Statistical Atlas of the Knee

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Outline

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  - What are the applications?
  - Basic atlas construction process
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Project Summary

• Improve and automate the statistical atlas building pipeline developed by Gouthami Chintalapani at the Johns Hopkins University

• Build a statistical atlas of the knee using CT images
What is a statistical atlas?

- A **model** of an organ that captures the **inherent anatomical variability** in the given training population.

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http://engineering.mines.edu/image/project/8-pelvic_coordinate_system1.jpg
Applications

• Monitoring disease progression
• Accounting for anatomical variation in large populations
• Surgical planning
• Post-operative evaluation
Basic Atlas Construction Process

1. **Model representation**
   - Template CT
   - Template Mesh

2. **Model alignment**
   - Model Creation and Correspondence (Registration)
   - Meshes

3. **Statistical analysis**
   - Principal Component Analysis
   - Basis Vectors
   - Mean Mesh

4. **Bootstrapping**

*Shamelessly stolen from G. Chintalapani’s PhD dissertation*
Step 1: Model Representation / Paramaterization

- Select template image
- Segment the anatomical region
- Labelled raw binary volume
- Mesh the labelled Region (tetsplit)
- Template Mesh Files

Anonymized, sorted training CT data

Preprocess the rest of the CT data

Raw, Binary, Downscaled Data

Segmentation is done manually with Analyze. It will be semi-automated with ITK-SNAP.
Step 2: Model Correspondence / Alignment

- Training volumes
- Template mesh
- MJOLNIR 3D-3D deformable registration
- Warped volume
Step 3: Statistical Analysis

1. Registered Mesh Instances
2. Compute The Mean Mesh
3. Perform PCA
4. Principal Components And Eigenvalues
Goals, Motivation & Significance

• making the segmentation semi- or fully-automated
  – Less prone to human error
  – Less time consuming

• automating the pipeline
  – More accessible to non-programmers

• build a statistical atlas of the human knee
  – Will be used to perform post-operative evaluation of ACL surgeries
Technical Approach - Milestones

1. Create a statistical atlas of the knee with the current pipeline (by the end of February)
   - Understand the components and limitations
2. Obtain a semi-automated segmentation method (by spring break)
   - Replace Analyze with ITK-SNAP
   - Evaluate the performance of the substitute
3. Automate the pipeline
   - Write a shell script to guide the user through the process
4. Estimate the position of the ACL tunnel from post-operative CT scans
   - Use image processing toolkit
Deliverables

• **Minimum**
  – Replace Analyze in the pipeline (used for preprocessing of images) with ITK-SNAP
  – Replace Analyze with MATLAB to perform other image processing tasks
  – Automate the pipeline developed by Gouthami Chintalapani
  – Build a statistical atlas of the bone structures of the knee

• **Expected**
  – Develop a semi-automated method for segmentation of the knee
  – Estimate bone tunnel locations using post-operative CT scans of ACL surgery patients
  – Prepare detailed documentation of the improved pipeline

• **Maximum**
  – Develop a fully automated method for segmentation of the knee
  – Develop a 3D-3D model-based registration algorithm
Dependencies

- Knee or leg CT image datasets
  - Post-operative CT scans (Hong Kong dataset provided by Ben)
  - Whole leg CT (Hopkins dataset, pending IRB approval)
- Computer for software development
  - Lab desktop: femur.compscidhcp.jhu.edu
- Software required for the atlas building pipeline
  - MATLAB, Analyze, Insight Toolkit (ITK), ITK-SNAP, Mjolnir, tetsplit, FANTASM
  - Gouthami’s scripts
- Linux account on the Stomach server
- Understanding of Gouthami’s atlas building pipeline
  - Written reference documentation
  - Gouthami’s PhD dissertation obtained from CS department
- Poster printing budget
  - For a 2x3 feet matte print at Digital Media Center: $32.55 (or $42.00 if paid using budget code)
- People
  - Ben and Dr. Taylor for continued help and guidance
Management Plan

• Regular weekly meetings with Ben
• After reaching each milestone, the remaining plan will be revised.
• Attend SARR meeting
• If IRB approval cannot be obtained for the Hopkins dataset, focus efforts on the Hong Kong dataset
• We will collaborate on each task and share responsibility equally.
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Reading List


