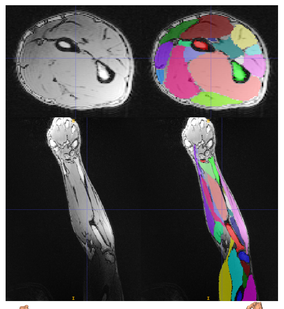
Automatic MRI Bone Segmentation

Toki Migimatsu, Advisor: Gordon Wetzstein
Department of Computer Science, Stanford University

Motivation

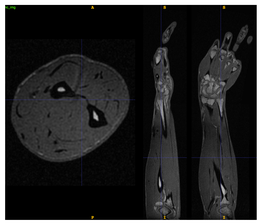


Magnetic Resonance Imaging (MRI) provides a safe and non-invasive way to study internal tissues and create detailed **musculoskeletal models** of the body. Aside from **clinical applications**, these models can be used in areas ranging from **character animation** to **assistive robotics**, where accurate models of human motion are important.

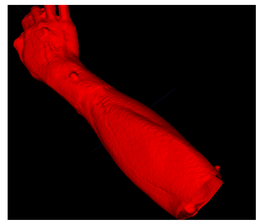
However, obtaining these musculoskeletal models requires **manual segmentation**, a prohibitively time-consuming process; **segmenting one knee alone takes an expert hours** [1].

Automatic segmentation could allow the **mass generation** of musculoskeletal models.

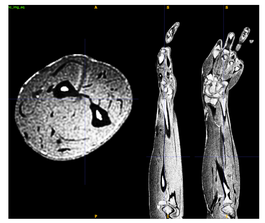
Segmentation Technique



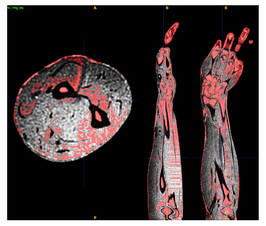
Original



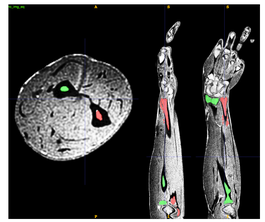
Mask: LoG, Morphological Close



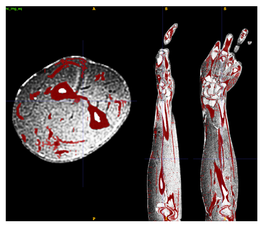
3D Adaptive Equalization



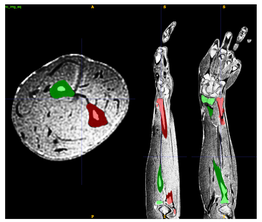
Trabecular: 2-pass Bright-on-Dark MSER



Trabecular: Connected Components



Cortical: Dark-on-Bright MSER



Cortical: Connected Components

Challenges & Future Work

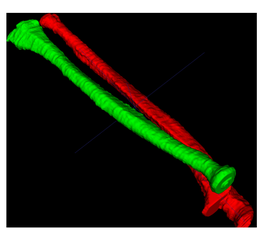
Current methods for automatic segmentation rely on **prior datasets to generate new segmentations** [1]–[3]. However, large databases of manual segmentations are unavailable for most bones. Other methods are **semi-automatic** [4] [5], and require rough manual segmentations to start. Examples of fully automatic segmentation do not exist in literature.

Challenges in automatically segmenting MRI include **low signal-to-noise**, **highly inconsistent lighting**, and **varying appearances of a single bone** due to the trabecular and cortical tissues.

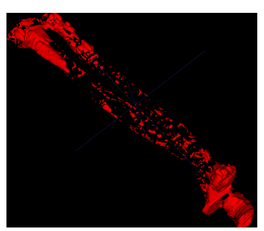
Future work includes experimenting with an MSER algorithm that uses **3D level sets** (instead of running 2D MSER along multiple axes), and refining the segmentation method to work on **bones with smaller cortical layers**.

[1] 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," in *Proc. MICCAI Workshop Medical Image Analysis for the Clinic*, Ed., 2010.
[2] J. Schmid and N. Magnenat-Thalmann, "Mri bone segmentation using deformable models and shape priors," English, in *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2008*, vol. 5241, Springer Berlin Heidelberg, 2008.
[3] Y. Xia, S. Chandra, O. Salvado, J. Fripp, R. Schwarz, L. Lauer, C. Engstrom, and S. Crozier, "Automated mr hip bone segmentation," in *Digital Image Computing Techniques and Appli- cations (DICTA), 2011 International Conference on*, Dec. 2011.
[4] A. Rusu, *Segmentation of bone structures in magnetic resonance images (mri) for human hand skeletal kinematics modelling*, 2011.
[5] E. Jolivet, E. Dion, P. Rouch, G. Dubois, R. Charrier, C. Payan, and W. Skalli, "Skeletal muscle segmentation from mri dataset using a model-based approach," *Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization*, 2014.

Experimental Results

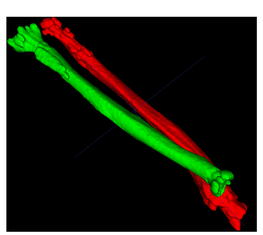


Ground Truth

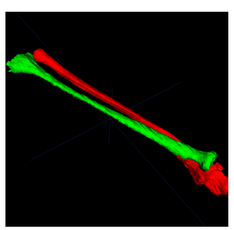


Error

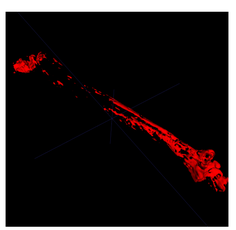
Accuracy: 98.30%
False positives: 0.60%
False negatives: 0.10%



Automatic Segmentation

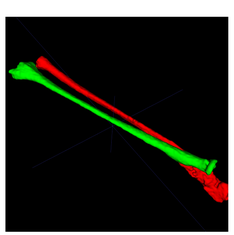


Ground Truth

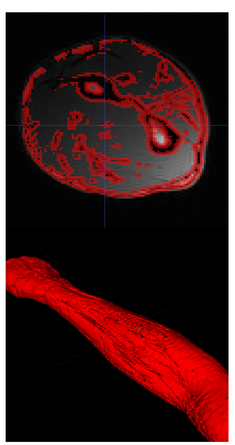


Error

Accuracy: 97.78%
False positives: 0.02%
False negatives: 2.20%



Automatic Segmentation



Failed attempt: 3D Sobel