Assessment of the Suitability of the Dice Similarity Coefficient as a Dosimetry Metric Using a Treatment Planning Study in Prostate Cancer

Da Wang
University of Washington, Radiation Oncology
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Introduction

- Contour: Segmentations of tumors and OARs
  - Evaluation of dose distribution
  - Inverse planning algorithm
- Contouring is very labor intensive
**Introduction**

- Auto-Contouring: Decision Forest Machine Learning

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**Auto-Contours’ Evaluations**

\[ DICE = \frac{1}{2} \times (\text{intersect} + \text{union}) \]

- DICE = 0
- 0 < DICE < 1
- DICE = 1
Methods

- DICE coefficients (MS Auto-Contour software)*
  - Bladder 0.94-0.97
  - Femurs 0.96-0.97
  - Prostate 0.75-0.76
  - Rectum 0.63-0.87
  - SV 0.49-0.7

DVH Metrics

- V80Gy V75Gy
- Max Dose
- V(95%Rx) V(Rx)
- V75Gy V70Gy

* Macomber, M. et al.

Methods

- 24 prostate patients
  - Reproduced plan
  - Approved plan
  - Auto-contouring plan
  - VMAT

Table III. Quantitative metrics to evaluate image registration.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Evaluation metric</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dice similarity coefficient (DSC)</td>
<td>Volumetric overlap of 2 contours on registered images</td>
<td>Within the contouring uncertainty of the structure ±0.80-0.90%</td>
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</tbody>
</table>

*DSC calculations are dependent on the volume of the structure, therefore very large or very small structures may have different expected DSC values for contour uncertainty.
Results

- Approved plans and Reproduced plans and show no significant difference on all selected metrics:

  - PTV V(Rx)  
    - Approved: 79.3±12.1%
    - Reproduced: 77.1±15.0%
  - PTV V(95%Rx)  
    - Approved: 99.3±0.7%
    - Reproduced: 98.1±2.5%
  - GTV V(Rx)  
    - Approved: 94.5±10.3%
    - Reproduced: 93.0±12.3%
  - Bladder Wall V75Gy  
    - Approved: 10.7±5.0%
    - Reproduced: 10.3±4.9%
  - Rectal Wall V70Gy  
    - Approved: 13.9±4.6%
    - Reproduced: 13.8±4.1%
  - Rectal Wall V50Gy  
    - Approved: 36.5±6.2%
    - Reproduced: 37.9±5.5%
  - Rectal Volume V70Gy  
    - Approved: 13.8±3.84%
    - Reproduced: 14.0±3.6%

Results

- DICE(GTV) ~ DICE(PTV)
**Results**

- **V95% isodose line**

**Reproduced Plan**  **Auto-contour Plan**

**Results**

- **DICE(PTV) ~ DVH Metrics**

DICE(GTV)=0.75
**Results**

- **DICE(GTV) and V(Rx) ratio**
  - DICE(GTV) = 0.93 -> PTV-V(95%Rx) = 100%
  - DICE(GTV) = 0.90 -> PTV-V(95%Rx) = 97.5%
  - DICE(GTV) = 0.80 -> PTV-V(95%Rx) = 87.6%
  - DICE(GTV) = 0.94 -> PTV-V(Rx) = 100%
  - DICE(GTV) = 0.90 -> PTV-V(Rx) = 96.0%
  - DICE(GTV) = 0.80 -> PTV-V(Rx) = 85.7%

- **DICE(P2V) ~ DVH Metrics (ratio)**
  - DICE(GTV) = 0.93 -> PTV-V(95%Rx) = 100%
  - DICE(GTV) = 0.90 -> PTV-V(95%Rx) = 97.5%
  - DICE(GTV) = 0.80 -> PTV-V(95%Rx) = 87.6%
  - DICE(GTV) = 0.94 -> PTV-V(Rx) = 100%
  - DICE(GTV) = 0.90 -> PTV-V(Rx) = 96.0%
  - DICE(GTV) = 0.80 -> PTV-V(Rx) = 85.7%

- **DICE(GTV) and V(Rx)**
  - DICE(GTV) = 0.85 -> GTV-V(Rx) = 100%
Results

- DICE(Bladder) - Bladder Wall V75Gy ratio
- DICE(Rectum) - Rectal Wall V70Gy, V50Gy ratio,
  - Rectal Volume V70Gy ratio

Methods

- Isodose lines

Reproduced Plan  Auto-contour Plan
Methods

- Rectum Wall V70Gy ~ DICE(PTV)
Methods

Δd \{ + \text{Target moves away from OAR} \\
− \text{Target moves towards OAR} \}

Results

- Rectum wall V70Gy ratio ~ DICE(PTV) & Δd

Rectal Wall V70Gy
y = 0.53 DICE(PTV) − 0.70 Δd + 0.40

Rectal Vol V70Gy
y = 0.47 DICE(PTV) − 0.75 Δd + 0.41

Rectal Wall V50Gy
y = 0.88 DICE(PTV) − 0.27 Δd + 0.18
Results

- Bladder wall V75Gy ratio ~ DICE(PTV) & Δd

\[
y = 1.43 \text{DICE(PTV)} - 0.74 \Delta d - 0.25
\]

Conclusion

- DICE can accurately predict the plan quality for target: PTV-V95%, PTV-V100%, GTV-V100% metrics
- OAR dosimetry metrics (V75Gy, V70Gy, V50Gy) have linear correlation with DICE(PTV) and Δd
THANK YOU FOR YOUR ATTENTION!