Overview and Current Status of Segmentation in Radiation Oncology

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Disclosures

• No conflict of interest

• I participate in research with Elekta
<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Maccia 2012</td>
<td>Simmat 2012</td>
</tr>
<tr>
<td>Daisne 2013</td>
<td>Thomson 2014</td>
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<tr>
<td>Langmack 2014</td>
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<td>Walker 2014</td>
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<td>Eldesoky 2015</td>
<td></td>
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</tbody>
</table>
Consistency?

Without Auto-segmentation  
With Auto-segmentation

Young, IJROBP 2011
## Inter-observer variability

<table>
<thead>
<tr>
<th>Structure</th>
<th>Inter-observer variability</th>
<th>Automatic segmentation accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parotid gland</td>
<td>0.66 ± 0.1 [1]</td>
<td>0.74 [4]</td>
</tr>
<tr>
<td></td>
<td>0.76 ± 0.08 [2]</td>
<td>[0.73,0.79] [5]</td>
</tr>
<tr>
<td></td>
<td>0.85 [3]</td>
<td>0.85 ± 0.03 [6]</td>
</tr>
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</table>

**All scores are Dice**

Segmentation without prior knowledge

• Level set method

Update equation:
\[
\frac{d \Psi}{dt} = -k_I (F_A + F_K) ||\nabla \Psi||
\]
Atlas-based segmentation

Subject

DIR

Warped contours

Atlas contours

Atlas selection

Atlas selection...
Multi-atlas segmentation

Subject

Atlas 1

Atlas 2

Atlas n

DIR

DIR

Warped contours

Warped contours

Warped contours

Label fusion

Final segmentation
Atlas-selection

- Choose the atlas most similar to the target image
- Example:
  - Perform rigid registration against multiple atlases
  - Choose atlas that maximizes mutual information
MICCAI 2015 Grand Challenge

- Top three teams – All used shape models
  - imorphics
  - BaVarian
  - Fraunhofer

Optic Nerves: 0.63 +/- 0.10
Optic Chiasm: 0.57 +/- 0.14
Model-based segmentation

• Example

Eye globe is a sphere, parameterized by position and radius

\[
E(S, B) = \int_S (I - u_S)^2 - \int_B (I - u_B)^2
\]

Optimize sphere parameters to minimize an energy function
Machine learning

- Patch-based learning

Positive samples

Negative samples

Learning system

Classifier