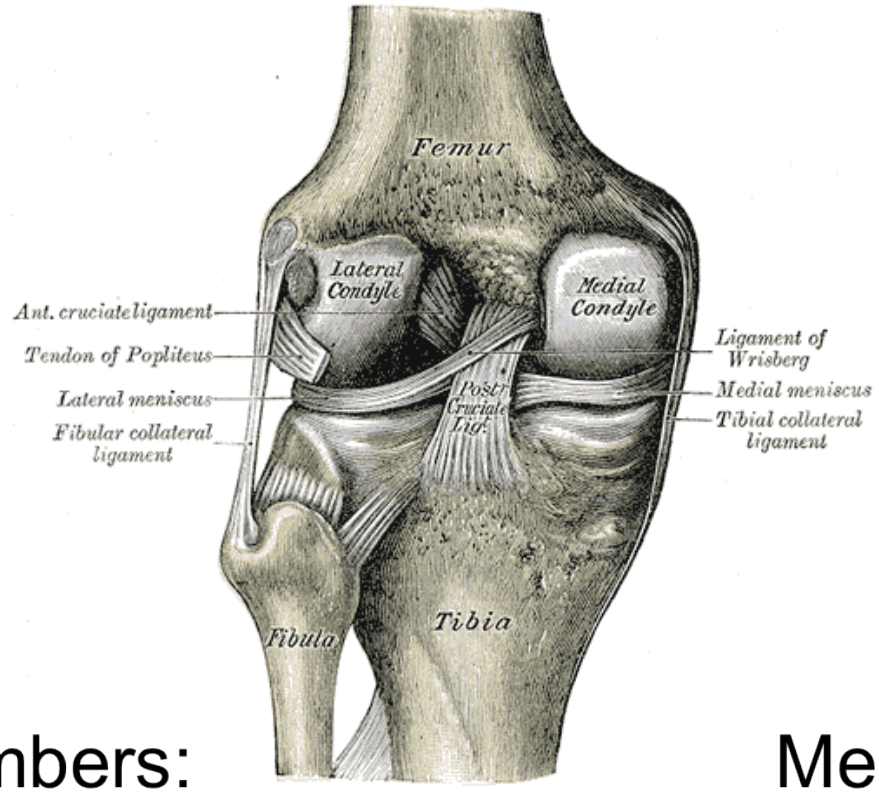
Statistical Atlas of the Knee



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Outline

- Project summary
- Background
  - What is a statistical atlas?
  - What are the applications?
  - Basic atlas construction process
- Goals, Motivation & Significance
- Technical Approach
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- Management Plan
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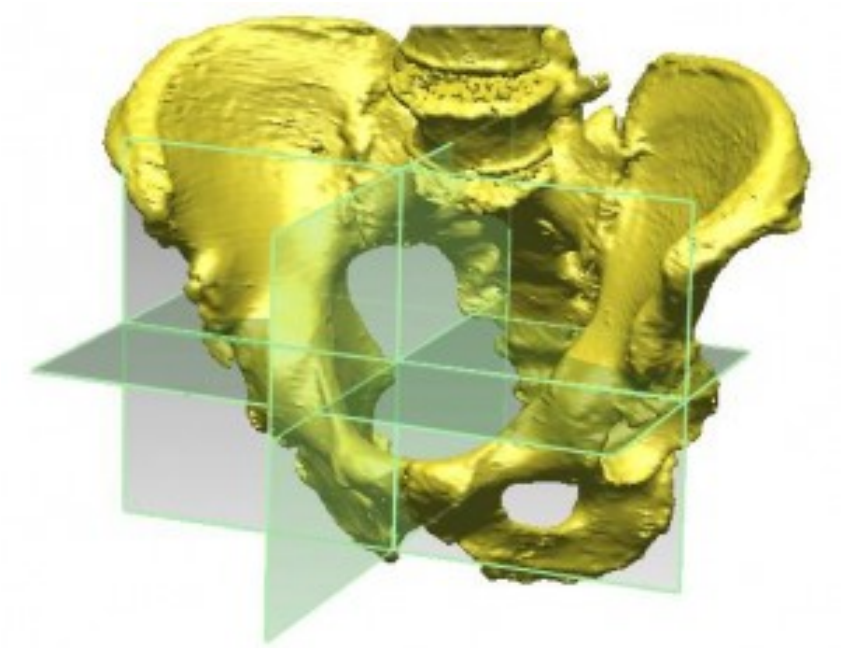
Project Summary

- 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?

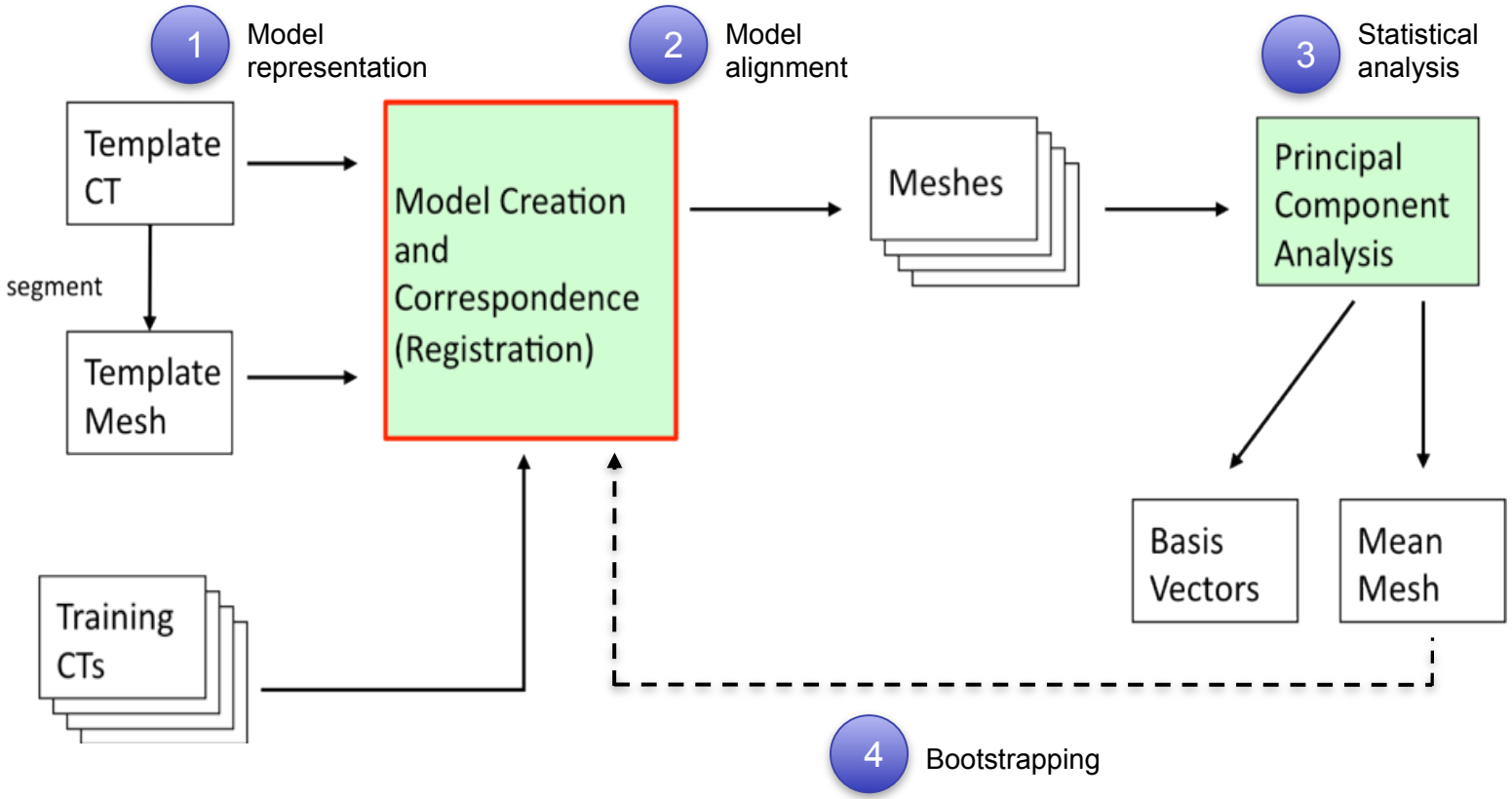
- A **model** of an organ that captures the **inherent anatomical variability** in the given training population.



Applications

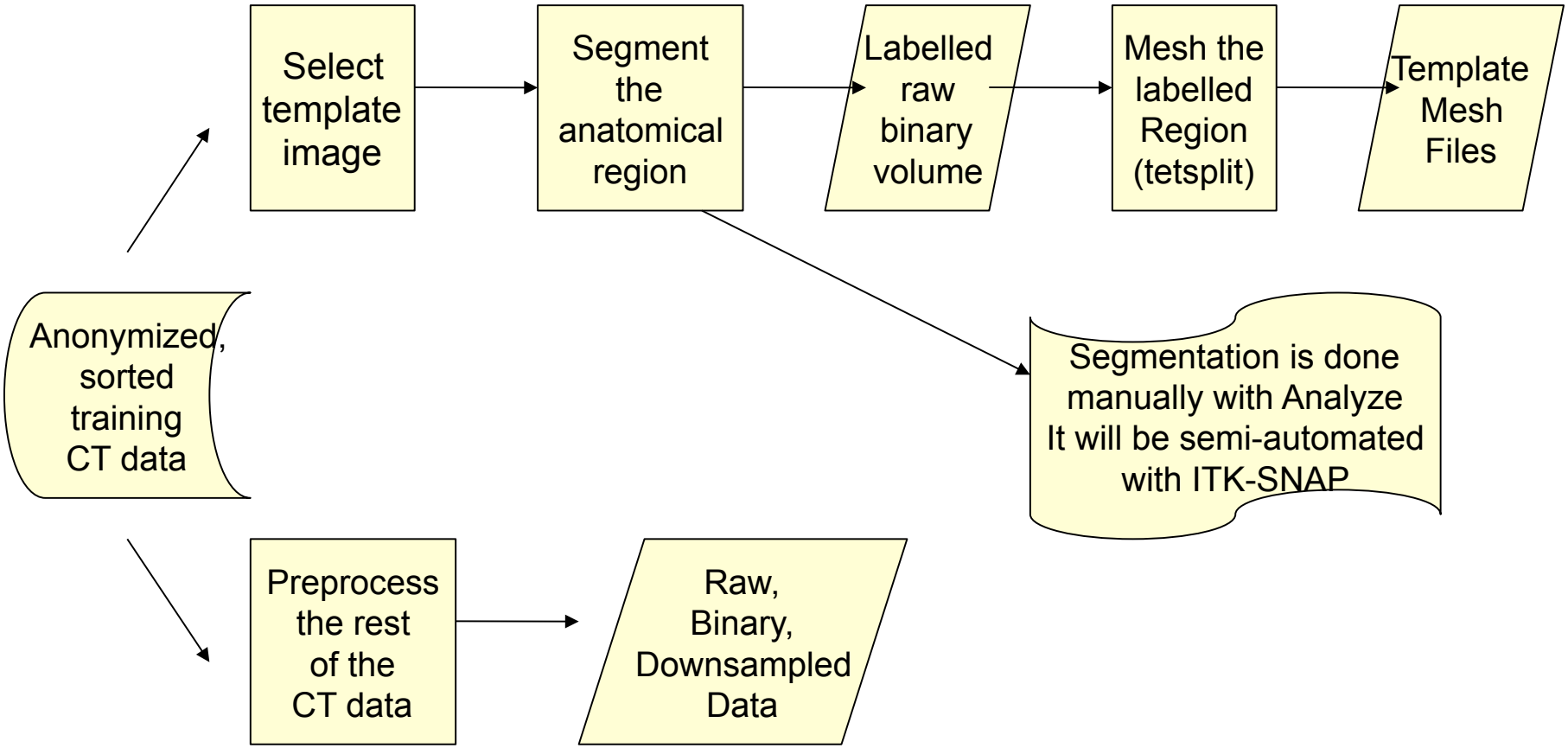
- Monitoring disease progression
- Accounting for anatomical variation in large populations
- Surgical planning
- Post-operative evaluation

Basic Atlas Construction Process

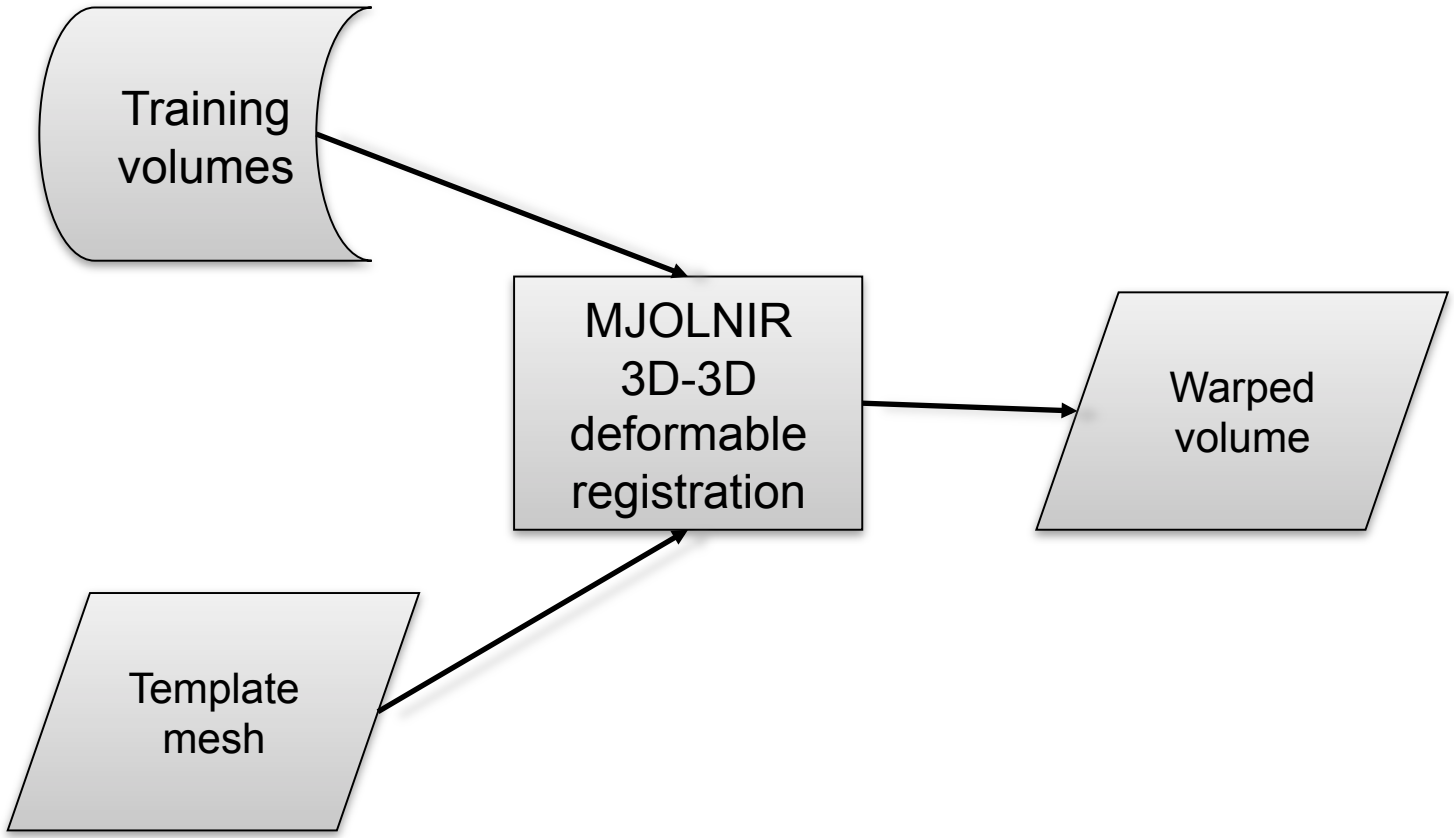


Shamelessly stolen from G. Chintalapani's PhD dissertation

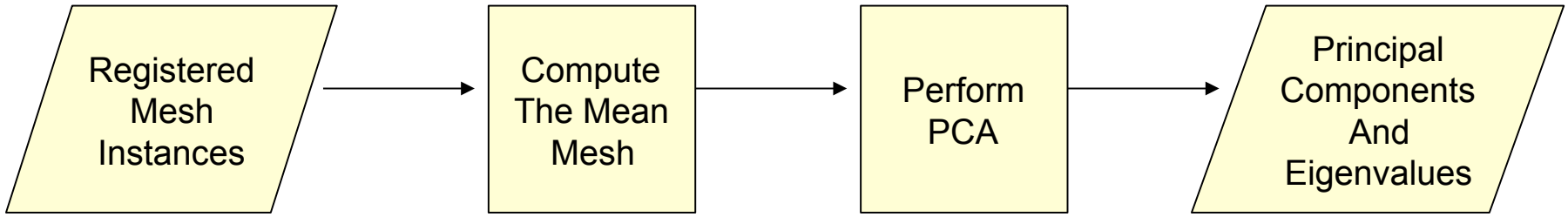
Step 1: Model Representation / Paramaterization



Step 2:
Model Correspondence / Alignment



Step 3: Statistical Analysis



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.

Timeline

Task \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Project Proposal Presentation							Spring break							Project presentation
Background Reading														
Understand current pipeline														
Run pipeline, obtain preliminary knee atlas														
Automate segmentation														
Automate the pipeline														
Build knee atlas from CT images														
Bone tunnel estimation														
Documentation														
Prepare poster and submit for printing														

Reading List

1. M.A. Baldwin, J.E. Langenderfer, P.J. Rullkoetter, and P.J. Laz. Development of subject-specific and statistical shape models of the knee using an efficient segmentation and mesh-morphing approach. Computer Methods and Programs in Biomedicine 97 (2010) 232–240.
2. G. Chintalapani. *Statistical Atlases of Bone Anatomy and Their Applications*. Diss. Johns Hopkins University, 2010.
3. G. Chintalapani, L.M. Ellingsen, O. Sadowsky, J.L. Prince, and R.H. Taylor. Statistical Atlases of Bone Anatomy: Construction, Iterative Improvement and Validation. MICCAI, 2007. Part I, LNCS 4791, pp. 499-506. N. Ayache, S. Ourselin, A. Maeder (editors).
4. L.M. Ellingsen, G. Chintalapani, R.H. Taylor, and J.L. Prince. Robust deformable image registration using prior shape information for atlas to patient registration. Computerized Medical Imaging and Graphics 34 (2010) 79–90.
5. T. Heimann, H. Meinzer. Statistical shape models for 3D medical image segmentation: A review. Medical Image Analysis 13 (2009) 543-563.
6. H. Seim, D. Kainmueller, H. Lamecker, M. Bindernagel, J. Malinowski, and S. Zachow. Model-based Auto-Segmentation of Knee Bones and Cartilage in MRI Data. http://www.diagnijmegen.nl/~bram/grandchallenge2010/215.pdf.