Interactive Graph-Cut Segmentation for Fast Creation of Finite Element Models from Clinical CT Data for Hip Fracture Prediction

Group 21

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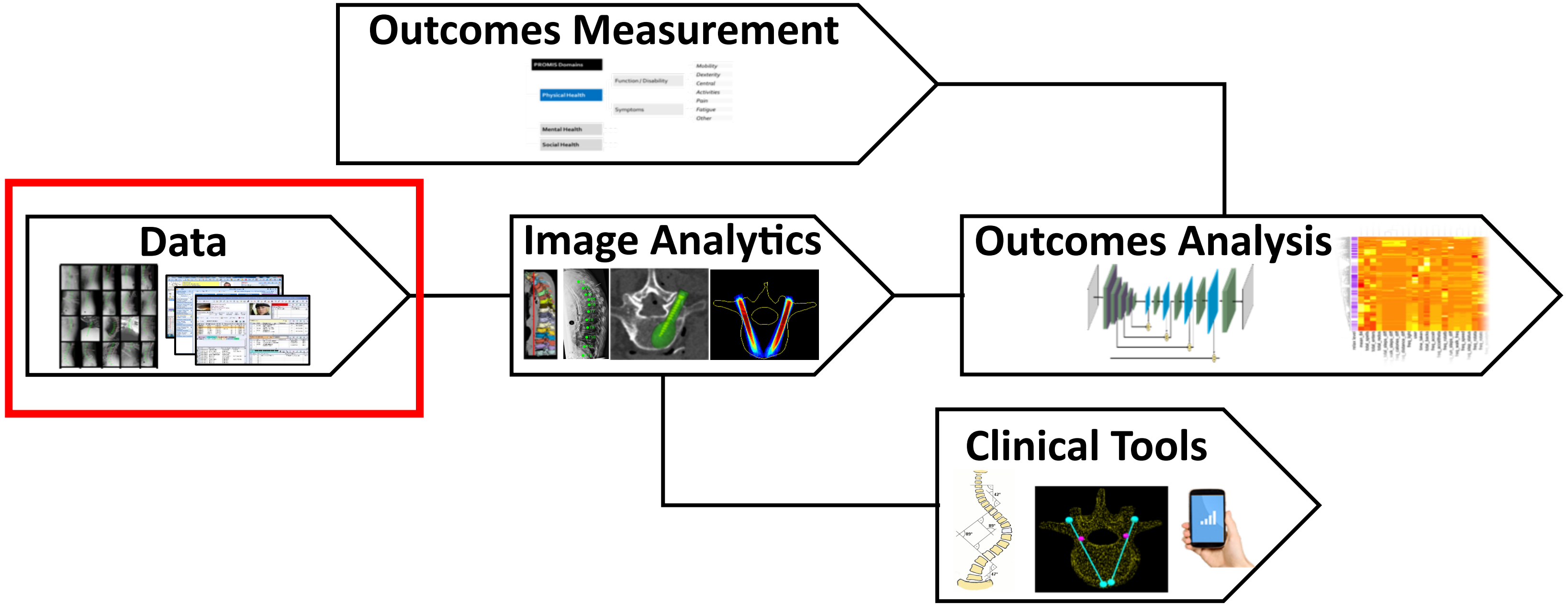
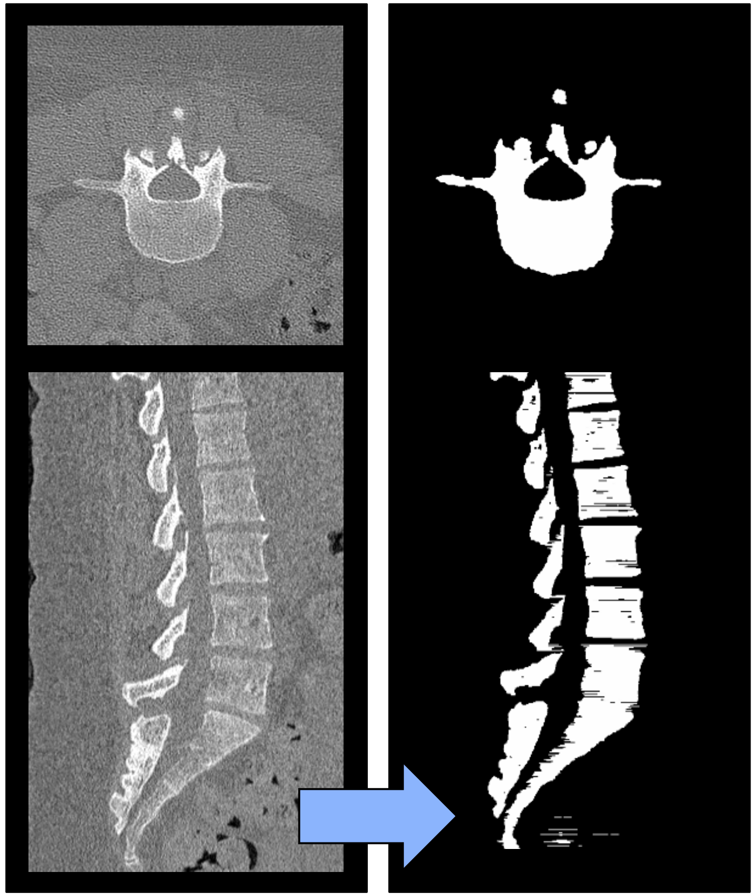
Project Goals

- Develop and test “max-flow/min-cut” segmentation method for spine CT images
- **Main Deliverable**
  - Accurate segmentation of N=200 spine CT dataset





Paper Details

Title

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Date

May 10th, 2016

Journal

Computer Methods in Biomechanics and Biomedical Engineering

Vol. 19, No.16, 1693-1703

Paper Selection

- Paper covers a similar methods to our project
  - Used graph cuts for femur CT segmentation
  - Discusses segmentation validation methods

- Provides additional inspiration for our project

Paper Goals

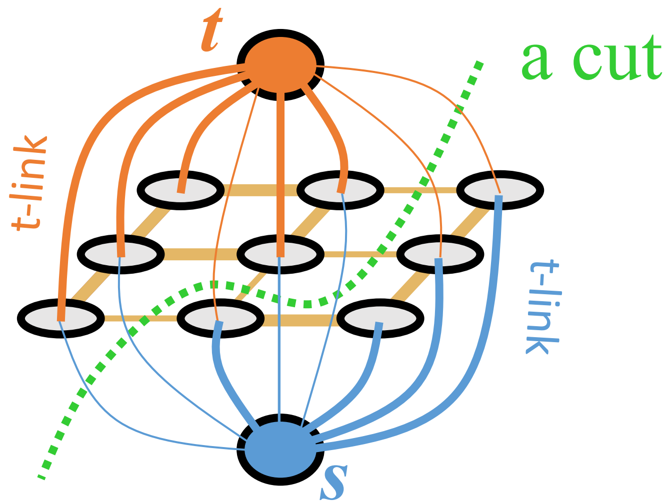
Assess patient risk of hip fracture from a CT scan of femur

- Currently method is not feasible due to inaccuracies, time intensive nature and extra radiation exposure
- Goals
  - Create an automated method for bone segmentation from clinical CT scans
  - Compare the accuracy in femur strength prediction when using manual segmentation

Paper Overview

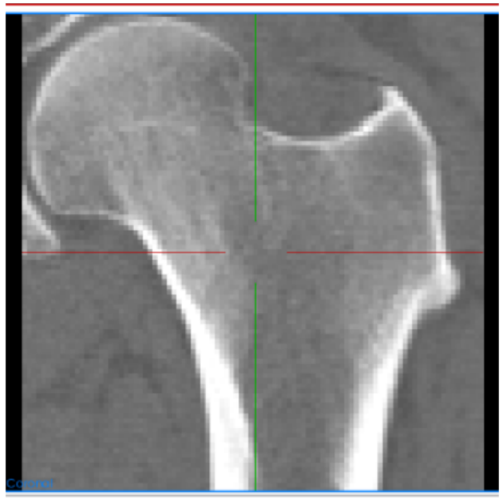
- Data
  - 48 CT scans of “normal”, osteopenic, and osteoporotic femurs
- Two Methods
  - Segmented manually – “Truth”
  - Segmented using graph cuts
- Application of Segmentation
  - Created surface models from segmentation
  - Simulate stresses on femur during a fall

Segmentation Methods



Manual

- Used MITK
- Region growing + touchup/full manual contouring
- Interpolated every other slice



Graph Cut

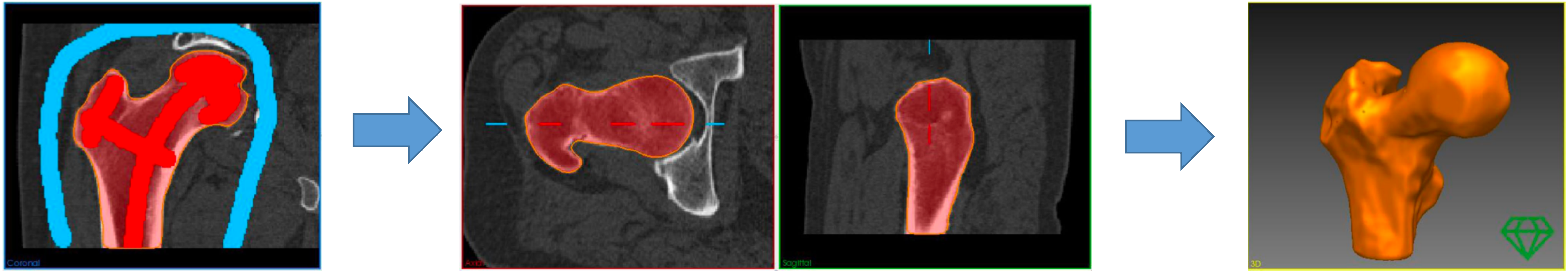
- 3D Max-Flow/Min-Cut Algorithm
- Priors based on user selection
  - Placed in coronal center slice
- Touch-up after segmentation

Creation of Surface Model

Start: Binary mask

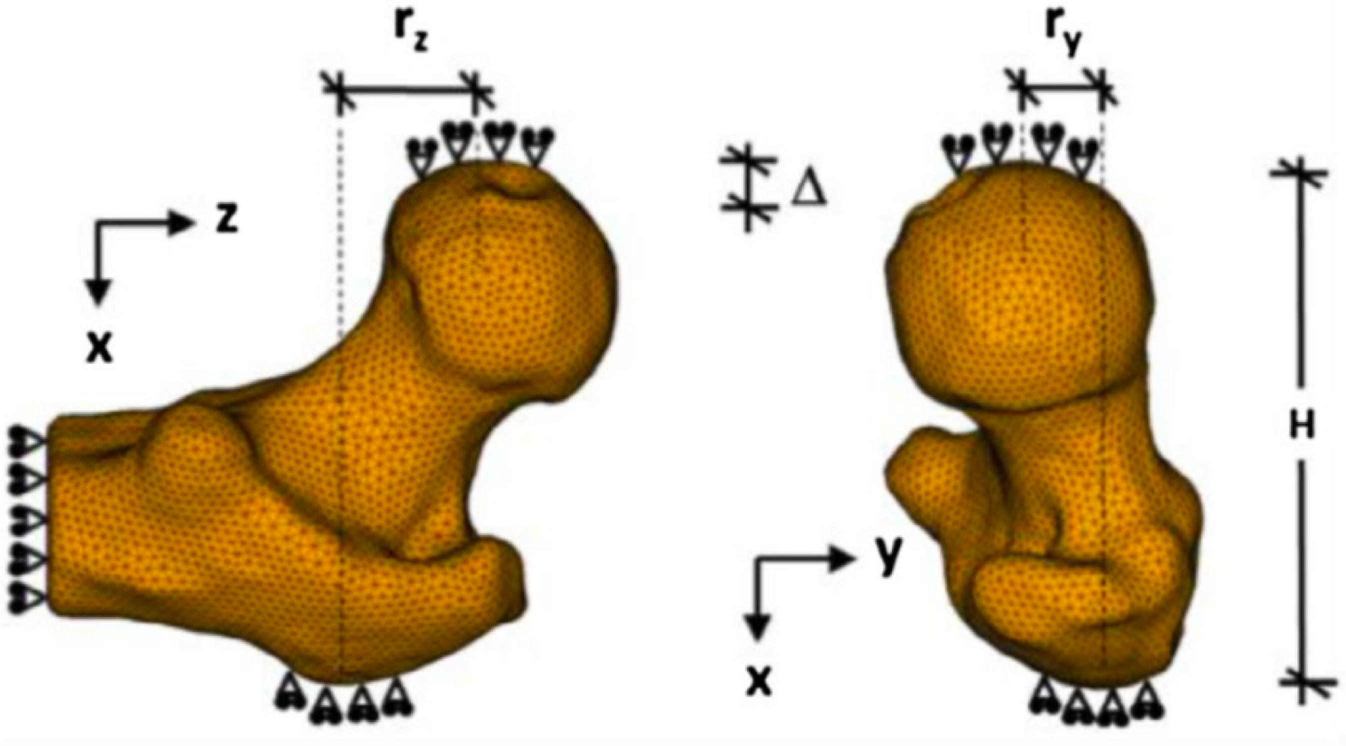
1. Gaussian filter
2. Marching Cubes

End: Meshed anatomy



Stress on Femur

- Density extracted from voxel intensities
- Models simulated stress from a sideways fall on the hip
- Measured
  - Stiffness
  - Force

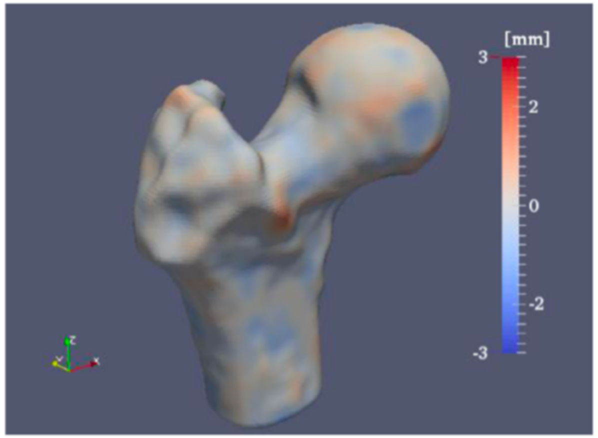


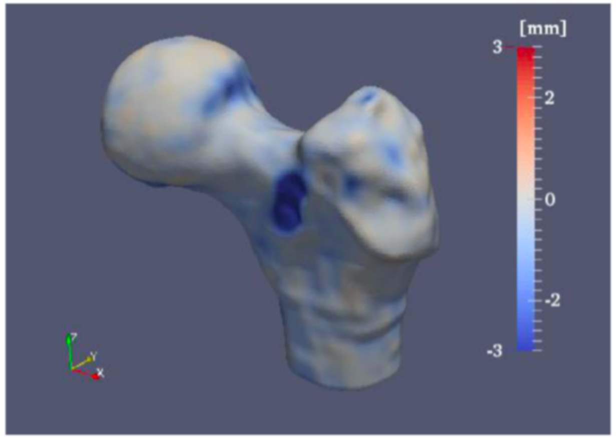
Validation of Segmentation

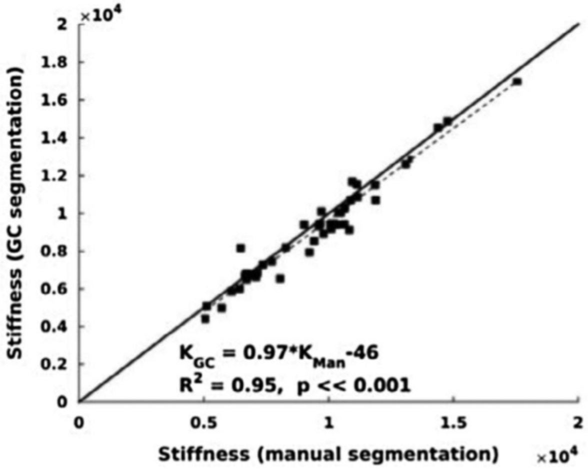
- All 48 bones segmented with both methods by one person
- Inter-operator reproducibility study
  - 12 bones segmented by 2 additional operators
- Metrics
  - Dice Coefficient
  - Hausdorff distance
  - Surface to Surface distance

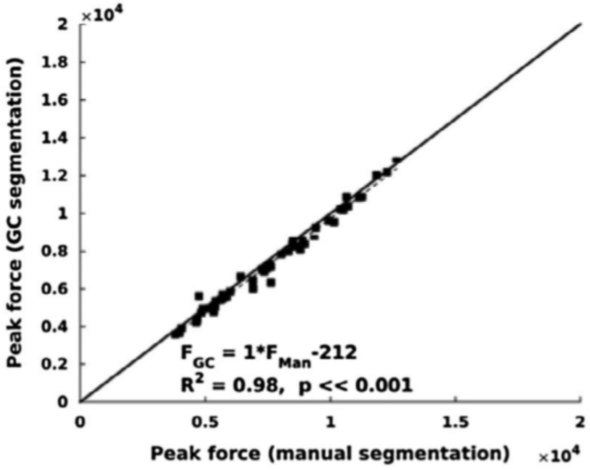
Results

- Segmentation Comparison
  - Hausdorff distance: 3.75 mm ± 1.26
  - Dice Coefficient: 0.973 ± 0.005
  - Surface to Surface: -0.22 mm ± 0.12
- Inter-operator study
  - Graph cuts were very consistent
  - Manual method varied more
- Effect on bone stress
  - Very strong linear correlation
  - Femoral head shape can cause large errors









Conclusion / Paper Assessment

Pros

- Graph cut method achieved similar bone stress profile to the manual method
- Graph cut method is much more efficient than manual method
  - Graph Cut: 2-5 min
  - Manual: 20-35 min
- Graph cut method is consistent for different operators

Cons

- The stress profile can be volatile with regards to the femoral head segmentation
- Manual ”truth” varied based on operator
- Didn’t analyze the performance based on bone quality (“normal” to osteoporotic)

Citation

- Yves Pauchard, Thomas Fitze, Diego Browarnik, Amiraslan Eskandari, Irene Pauchard, William Enns-Bray, Halldór Pálsson, Sigurdur Sigurdsson, Stephen J. Ferguson, Tamara B. Harris, Vilmundur Gudnason & Benedikt Helgason (2016) Interactive graph-cut segmentation for fast creation of finite element models from clinical ct data for hip fracture prediction, Computer Methods in Biomechanics and Biomedical Engineering, 19:16, 1693-1703, DOI: 10.1080/10255842.2016.1181173