

<http://www.cs.ucf.edu/~bagci>

[PROGRAMMING ASSIGNMENT] (2)

MEDICAL IMAGE COMPUTING

DR. ULAS BAGCI • (SPRING) 2016 • UNIVERSITY OF CENTRAL FLORIDA (UCF)

Coding Standard and General Requirements

Code for all programming assignments should be **well documented**. A working program with no comments will receive **only partial credit**. Documentation entails writing a description of each function/method, class/structure, as well as comments throughout the code to explain the program flow. Both main code and necessary *cmake* files need to be submitted.

Submit by **9th of March 2016**, 11.59pm.

Graph-Cut Image Segmentation [10 pts]

Implement Boykov/Kolmogorov's Max-Flow/Min-Cut algorithm for 3-D medical image segmentation problem. Specifically, you will be given three different MRI sequences of the same patient's thigh scans. You are responsible to extract/delineate the following tissues with graph-cut algorithm: *fat*, *bone*, and *muscle*. Please see figure below for identification of the tissues.

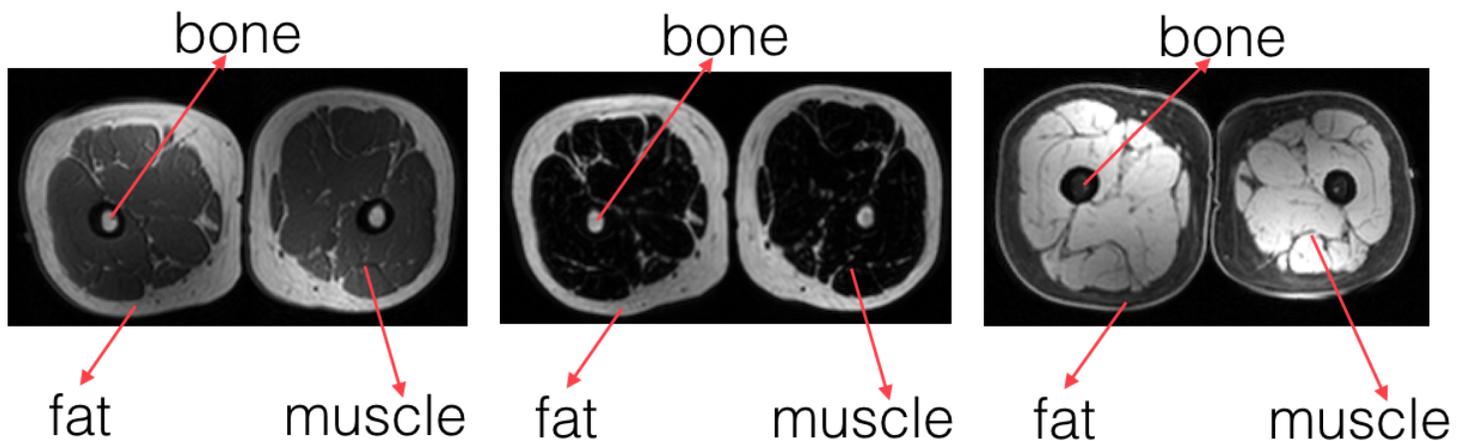


Figure 1: Three different MRI sequences are illustrated. Each thigh image pertaining to the same subject. Images (above) are having in-plane resolution of $288 \times 288 \times 20$, with voxel sizes of $1.389 \times 1.389 \times 2.1$ mm (i.e., x, y, and z dimensions are given in mm).

Motivation: Interestingly, amount of fat, muscle, and bone tissue in thigh region is associated with many diseases including aging, diabetes, and COPD. MRI can be used to measure these tissues non-invasively, and your task is to make this whole operation automatic, fast, and reliable.

Your tasks:

- Download 3 MR images from the webcourse. They are in nifti (.nii) format and readable by ITK.
- Segment fat, bone, and muscle tissues for each MRI modalities, and output results as binary images (i.e., includes 0s for background and 1s for objects)
- Compute volume of each tissue and report them in mL . Note that $1 mL=1000 mm^3$. Once you segment the images, then it is fairly easy to count voxels with label 1s (i.e., object of interest), and then multiplying the total voxel count with voxel dimensions will give you the volume in mm^3 .
- You will *not* have ground truth images to quantitatively measure how good your segmentation algorithm is; however, visually you can test your results with optimized parametrization.
- You can use the same images to train your algorithm (for instance data term in Graph-Cut).
- You may want to clean MR images first if you desire. In any case, it is strongly suggested that you remove bias field from MR images if there is any, and there should be denoising algorithm conducted prior to segmentation process. Make sure that your denoising algorithm will preserve edges while smoothing large areas.
- In your *short report*, please explain which image is good for what kind of tissue based on your observations and experimental results in this particular thigh segmentation problem.
- You can use ITK-SNAP, SLICER or other free software for 3D visualization of the segmentation result as follows (example): open ITK-SNAP, load your input image, and then load the segmented image (your binary output) as "segmentation mask". Left corner, you will see update button. Click update button and see the segmentation results in 3D. It is a good habit to load your image into the visualization software and then "fuse" segmentation in different color (with opacity) for visual inspection. See figure below.
- You will be credited based on the performance of your algorithm.
- BONUS [+5] If you can *automatically* separate both legs and report the volume of tissues for each legs, you will get extra credits for this work.
- BONUS [+5] If you add/design a new cost term for the graph-cut formulation of MRI volume of the thigh and your segmentation results improve, you will get extra credits for this work.

Some example ITK codes can be found in the following:

<http://www.itk.org/ItkSoftwareGuide>

<http://itk.org/Wiki/ITK/Examples>

Example code for **difference operation on two images**:

<http://itk.org/Wiki/ITK/Examples/ImageProcessing/SquaredDifferenceImageFilter>

Graph-Cut example C++ Code can be found in the following:

<http://vision.csd.uwo.ca/code>

(you are allowed to use existing codes in ITK too)

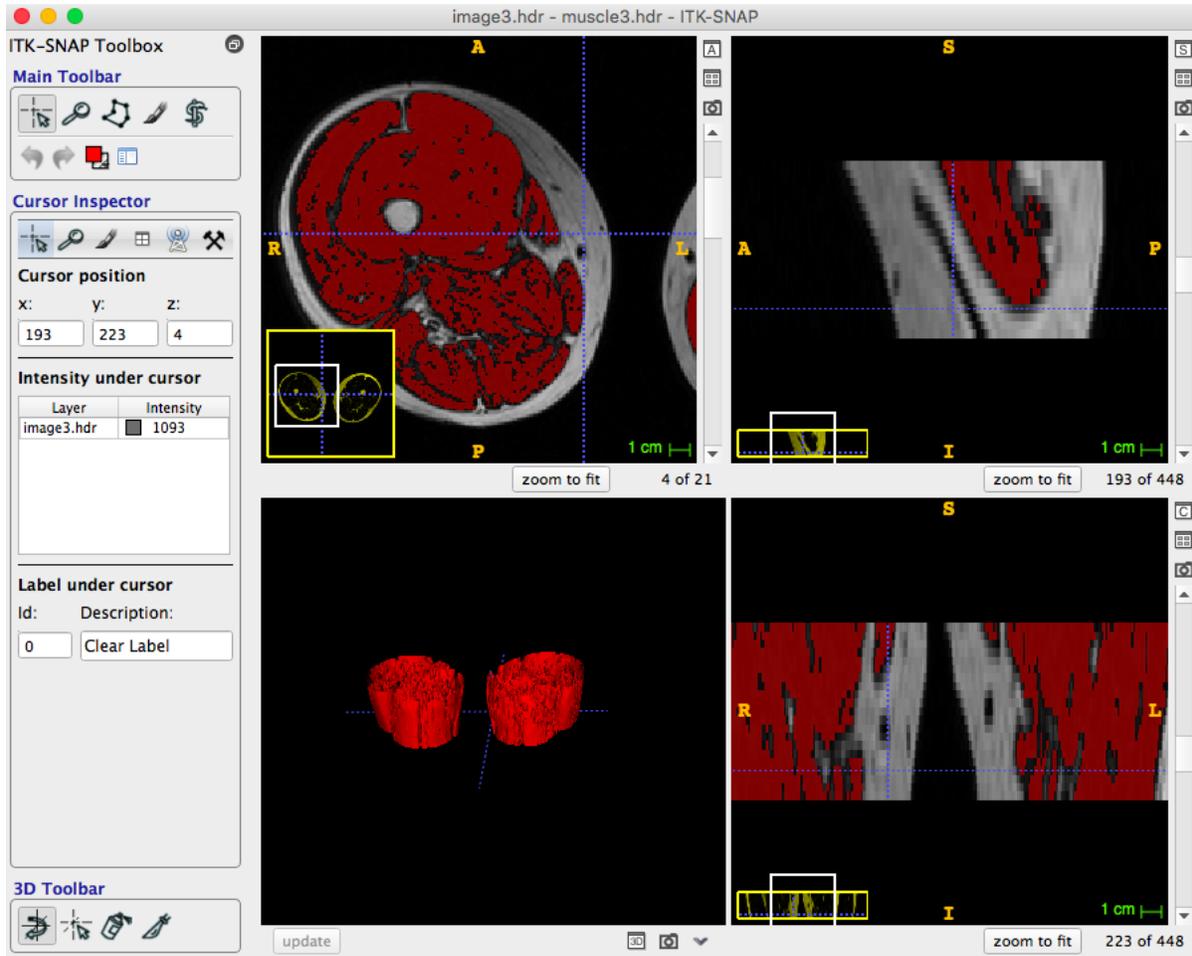


Figure 2: Segmented muscle from a specific sequence MRI is shown. For each MRI, you are expected to have 3 binary images (fat, bone, and muscle), or you can represent these three tissue in a single output file too (1 for fat, 2 for bone, and 3 for muscle in the encoded output). Feel free to use either way.