, target homogeneity decreased when pushing sparing with feasibility, however still well within allowed values in protocol.
Automatic Planning with Dose Prediction

Conclusions

• Auto-Planning alone has been shown through peer-reviewed research to improve plan quality
• Personalizing Auto-Planning inputs through PlanIQ Feasibility based dose objectives can further improve OAR sparing
• PlanIQ Feasibility can improve up-front clinical decision making prior to plan creation by
  • Preventing optimization against unachievable goals
  • Providing more complete information on achievable goals based on patient geometry
  • Improving goal priority setting (high, medium, low) prior to planning based on patient geometry

Thank you