Tumor and Normal Organ Segmentation Review

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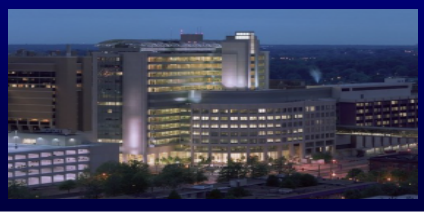
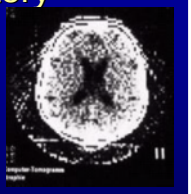


Organ and Tumor Segmentation for Radiation Therapy

- Tao Ju
- Chris Abraham
- Garima Gokhroo
- Ross Sowell
- Liu Lu
- Cindy Grimm
- Parag Parikh
- James Hubenschmidt
- Joe Deasy
- Tianyu Zhao
- Aditya Apte
- Sasa Mutic
- Jeff Bradley
- Jeff Michalski
- Wade Thorstad

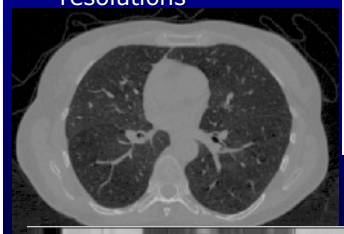
CT Scanner History

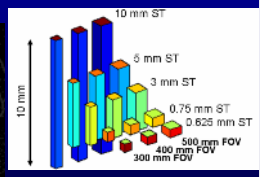
- CT scanners used relatively thick slices
  - Originally due to hardware
    - Thick slices (single slice)
    - Long time to scan fine slices
    - Tube heating limits
  - Later due to treatment planning system and network limitations
  - 100 CT slices was unheard of!
- In-plane and out-of-plane spatial resolutions were very different



Use of Coarse CT Scans

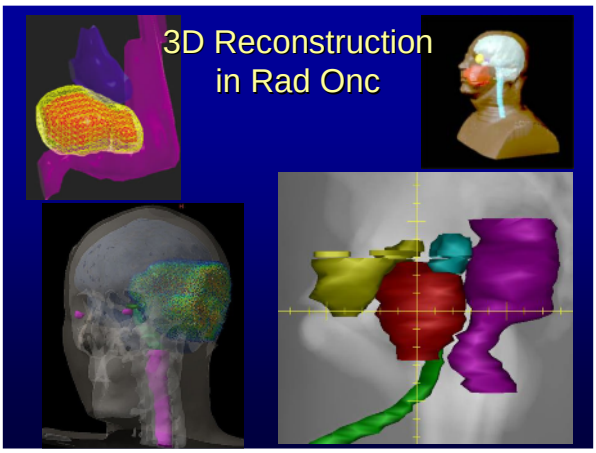
- Transverse orientation displays uniform spatial resolution
- Other orientations display widely differing resolutions





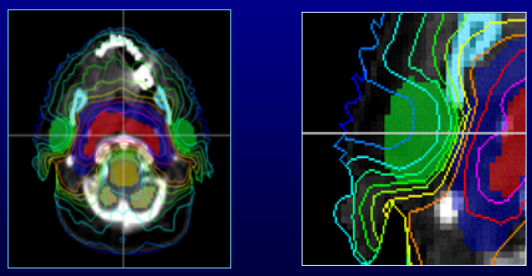
Isotropic Voxels

3D Reconstruction in Rad Onc



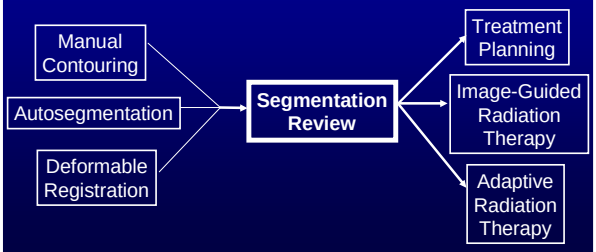
What Qualities Should Segmentation Process Have?

- Accuracy

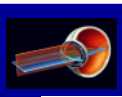


What Qualities Should Segmentation Process Have?

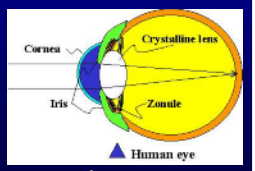
- Efficiency



Challenge



- Use 3D information to quantitatively segment structures
- Display technology is 2D
- Human vision is 2D
  - Retinal surface
  - Some qualitative 3D information provided by
    - 2 eyes (stereoscopic)
    - Focus
    - Content



- 3D rendering is unable to provide quantitative spatial information to the user

Hypotheses

- Binary representations of structures will continue to be used in Radiation Oncology
- Quantitative interactions are required between image datasets and planner: can only be done using 2D projections through datasets
- Transverse scans are *not* the anatomically optimal orientation for segmentation of all tumors and normal organs

Contouring in Anatomically Optimized Planes

- Use of these planes may allow more efficient and accurate segmentation
- Use of these planes may allow more efficient segmentation *review*
- Challenges:
  - Navigation and training for radiation oncologists, dosimetrists in use of oblique planes
  - Defining structures using oblique planes

Segmenting Structure with Oblique Contours

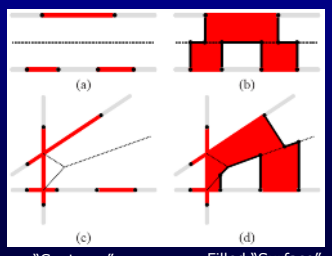
- Similar problem to defining the globe with lines of latitude and longitude.

Algorithm for Surface Generation

- Medial Axis based initial surface generation
- 2D example

Parallel Planes

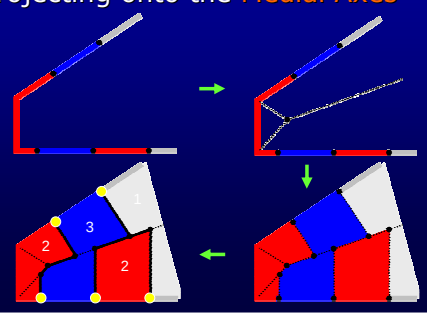
Oblique Planes



"Contours" Filled "Surface"

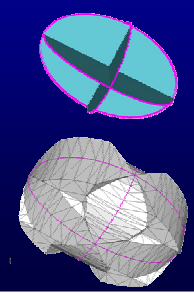
Scenario 3 [Liu et al., 2008]

- Projecting onto the Medial Axes

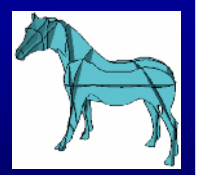


Algorithm for Surface Generation

- 3D examples

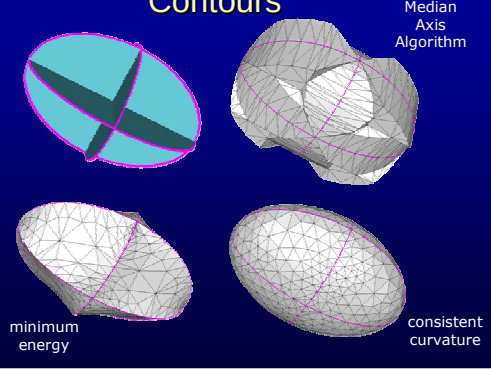


Contours



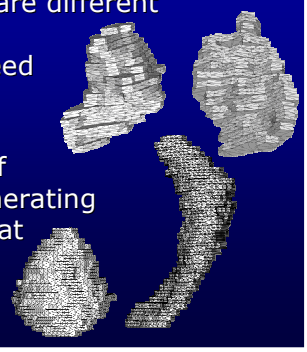
Resulting Medial Axis surface

Segmentation With Oblique Contours



Process Plan: Library

- In order to compare different approaches to segmentation, need "gold standard" dataset
- Develop library of structures by generating mesh surfaces that accurately reflect structure

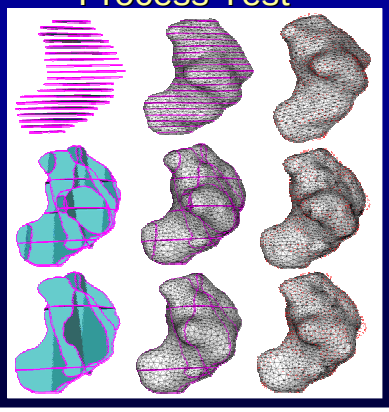


Process Test

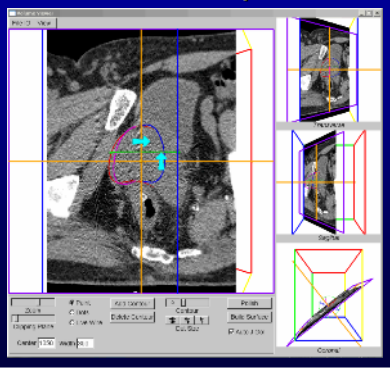
19 Parallel Planes

10 Oblique Planes

6 Oblique Planes



Tool Development



Conclusions

- CT technology has greatly improved
- We still use CT for segmentation
- Anatomically optimized views may improve segmentation accuracy for some sites
- Challenge is **navigation** and **training**