Impact of Automatic Planning
From the Clinician’s Perspective

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Abstract
Recent advances in optimization and machine learning methods, it is now conceivable
that the design of an individual treatment plan can be made with little, if any, human
intervention. Adding autosegmentation processes to automated planning will result in
dramatic increase in the efficiency and consistency of individual plans. Once the
anatomic information, through imaging, is acquired for planning purposes, the majority of
the steps required for the generation of the optimal plan could be automated. Such
efforts are already being pursued at many institutions. However, since treatment plan
design is one of the most important steps affecting the quality of a delivered treatment,
human intervention, or at least supervision, will be crucial for the gradual development of
confidence in these automated processes. In this talk, I will provide my insights on the
aspects of automated treatment planning that would be addressed for this practice to
become an integral part of the future practice of radiation therapy.Learning Objectives:1. Understand the concerns related to the implementation
and practice of automated treatment planning from a clinician’s perspective.
2. Understand the impact of automated treatment planning on improving quality and consistence of radiation therapy from a
clinician’s perspective.

Objectives
1. Understand the concerns related to the implementation
   and practice of automated treatment planning from a
   clinician’s perspective.

2. Understand the impact of automated treatment planning
   on improving quality and consistency of radiation therapy
delivery from a clinician’s perspective.
Important Disclosures

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- Bayer Healthcare
- Elekta
- Varian Medical
- Viewray Inc.

Automated Treatment Planning

Elements:
- Autosegmentation
- Autoplan –
  - Margins
  - Priorities
  - Etc
- Auto-reports
- Libraries – Local / Other (expert users)
- Registry data

Outline

1. Clinical context – Background
   Problems that can be addressed with automated planning

2. Concerns
   Potential problems associated with automated planning

3. Possible first clinical applications
   Practical steps

4. New Opportunities
   Novel applications for automated planning
Objectives

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Typical RT Course Planning and Planning Related Tasks

Automated Treatment Planning
Shift focus from actual planning to overall process supervision

Benefits:
- Expediency / Efficiency
  - e.g. H&N planning turnaround
- Standardization
  - e.g. Breast planning, identifying outliers
- Learning
  - e.g. Improvement of plans, training
- Automated documentation:
  - e.g. Automated report generation
- Safety:
  - e.g. Standardization, guidelines, etc
- Culture change:
  - Change planning mentality from an “optimizer” to a “supervisor”
Automated Treatment Planning
Not a new thing

Many aspects already automated

Automated Treatment Planning
A Necessity in the future?

More complex devices

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Concerns

- Too much automation?
  Auto-segmentation
- Differences in different platforms
- Errors — systematic errors
- Cutting dosimetrist jobs? No!
  New challenges:
  - Oversee entire process
  - More complex deliveries
  - Oversee dose accumulation processes
  - ADAPTIVE RT

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Possible first clinical applications
Practical steps

- Clinical cases;
  - Palliative
  - Whole brain
  - Prostate
- Planning — Structure Naming Standardization
- Automatic generation of plan quality reports
- Building of case libraries
- Plan quality data collection / Registry data
Simulation + (Near) Automated Planning


Helical tomotherapy-based STAT RT: Dosimetric evaluation for clinical implementation of a rapid radiation palliation program.

CT simulation, treatment planning, and treatment delivery in one session

- Whole brain
- Central obstructive lung mass
- Multilevel spine disease
- Hip metastasis

Clinically acceptable dosimetry: conformity and homogeneity superior to standard 3D plans

Nomenclature Standardization

Physics Contribution

Standardizing Naming Conventions in Radiation Oncology

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Nomenclature Standardization

Table 1. Examples of target volume (TV) names

<table>
<thead>
<tr>
<th>TV</th>
<th>ICU Primary/ Site/ Prescription</th>
<th>Name</th>
<th>Node</th>
<th>Number</th>
<th>Dose (cGy)</th>
<th>Proposed name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV Primary</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>PTV Node</td>
<td>Multiple 1</td>
<td>1000</td>
<td>PTV1</td>
<td>5000</td>
<td>PTV1</td>
<td>PTV1_5000</td>
</tr>
<tr>
<td>PTV Node</td>
<td>Multiple 2</td>
<td>2000</td>
<td>PTV2</td>
<td>5000</td>
<td>PTV2</td>
<td>PTV2_5000</td>
</tr>
<tr>
<td>PTV Primary</td>
<td>1</td>
<td>1000</td>
<td>PTV1</td>
<td>1000</td>
<td>PTV1</td>
<td>PTV1_1000</td>
</tr>
</tbody>
</table>

Abbreviation: ICU = Intensive Care Unit or Radiation Units and Measurements.

Table 2. Planning organs at risk volumes

<table>
<thead>
<tr>
<th>Organ at risk name</th>
<th>Left/Right</th>
<th>Margin (mm)</th>
<th>Proposed name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal Cord</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Spinal Cord PRV</td>
<td>N/A</td>
<td>5</td>
<td>SpinalCord_PRV</td>
</tr>
<tr>
<td>Parotid</td>
<td>Left</td>
<td>0</td>
<td>Parotid_L</td>
</tr>
<tr>
<td>Parotid</td>
<td>Right</td>
<td>0</td>
<td>Parotid_R</td>
</tr>
<tr>
<td>Total parotid</td>
<td>Left/Right</td>
<td>0</td>
<td>Parotid</td>
</tr>
<tr>
<td>Kidney</td>
<td>Left</td>
<td>10</td>
<td>Kidney_L</td>
</tr>
</tbody>
</table>

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New Opportunities: Novel Applications for Automated Planning

Off-line Adaptive Radiotherapy

Off-line Adaptive Radiotherapy:

Adaptive Radiotherapy (ART) Workflow

- Use CT of the day
- Estimate actual dose on CT of the day: Recalculate dose
- Adjust contours of the day
- Identify new hot/cold spots
- Adjust according to hot/cold spots
- Prospective daily dose calculation
**Image and Contour Review**

- Compute Dose
  - Adjust contours based on changes in anatomy
  - Calculate dose on the daily CT (Verification Dose)

**Treatment evaluation**

- Evaluate
  - Evaluate individual treatment fractions
  - Verification Dose vs. Planned Dose

**Dose Review – Replanning?**

- Planning
  - Work with a single fraction or the sum of multiple verification doses
  - Create contours from hot or cold spots in a particular structure
New Opportunities: Novel Applications for Automated Planning

**On-line Adaptive Radiotherapy / Real-Time Radiotherapy**

*(IMAGINE THE FUTURE)*

**Real-Time Radiotherapy**

Initial treatment plan generated automatically using prior knowledge – Best plan of the day

Assessment and adjustments:
- Daily (all fractions) with good in-room images
- On-line
- Intra-fraction variations included
- Deformable registration
- Dose accumulation (inter/intrafraction)
- **Real-time automated (re)planning**
- In-vivo dosimetry

Continuous soft-tissue imaging with automated planning / delivery

In-room MRI / MRI guidance
Pilot (Navigation) Scans

20 sec Pilot Scan

Automatically Identify & Locate Tissues
Automatically Identify & Locate Tissues

Predict Dose On Demand
Optimize On Demand

Track Tissues & Control Therapy
Track Tissues & Control Therapy

Physician Review

Physician Workstation: Overall review and supervision
Automated Planning - Conclusions

Automated treatment planning has many potential advantages from improving throughput to improving safety.

Automated treatment planning will still require significant supervision. (No change in the physician approval process for initial plans).

Simple cases (simple geometries) can be ideal first clinical applications for automated planning, but complex deliveries will require it.

In the future, automated planning will increasingly be part of our routine in generating initial plans, and/or in the context of adaptive RT.

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