BME42-731/ ECE18-795/CB02-740 Bioimage Informatics
Spring 2014
Project Assignment #4

Image Segmentation

Assigned on Apr-09-2014
Report due on May-05-2014 by 5PM in TA's office.
Groups 5 & 6 will give presentations at scheduled time.

A. Overview

The focus of this project is on image segmentation techniques. As in previous projects, please use the image data provided. The assignment is organized into two parts.

In the first part you are asked to study and test several image segmentation algorithms that are implemented in the ITK software package. An overview of ITK is provided at the end of this file. Specifically, you need to call the segmentation functions provided by ITK in MATLAB through the MAT-ITK interface, which was developed at Simon Fraser University.

In the second part you are asked to study and test several graph-cut and active-contour image segmentation algorithms. For this part you are asked to download related code from the web and then test them on provided images.

The total score for this project assignment is **140** points.

B. Part I: Image segmentation using MAT-ITK (total score = 80 points)

B.1 MAT-ITK and image data

The MAT-ITK package and the image data set can be downloaded from the course portal in CMU blackboard (http://www.cmu.edu/blackboard/).

The data set is divided into two parts. The first part consists of two static images (60x_02.tif, Blue0001.tif). The second part is a time-lapse image sequence of mitochondria transport within Drosophila segmental nerves.

B.2.1 Segmentation of static images

Apply the two segmentation techniques assigned to your group to the two static images (20 points). We will assign these techniques randomly to each group.

B.2.2 Segmentation of image series

Apply the two segmentation techniques assigned to your group to the time-lapse image sequence and generate AVI movies to visualize your segmentation results. (20 points)

B.2.3 Theoretical background

In your report and presentation, give an outline of the theoretical background for each of the two algorithms chosen by your group. Feel free to use any references that are relevant. **Be sure to identify and explain key equations.** (40 points)

For B.2 and B.3, it is expected that you will research the document provided by the ITK project. Whenever applicable, you are expected to tune related parameters for optimized performance and to use image morphology operations to further improve the segmentation results. Results from all groups will be compared.

C. Part II: Image segmentation using graph-cut and active contour (total score = 60 points)

C.1.1 Graph cut based image segmentation (15 points)

As you have learned from the reading assignment, there are different graph cut based image segmentation algorithms. You are required to identify two graph-cut algorithms, download the code, and test the algorithms on the same images described in C.2.1 and C.2.2. You will use the implementation provided by the authors but should tune the parameters to optimize the results to the extent possible. To start, please take a look at the following web links:

http://www.cis.upenn.edu/~jshi/software/
http://cs.brown.edu/~pff/segment/

If you need a free C/C++ compiler, please try Microsoft Visual Studio Express.

C.1.2 Active contour based image segmentation (15 points)

Similar to C.1.1, identify two active contour algorithms, download the code, and test them on the same images described in C.2.1 and C.2.2. You will use the implementation provided by the authors but should tune the parameters to optimize the results to the extent possible. The following are some useful links

http://www.iacl.ece.jhu.edu/static/gvf/
http://www.imagecomputing.org/~cmli/DRLSE/

C.1.3 Theoretical background

In your report and presentation, **briefly explain basic principles of the algorithms** chosen by your group. Briefly compare the results using the graph-cut and active contour algorithms with those of the ITK algorithms you have tested. Feel free to use any references that are relevant. (30 points)

D. Report format

Please follow the recommended report format as described in Lecture 09.

Page size: letter
Line space: single
Page margins: no less than 1 inch
Font size: 12 points for the main text; 10 points for listed references

E. Submission of MATLAB code and results

We will follow the same protocol of code and results uploading as in previous project assignments.

Introduction to ITK

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September 2010

ITK (Insight Segmentation and Registration Toolkit) is an open-source, cross-platform system that provides developers with an extensive suite of software tools for image analysis. Since ITK is originally written in C++, MATITK is written, allowing users to access certain ITK algorithms in MATLAB.

To use MATITK, you should copy “matitk.dll” to the desired location, launch MATLAB and set search path of MATLAB or change current directory to the location of “matitk.dll”. For help, you can type matitk('?') in MATLAB’s command window.

Generally, MATITK includes three categories of algorithms, such as: filtering, segmentation, and registration methods. You can type matitk('f'), matitk('s') and matitk('r') respectively to understand the algorithms in each category.

To use one method in MATITK, you need to input in the following format:
matitk(operationName,[parameters],[inputArray1],[inputArray2],[seed(s)Array],[Image(s)Spacing])

1. operationName, specifies the implemented ITK method to be invoked.

2. parameters, specifies the required parameters of the ITK method to be invoked.

3. inputArray1 and inputArray2, specify the input image volume. They must be three dimensional and contain double, float, unsigned char or signed integer data type elements. In the case where a second image volume is not required for the method being invoked, provide [] as the fourth argument.

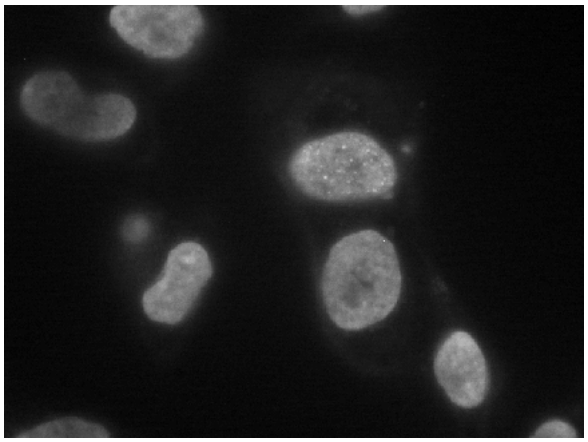
4. seedsArray arguments specify the seed points (in MATLAB coordinate system) in the following order: [x_1, y_1, z_1, x_2, y_2, z_2, …, x_n, y_n, z_n]. Because it is three dimensional, the number of elements in seedsArray should be a multiple of three. In the case where seeding is not required for the method being invoked, provide [] as the fifth argument.

5. The last optional argument specifies the spacing of the supplied image volume. The performance of certain ITK methods may be affected by the spacing. If this argument is omitted, an isotropic spacing of [1,1,1] is assumed.

As you may see above, input data must be 3D, so when you need to process a 2D image, you have to first convert it to a 3D data before using MATITK. Here, I will give an example for nuclei segmentation in a 2D image:

```
% load image and get the size of this image
filename = 'Blue0001.tif';
Img = double(imread(filename));
imgSz = size(Img);

% show original image
figure; imagesc(Img); colormap gray; axis off; axis equal;
```



```
% in order to use matitk, we have to use 3D data
% so we first build a 3D volume of two layers, and each layer
% contains the original image
D = zeros(imgSz(1),imgSz(2),2);
D(1:imgSz(1),1:imgSz(2),1) = Img(1:imgSz(1),1:imgSz(2));
D(1:imgSz(1),1:imgSz(2),2) = Img(1:imgSz(1),1:imgSz(2));

% implement segmentation using Otsu's method
b = matitk('SOT',[max(D(:))], double(D));
figure; imagesc(squeeze(b(:,:,1))); colormap gray; axis off; axis equal;
```

For details of MATITK usage, please see: http://www.sfu.ca/~vwchu/matitkusage.html