Segmentation Using a Region Growing Algorithm

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Abstract

This document describes an example implementation of segmenting the ventricles of the brain using the Insight Toolkit. Ventricle segmentation is done using the simple confidence connected region growing algorithm.

Included with this paper is the source code, input data, parameters and output data used to validate the implementation described in this paper.

Contents

1 Image Segmentation by Region Growing

The basic premise of a region growing algorithm is to start at some point or set of points in an image, called a *seed region*, and then expand that region into neighboring pixels according to some criteria. There are a number of different region growing algorithms that use different criteria to select which neighboring pixels to include in the segmented region.

The confidence connected approach to region growing, as described in the ITK Software Guide [2], first starts at the seed region and computes the mean m and standard deviation σ of the region intensities. Neighboring pixels are included in the segmented region if their intensities fall between $m - f\sigma$ and $m + f\sigma$, where f is a user-defined multiplier which, essentially, determines the "sensitivity" of the algorithm. The process

then repeats for a user-specified number of iterations, recomputing m and σ at each iteration over the entire segmented region.

Selecting the parameter f in the confidence connected algorithm greatly determines the quality of the resulting segmentation. Selecting too low a value for f results in not all of the desired region being selected by the segmentation process; too high a value for f results in too much of the image being selected. In practice, the author found that it was necessary to "tweak" the value of f through trial-and-error to get a better result.

2 Implementation

The example implementation and sample files included with this project demonstrate how to segment the brain ventricles using the `itk::ConfidenceConnectedImageFilter` filter included with the Insight Toolkit (ITK). The sample image used in this document, originally provided by Elizabeth Bullitt [1], was obtained from the MIDAS database and can be found at `http://hdl.handle.net/1926/1096`.

2.1 Software Requirements

The following software was used to build the example implementation:

- Insight Toolkit 3.4.0
- CMake 2.4
- g++ 4.1.2

The provided source code may be compatible with other version of CMake and the Insight Toolkit, but other configurations have not been tested.

2.2 Implementation

The source code included with this document was based on the original file

`Examples/Segmentation/ConfidenceConnected.cxx`,

which is distributed with ITK. The original code was modified to support the three-dimensional brain image data used in this example, which also included the addition of two required command-line arguments. The required command line arguments, in order, are:

- `inFile` — The input file on which the segmentation will be done
- `outFile` — The file to which the resulting segmented image will be written
- `seedX` — The x-coordinate of the initial seed point
- `seedY` — The y-coordinate of the initial seed point
- `seedZ` — The z-coordinate of the initial seed point
- `multiplier` — The value of the parameter f in the confidence connected region growing algorithm

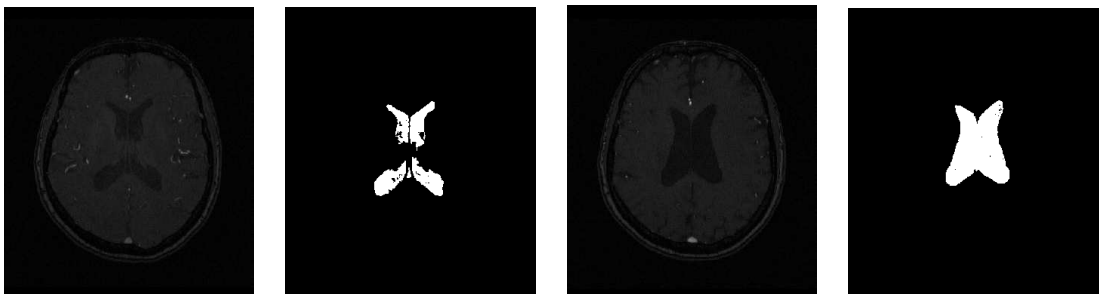

Figure 1: Selected results of the segmentation. From left to right, the first two images are of Z-Slice 58 and the last two images are of Z-Slice 68.

3 Results

Figure 1 shows the results of the implementation included with this document on the sample image mentioned in Section 2.

The output was produced using an initial seed point of $(225, 210, 70)$ and a multiplier value $f = 2.2$. The seed point was selected using ImageViewer to view the original brain data file. The multiplier f was found by a brief application of trial-and-error. A multiplier of $f = 2.0$ was selected and incremented by .1 until the resulting segmentation selected too much of the image.

The exact command-line used to produce the above results was:

```
./ConfidenceConnected Normal075-MRA.mha Normal075-MRA.out.mha 225 210 70 2.2
```

References

[1] Elizabeth Bullitt. http://hdl.handle.net/1926/1096, September 2007. 2

[2] L. Ibanez, W. Schroeder, L. Ng, and J. Cates. *The ITK Software Guide*. Kitware, Inc. ISBN 1-930934-10-6, http://www.itk.org/ItkSoftwareGuide.pdf, first edition, 2003. 1