Artificial Intelligence (AI) Potential to Shorten Learning Time with Computed Tomography (CT) Images for Head and Neck Organs at Risk (OAR)

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Contouring computed tomography (CT) images is the process of denoting the boundaries of an organ/structure in 3D space. This allows structures to be targeted or avoided during radiotherapy planning.
Traditionally contouring is done by manually highlighting structures (e.g. Organs at Risk, or OAR). This is a time and labor-intensive process, requiring strong anatomical knowledge.\textsuperscript{1}

Can commercially available artificial intelligence (AI) programs supplement the education of those learning to contour?
AI Contouring Workflow

- Create/refine human contours
- Run AI programs
- Compare human and AI contours
Five OAR were contoured manually across three patient CT sets. Contours were generated by a medical student and board-certified radiation oncologist team. These were considered the “Ground Truth,” or reference contours.

New contours for the same five OAR were then generated using two different commercially available AI programs (dubbed V1 and V2).

The human-made and AI-made contours were then compared using a metric called the Dice Similarity Coefficient (DSC).
OAR Contoured (Examples)

5 – Mandible
1 – Parotid Glands
4 – Spinal Cord
2 – Muscular Constrictors

4 – Brachial Plexus
Methods/Description

Dice Similarity Coefficient (DSC)

Higher DSC $\alpha$ Better contour
### Results

- **DSC Results by OAR**

<table>
<thead>
<tr>
<th>Contour Type</th>
<th>OAR</th>
<th>Average DSC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Mandible</td>
<td>84.7</td>
</tr>
<tr>
<td></td>
<td>Brachial Plexus</td>
<td>33.4</td>
</tr>
<tr>
<td></td>
<td>Parotids</td>
<td>80.8</td>
</tr>
<tr>
<td></td>
<td>Spinal Cord</td>
<td>74.3</td>
</tr>
<tr>
<td>V2</td>
<td>Mandible</td>
<td>83.8</td>
</tr>
<tr>
<td></td>
<td>Brachial Plexus</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td>Parotids</td>
<td>80.8</td>
</tr>
<tr>
<td></td>
<td>Spinal Cord</td>
<td>73.0</td>
</tr>
</tbody>
</table>

Note: Muscular Constrictors were only contoured in the V2 software package (average DSC = 58%)
Discussion

• Best OAR Contours:
  • Mandible (DSC = 83 to 85%)
  • Bilateral Parotid Glands (DSC = ~81%)

• Worst OAR Contours:
  • Bilateral Brachial Plexus (DSC = 25 to 33%)

• In general:
less complexity = better contour
Examples – Brachial Plexus (T1 Nerve)
Examples – Brachial Plexus (T1 Nerve)
Discussion

Examples – Mandible
Discussion

Examples – Mandible

Human-made

V1

V2
Discussion

• Impact Factors on OAR Contours:
  • Complexity
  • Size
  • CT Quality
    • Artifacts
    • Slice Size
Discussion

• AI Advantages
  • Speed
  • Repeatability
  • No need for window levels
Challenges

- Contouring = Hard
  - Time-intensive
  - Anatomy-intensive
  - Variation patient-to-patient
This small-scale analysis of five OAR across three patients is the beginning of an expanded analysis of >30 unique OAR across nine patients.

Subjective scoring will also be utilized to add clinical relevance and perspective.
We thank Gary Cobb with the ECU BSOM Radiation Oncology Dept. for his help facilitating access to the Varian Medical Training Software.