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 comment 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:**
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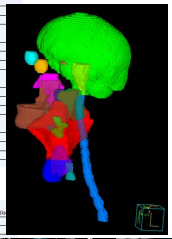
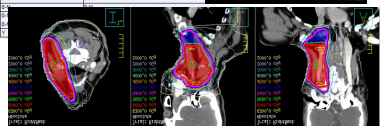
Which patient will do better?

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

HPV	1-Yes	HPV high risk positive
p16	1-Yes	p16 Positive
Tobacco Use	2	Quit Smoking
Smoking Hx Starting Age	17	
Smoking Hx Cigarettes/Day	20	
Smoking Hx Total Yrs	8	
Mucositis CTC3	0	None (mucositis)
Skin - Acute	0	No change over baseline
Watery eye	0	None
Nose Bleeding	0-No	0-No
Xerostomia	1	Mild mouth dryness; slightly thickened saliva
Salivary Gland	1	Mild
Saliva - Hopkins	0	Normal
Vomiting CTC4	0	No vomiting (ons)
Dehydration	0	None
Dysphagia	0	None
Aspiration	0	None
Taste - Hopkins	1	Taste change/loss not affecting ADLs
Percent Taste (%)	60	
Taste- abnormal (ie. metallic)	60% post surgical taste changes	
Voice Changes	0	Normal
Larynx	0	None
Larynx RTOG	0	None
Bone Change	0	None
Bone RTOG	0	None
Osteonecrosis of jaw	0	None
Dental: teeth	0	None
Dental caries	0	None
Trismus	0	None
Pain NCI	0	None
Tinnitus CTC4	0	None
Cough CTC	0	Absent

Weight (kg)	76.6	
KPS Score	80	Able to carry on normal activity; minor s/s of dis
FOIS	7	Total oral intake with no restrictions
PEG Tube (Placed)	0-N	0-N
PEG Tube (Used)	0-N	0-N
Ng Tube (Placed)	0-N	0-N
Ng Tube (Used)	0-N	0-N
PO	Y	Y

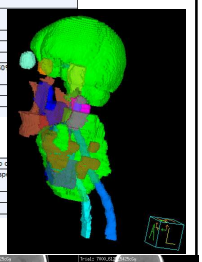


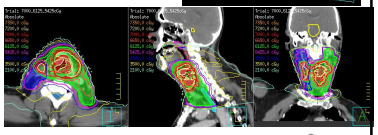


63-year-old man with T3 N2b M0 Stage IVA Squamous cell carcinoma, NOS of the Malignant neoplasm of larynx

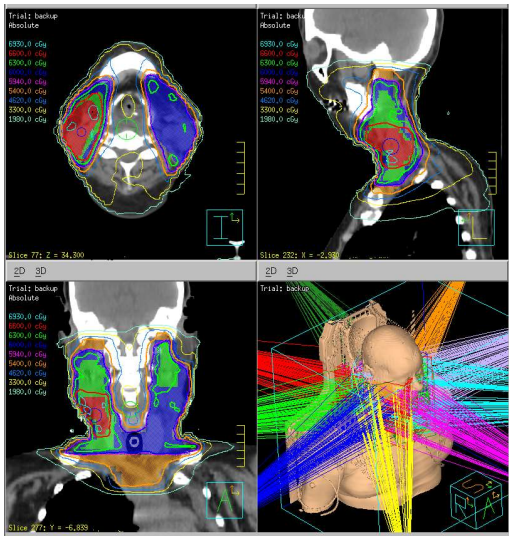
Tobacco Use	2	Quit Smoking
Smoking Hx Starting Age	23	
Smoking Hx Cigarettes/Day	60	
Smoking Hx Total Yrs	40	
Mucositis CTC3	0	None (mucositis)
Skin - Acute	0	No change over baseline
Watery eye	0	None
Nose Bleeding	0-No	0-No
Xerostomia	0	None (xerostomia)
Salivary Gland	0	Norm
Saliva - Hopkins	0	Normal
Dehydration	0	None
Dysphagia	0	None
Aspiration	0	None
Taste - Hopkins	1	Taste change/loss not affecting ADLs
Percent Taste (%)	85	
Voice Changes	4	Disabling; non-understandable, requires voice aid > 50
Larynx	4	tracheotomy, intubation, laryngectomy
Trismus	0	None
Pain NCI	1	Mild pain not interfering with Fx
Cough CTC	0	Absent

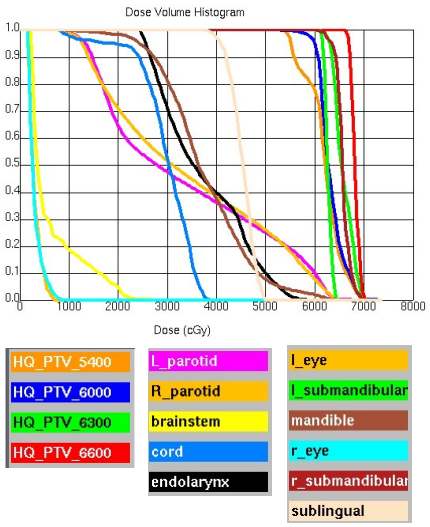
KPS Score	70	Cares for self; unable to carry on normal activity or to d
FOIS	5	Total oral intake of multiple consistencies requiring sp
PEG Tube (Placed)	1-Y	1-Y
PEG Tube (Used)	1-Y	1-Y
PO	Y	



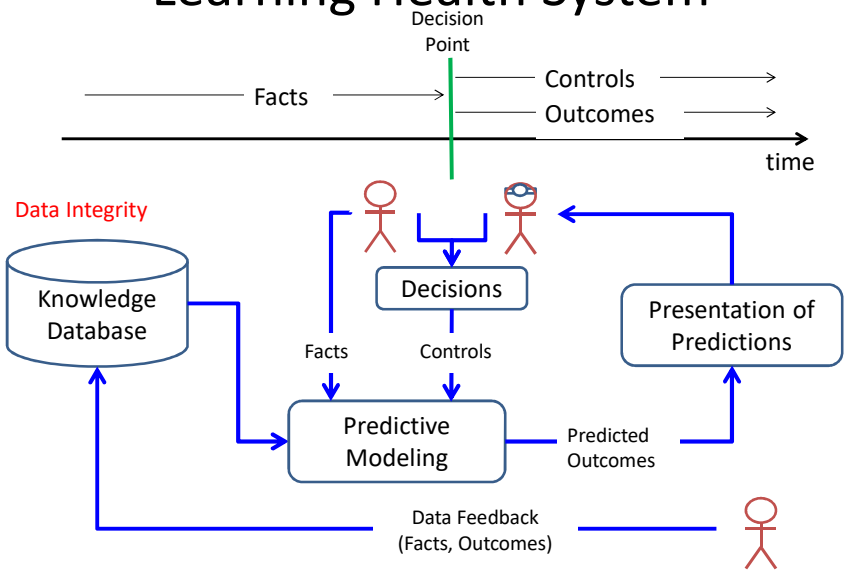


Precision Radiotherapy Treatment Planning

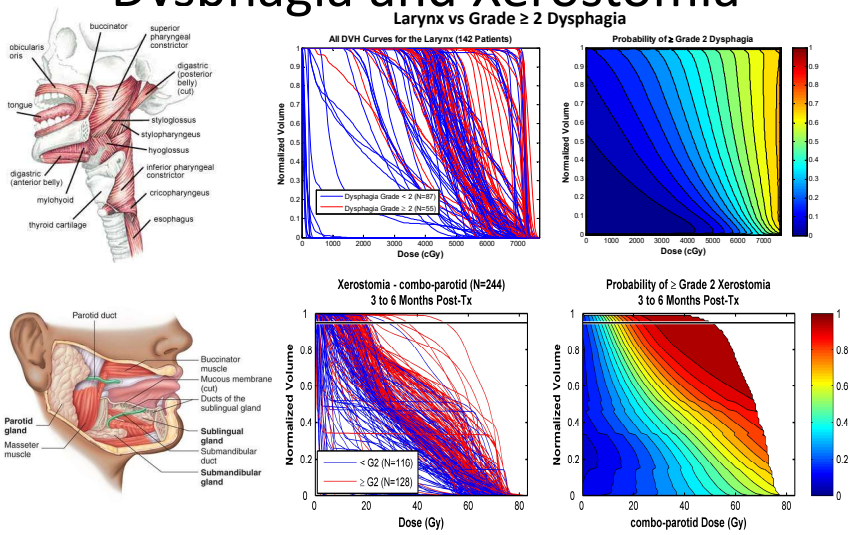




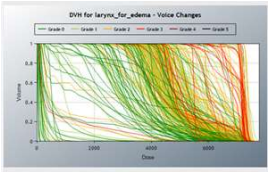
Learning Health System

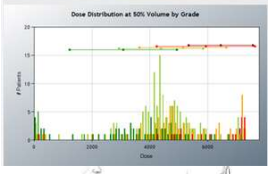


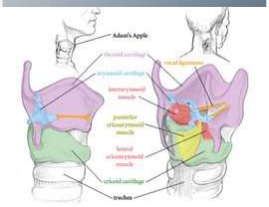
Dysphagia and Xerostomia

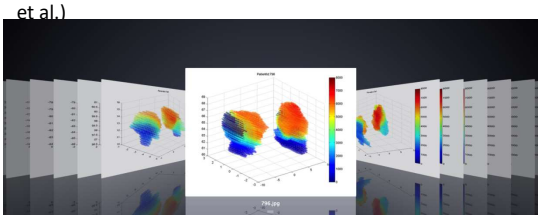


Spatially dependent features of dose in the structures (F. Marungo et al.)









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