Auto-Segmentation of Spine CT for Data-Intensive Analysis of Surgical Outcome

Group 23

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Team Members and Mentors

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Mentors

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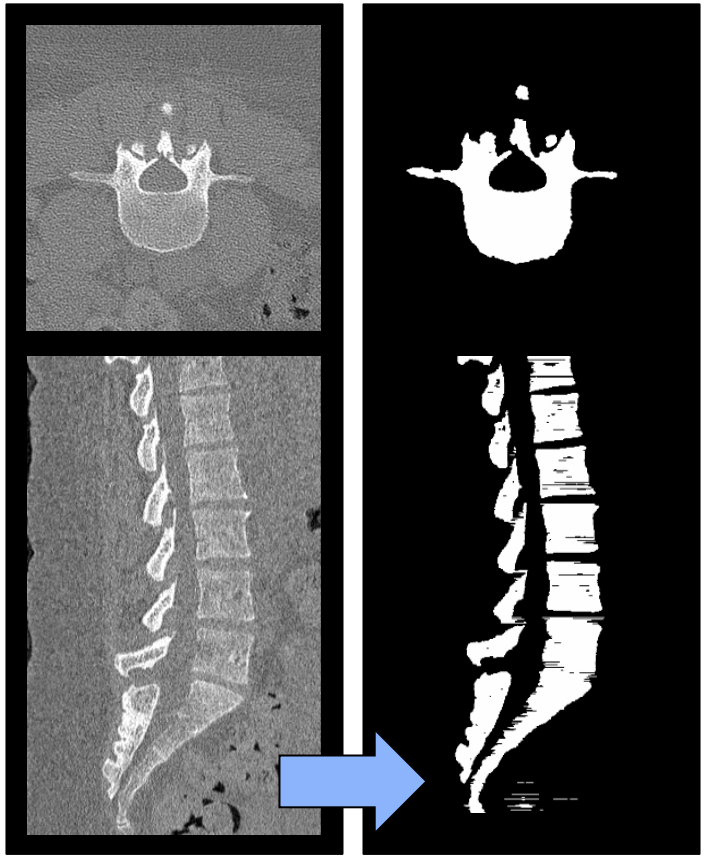
Goals

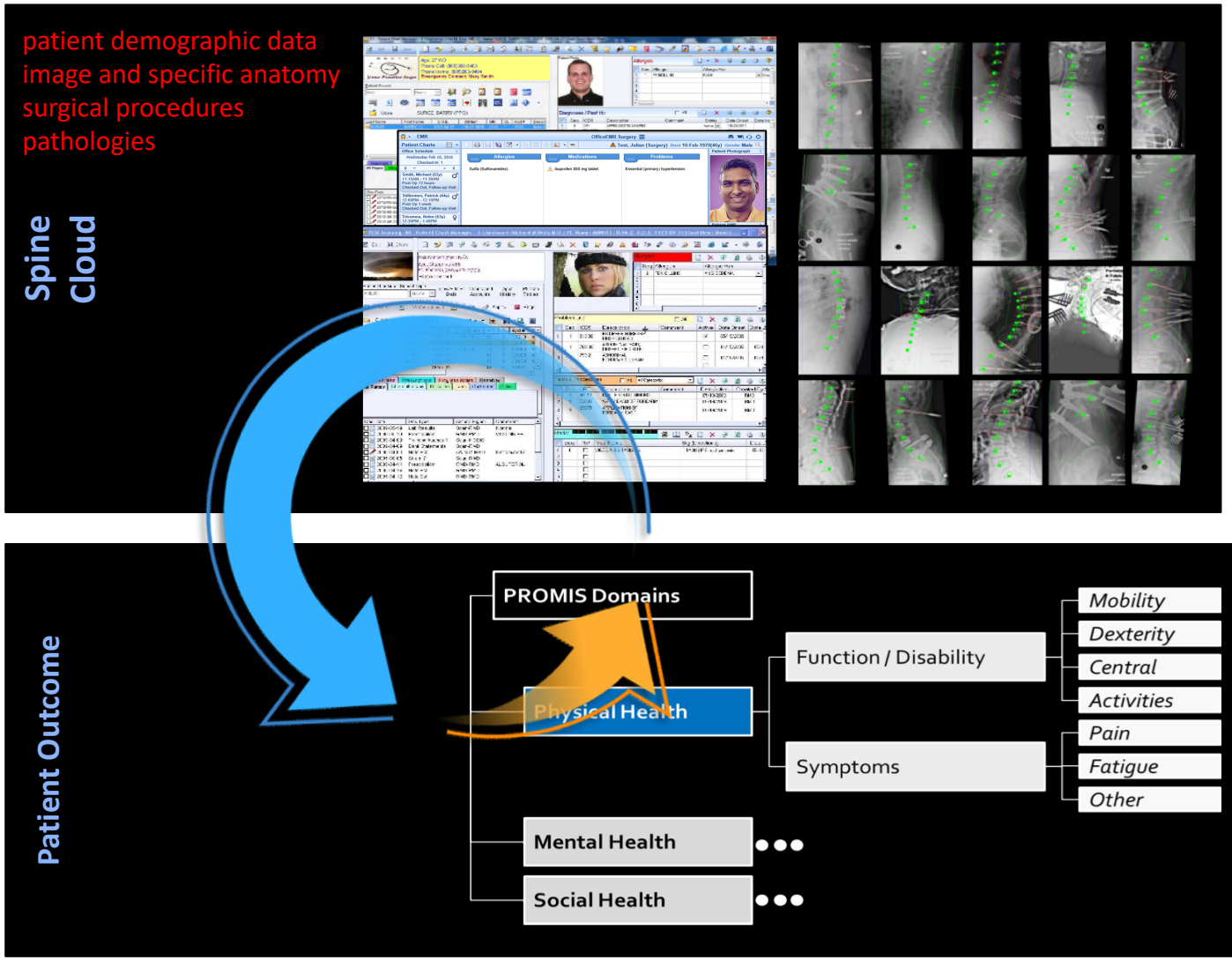
- Overall: To Develop and Test the “max-flow/min-cut” segmentation method for spine CT images
- Project Milestones
  - **Minimum** deliverable (3/9): Extend initial algorithm for automatic segmentation of spine CT and larger datasets
  - **Expected** deliverable (3/23): Evaluate accuracy vs. parameter selection on N=20 spine CT dataset (already manually segmented)
  - **Expected** deliverable (4/20): Accurate segmentation of N=200 spine CT dataset from The Cancer Imaging Archive (TCIA)



Background and Motivation

- ”Spine Cloud” – a big data approach to improve spine surgery outcomes
- Correlate defined clinical variables and anatomical quantification to patient surgical outcomes
- Inform future spine surgeries to create more favorable and consistent outcomes.

*Classified

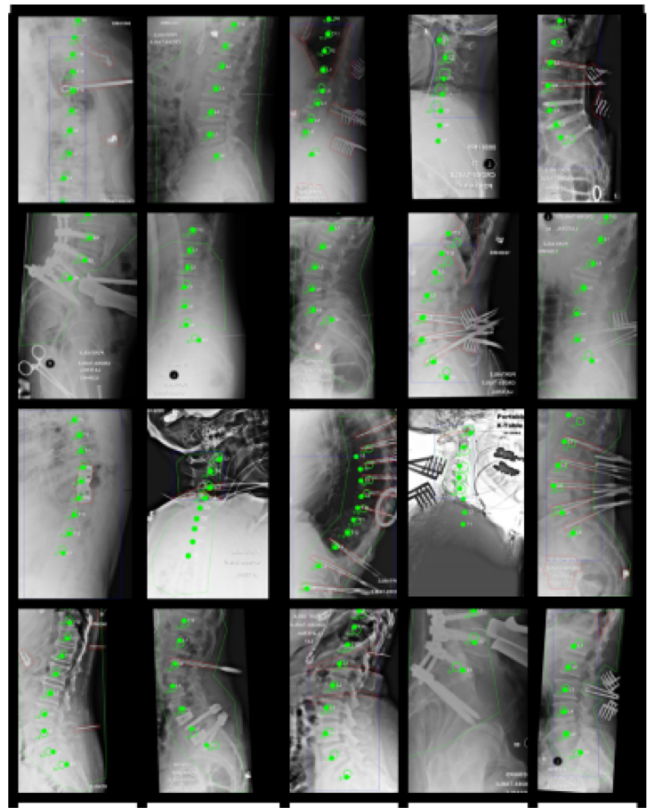


Background and Motivation

Challenge: A necessary component of “Spine Cloud” is a **large database** of annotated spine CT images based on accurate, automatic segmentation

Manual Segmentation is **time-consuming**, but **accurate**

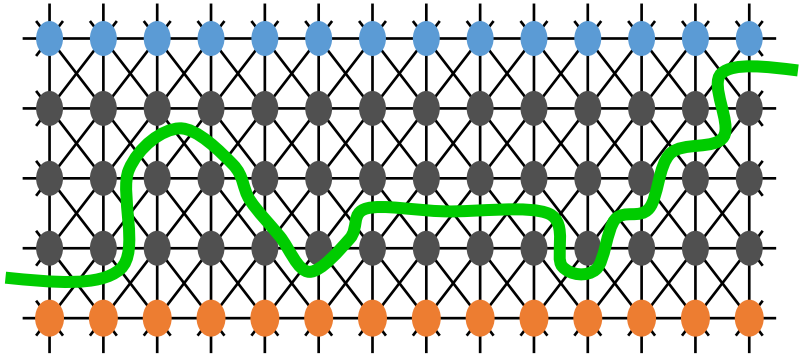
N=20 Dataset took an entire summer to segment



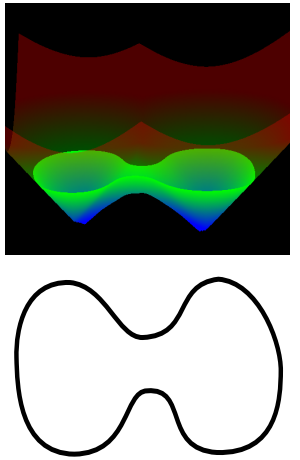
Technical Overview: Auto-Segmentation

- Simple techniques
  - Thresholding & Region Growing
  - Pros: Fast and Easy
  - Cons: Voxels are considered independently → Does not account for local neighborhood relations like smoothness and curvature (which is useful when segmenting anatomy)
- State-of-the-art techniques
  - **Max-flow/Min-Cut**
  - Machine Learning
  - Level Sets
  - All have comparable accuracies

Graph Cuts

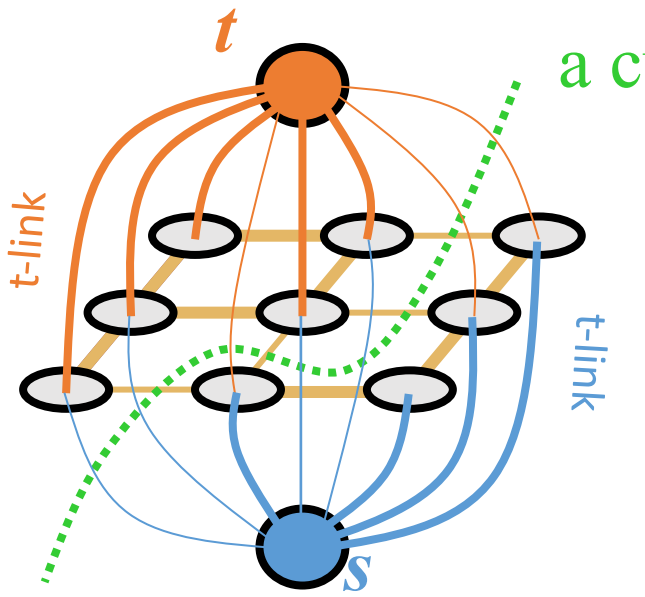


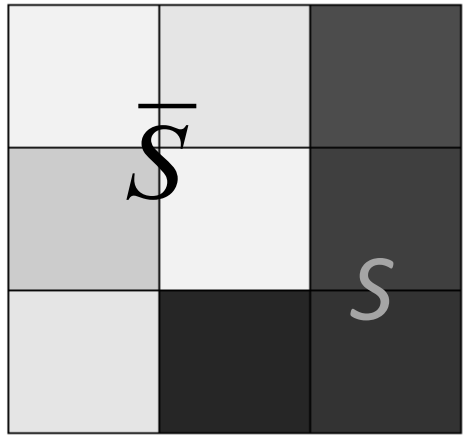
Level Sets



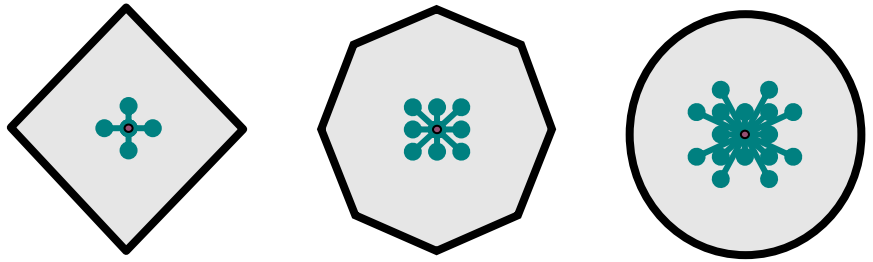
Technical Overview: Max Flow/ Min Cut

- Two types of nodes
  - Voxel Nodes
  - Terminal Nodes
- Nodes connected by edges
- Determining edge weights
  - Hounsfield intensities
  - Gradients
- Parameters
  - Weight-defining parameters
  - Number of neighborhood links





segmentation



Deliverables

- Minimum Deliverable:
  - Assess accuracy of N=20 segmented dataset
  - Implementation of Max-flow/Min-cut extended to spine CT
- Expected Deliverable:
  - Analysis of Parameter Sensitivity
  - Evaluation of Segmentation Accuracy
  - Generation of a large (N=200) segmented dataset
- Maximum Deliverable:
  - Methods for patient-specific parameter selection
  - Methods to accommodate spine anomalies

Dependencies

Dependency	Plan to Resolve	Date Expected	Contingency Plan
Access to I-STAR Lab	Gain Access	Completed	-
Workstation / MATLAB	Gain Access / Download	Completed	Remote access using TeamViewer
TCIA Collection (N20 and N200 Datasets)	Obtain from Mentors	Completed	-
Existing Generalized Implementation	Obtain from Mentors	Completed	-
Max Flow / Min Cut Segmentation Method	-	-	Consult Mentors & Explore alternative segmentation methods
Mentor Scheduling	Consult Mentors	Completed (Weekly meetings)	Skype / Accommodate with remote meetings

Project Timeline

		February			March					April				May		
		9	16	23	2	9	16	23	30	6	13	20	27	1	8	15
	Code and Documentation															
Pre-Deliverables	Literature Review															
	Gain Familiarity with 3D Data and Software															
	Setup workstation in I-Star Lab															
Minimum Deliverables	Validation of N20 Reference Set															
	Max-flow / Min-Cut implementation for Spine															
Expected Deliverables	Analysis of Parameter Sensitivity															
	Evaluation of segmentation accuracy															
	Segmentation of N200 dataset															
Maximum Deliverables	Patient-specific parameter selection															
	Accommodate spine irregularities															

Breakdown of Work

- Most tasks will be completed together
  - Exercise team coding practices
- Niko
  - Analysis of parameter sensitivity
  - Accommodating spine irregularities (i.e. instrumentation, morphology)
- Ben
  - Evaluation of segmentation accuracy metrics
  - Patient-specific parameter selection

Management Plan

- Biweekly team meetings at I-STAR lab (med campus)
- Weekly meetings with mentors to go over progress
- Code repository and documentation on github

Reading List

- Yuan, Jing, et al. “A Study on Continuous Max-Flow and Min-Cut Approaches.” *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 2010
- Boykov, Y.y., and M.-P. Jolly. “Interactive Graph Cuts for Optimal Boundary & Region Segmentation of Objects in N-D Images.” *Proceedings Eighth IEEE International Conference on Computer Vision. ICCV 2001*
- Boykov, Yuri, and Vladimir Kolmogorov. “An Experimental Comparison of Min-Cut/Max-Flow Algorithms for Energy Minimization in Vision.” *Lecture Notes in Computer Science Energy Minimization Methods in Computer Vision and Pattern Recognition*, 2001, pp. 359–374.
- L. Ford and D. Fulkerson. Flows in Networks. Princeton University Press, 1962.