Automatic Identification of Critical Areas of the Head and Neck for Refined Dose-Toxicity Analysis in Radiotherapy

• Design, implement, and evaluate an algorithm that creates spatially dependent dose features at the inter-organ level to identify specific areas of the head and neck that are more or less critical and sensitive to radiation damage.

• What Students Will Do:
  – Work with an existing database of over 900 radiation oncology patients
  – Develop a method to normalize the full anatomy based on standard set of commonly contoured regions
  – Develop an algorithm to identify non-contoured anatomical regions based existing contoured anatomy to find specific locations and spatially dependent dose features related to radiation induced toxicities
  – Generalize the model to enable the creation of spatially dependent features of the dose such as principle component analysis or gradient based features of the dose
  – Evaluate the impact of these features on taste, xerostomia and dysphagia toxicities with existing analysis tools.

• Deliverables:
  – An atlas normalization method that maps all patients to a common geometry
  – A method of defining a spatial region within the normalized atlas
  – An algorithm for creating spatially dependent features of the radiation dose in regions of the head and neck relative to existing contoured anatomy
  – Evaluated toxicity models for taste, xerostomia and dysphagia

• Size group: 1-3

• Skills:
  – 3D shapes, Volumetric Image Segmentation
  – Programming experience (SQL, C, C#, python)

• Mentors: Todd McNutt (tmcnutt1@jhmi.edu) Sierra Cheng (zcheng4@jhmi.edu)

Error Correction for Treatment Planning and a Learning Health System in Radiotherapy

• The goal is to improve the integrity of the anatomical 3D contours used in a learning health system with tools that can identify potentially erroneous data.
  – A second goal is to detect errant longitudinal measures such as weight.
  – The tools will tag or correct them and provide feedback in the clinical workflow.

• What Students Will Do:
  – Develop framework to run on the database that respond to errant data
  – Detect errant contours utilizing the database of hundreds prior patient's anatomical contours as a norm
  – Detect errant longitudinal data such as excessive changes in clinical status (e.g. weight)
  – Allow for customized data integrity checks to be added as needs are identified.
  – The system will be constructed to report findings in 3 ways
    • Listed report of all detected errors
    • Ability to tag data as suspect
    • Provide real time check on single data point entry when it is possible

• Deliverables:
  – The overall framework for errant contour detection
  – Documented API for developing new integrity checks

• Size group: 1-3

• Skills:
  – 3D shapes, Volumetric Image Segmentation
  – Programming experience (SQL, C, C#, python)

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  – Sierra Cheng (zcheng4@jhmi.edu)
Which patient will do better?

69-year-old man with Stage Squamous cell carcinoma, NOS of the Right Malignant neoplasm of tonsil

63-year-old man with T3 N2b M0 Stage IVA Squamous cell carcinoma, NOS of the Malignant neoplasm of larynx

Precision Radiotherapy
Treatment Planning
Learning Health System

- Facts
- Controls
- Outcomes
- time

Data Integrity

Knowledge Database

Predictive Modeling

Presentation of Predictions

- Facts
- Controls

- Predicted Outcomes
- Data Feedback
  (Facts, Outcomes)

Decision Point

- Dysphagia and Xerostomia
  Larynx vs Grade ≥ 2 Dysphagia

JPS/NOS (Cuts to the Larynx 1000 Patients)

Dysphagia vs Grade ≥ 2 Dysphagia

All DVH Curves for the Larynx (142 Patients)

Dysphagia Grade < 2 (N=87)

Dysphagia Grade ≥ 2 (N=55)
Spatially dependent features of dose in the structures (F. Marungo et al.)

<table>
<thead>
<tr>
<th>Method</th>
<th>Voice dysfunction n=99, n_+ =8, n_- =91</th>
<th>Xerostomia n=364, n_+ =275, n_- =89</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bagged Naïve Bayes (1000 iterations)</td>
<td>0.915</td>
<td>0.743</td>
</tr>
<tr>
<td>Bagged Linear Regression (1000 Iterations)</td>
<td>0.905</td>
<td>0.737</td>
</tr>
<tr>
<td>Naïve Bayes</td>
<td>0.900</td>
<td>0.734</td>
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<tr>
<td>Linear Regression</td>
<td>0.896</td>
<td>0.731</td>
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<tr>
<td>Random Forest (1000 trees)</td>
<td>0.724</td>
<td>0.683</td>
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<tr>
<td>NTCP_{LKB}</td>
<td>0.596</td>
<td>0.700</td>
</tr>
</tbody>
</table>