BRAINSCut **General Tutorial**

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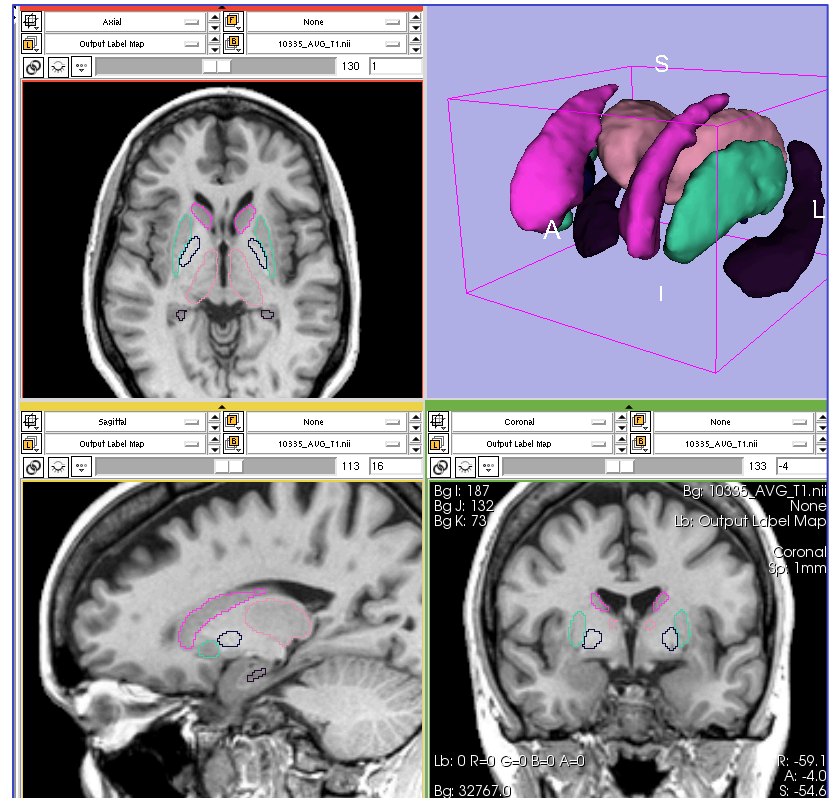University of Iowa

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NA-MIC Tutorial Contest: Summer 2011

Learning Objective

BRAINSCut

- This tutorial shows how to segment *regions of interest (ROI)* by using BRAINSCut.

- The tutorial example includes sub-cortical structure segmentation from human MR brain Image.

BRAINSCut Output example for sub-cortical structures

Pre-requisite

- This is NOT mandatory but would be helpful when you run command line module for BRAINSCut

  - Tutorial Name: Programming in Slicer3 Tutorial

  - Author: Sonia Pujol, Ph.D

  - Tutorial Link: http://www.slicer.org/slicerWiki/images/c/ca/ProgrammingIntoSlicer3_SoniaPujol.pdf

Material

This tutorial requires the installation of the Slicer3.6 release and the tutorial dataset. They are available at the following locations:

BRAINS download page

http://www.nitrc.org/projects/brains

Tutorial dataset: [name of dataset]

[Add a link to the tutorial dataset]

Platforms

- BRAINSCut Tutorial for human brain sub-cortical segmentation

http://wiki.na-mic.org/Wiki/index.php/Training:Summer_2011_Contest_Table

Overview

- The tutorial starts with brief background for BRAINSCut and followed by step-by-step instruction how to get sub-cortical volumetric segmentation.

- BRAINSCut Background

- BRAINSCut Process

  1. BRAINSCut I/O: *Understand and preparation*

  2. Train BRAINSCut: *Tell BRAINSCut what's your ROI*

  3. Apply BRAINSCut: *Get the actual volumetric segmentation*
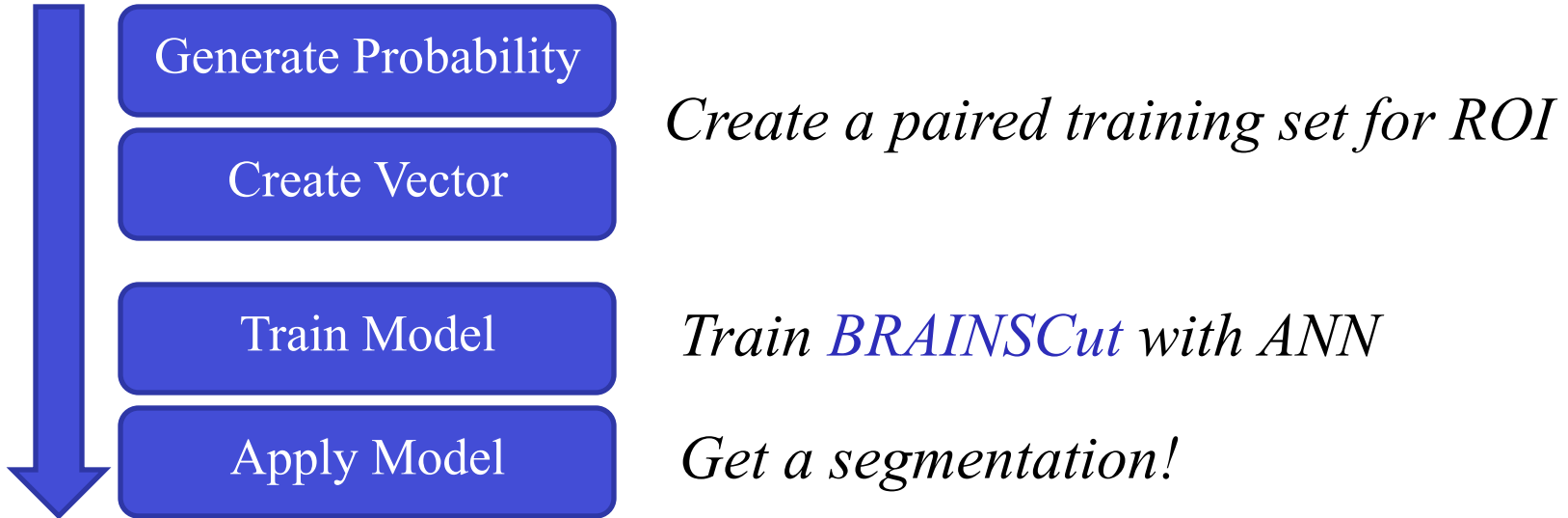
BRAINSCut Background

BRAINSCut uses *Artificial Neural Net(ANN)* learning mechanism in its segmentation process. Here briefly introduce how ANN works for image segmentation.

BIOLOGICAL NEURON

PERCEPTRONS

ARTIFICIAL NEURAL NETWORK
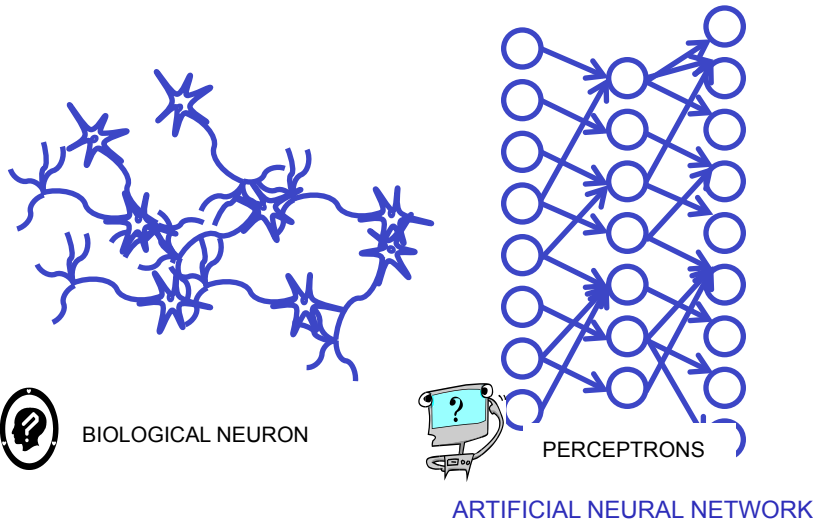
Inspired by human brain signaling of neuron, *ANN* learns from training set, which is paired set of input and output. This training process is simply adjusting process of network, including size of network(e.g. number of perceptrons) and weights to match computed output from input as similar as possible to the paired output.

BRAINSCut Process

Generate Probability

Create Vector

Create a paired training set for ROI

Train Model

Train BRAINSCut with ANN

Apply Model

Get a segmentation!

BRAINSCut process starts with preparation for learning/training for ROI. To train BRAINSCut, as stated in the previous slide, a paired input-output training set has to be provided. Processes of Generating probability map and Creating Vector together produces training data set for your ROI. Train Model process is followed by those step to learn about the structure and then completed with Apply Model step to get volumetric segmentation.

BRAINSCut Process

BRAINSCut I/O: Net Configuration File

: All the image volumes for BRAINSCut has to be indicated in the net configuration file(XML file format).

- Please download Tutorial Data File and see the following files.
  - File name: *BRAINSCutGeneralTutorialNetConfiguration.xml*

This file includes general setting for BRAINSCut with tutorial data set in it. After following the tutorial, you should be able to modify the net configuration file to fit your purpose.

BRAINSCut **Process**

BRAINSCut I/O: Net Configuration File

1. Open the net configuration file *(BRAINSCutGeneralTutorialNetConfiguration.xml)* with your favorite text editor
2. Here we need to change two variables for input and output directory name.
3. As shown in below figure, please change all *[BRAINSCutInputDir]* to your downloaded location.

Original provided file

Modified file example

```
34          ===================================================================
35   <DataSet Name="template"  Type="Atlas" >
36     <Image Type="T1" Filename="[BRAINSCutInputDir]/BRAINSCutTutorialNetConfigurationFiles/template_t1.nii.gz"/>
37     <Image Type="T2" Filename="na" />
38   </DataSet>
39
40   <!-- =============================================================
41        Probability Map   Description
BRAINSCutTutorialNetConfigurationFiles/BRAINSCutGeneralTutorialNetConfiguration.xml
```

```
34          ===================================================================
35   <DataSet Name="template"  Type="Atlas" >
36     <Image Type="T1" Filename="~/BRAINSCutTutorial/BRAINSCutTutorialNetConfigurationFiles/template_t1.nii.gz"/>
37     <Image Type="T2" Filename="na" />
38   </DataSet>
39
40   <!-- =============================================================
41        Probability Map   Description
BRAINSCutTutorialNetConfigurationFiles/BRAINSCutGeneralTutorialNetConfigurationEditing.xml        34,1        24%
```

BRAINSCut Process

BRAINSCut I/O: Net Configuration File

4. In a same way, please change all *[BRAINSCutOutputDir]* to your preferred location to store BRAINSCut output.

Original provided file

Modified file example

Now, we are ready to go…

BRAINSCut Process

Generate Probability

Create Vector

Train Model

Apply Model

Command Line Example

```
$>[BRAINSCut Build Directory]/BRAINSCut \
    --netConfiguration BRAINSCutGeneralTutorialNetConfiguration.xml \
    --generateProbability
```
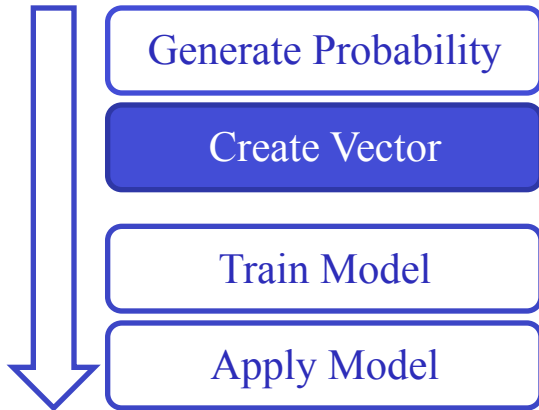

Right Caudate

Left Putamen

Left Globus
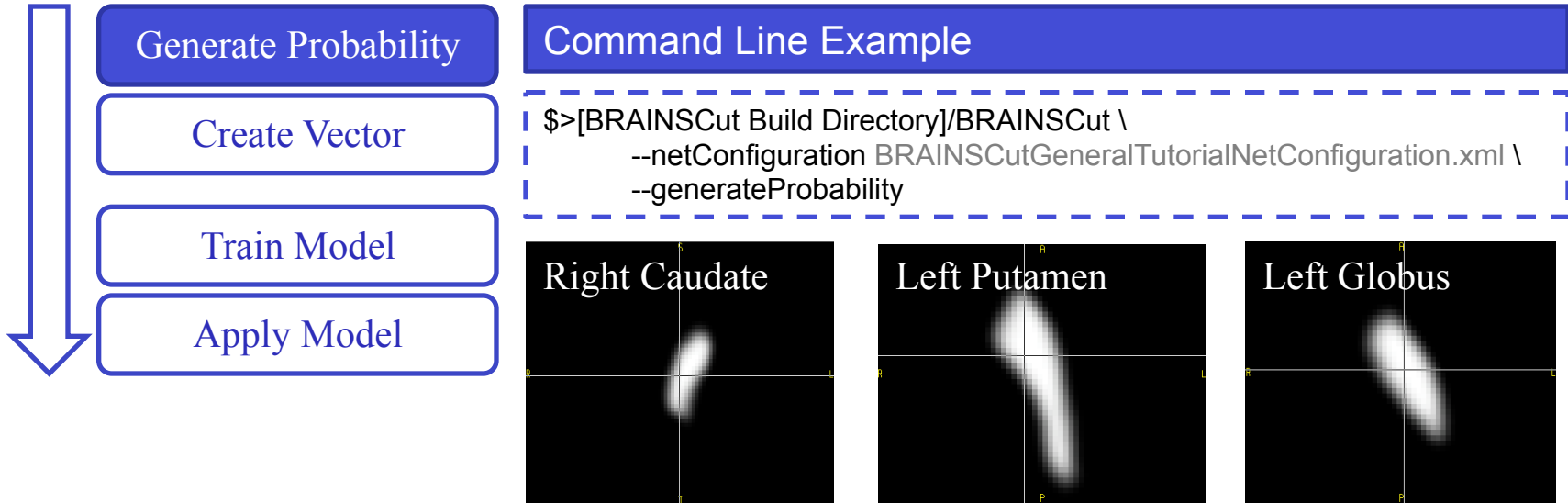
- Probability map is to identify rough region of segmentation. By registering each training data to the atlas data set, probability map(spatial prior) of each ROI could be created.
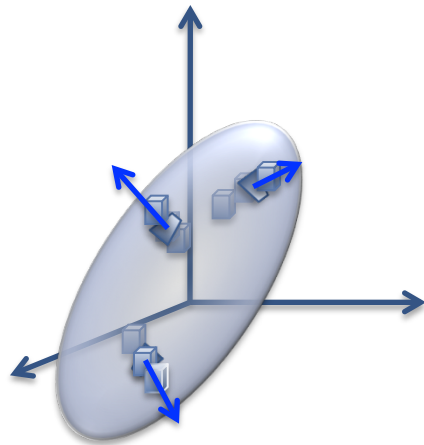- ROI could be specified in the net configuration file in the *<ProbabilityMap… />* section.

BRAINSCut Process

Generate Probability

Create Vector

Train Model

Apply Model

Neighbors along the Gradient Descents

Command Line Example

[BRAINSCut Build Directory]/BRAINSCut \
    --netConfiguration BRAINSCutGeneralTutorialNetConfiguration.xml \
    --createVectors

Training data, input-output paired set, will be generated by above command. When creating training vector, BRAINSCut will use all image types specified in the Atlas Data Set

```
<DataSet Name="template"
  <Image Type="T1" Filen                    r]/BRAI
  <Image Type="T2" Filename="na" />
</DataSet>
        <DataSet Name="Scan2"  Type="Train" >
          <Image Type="T1" Filename="@BRAINSCut_SOURCE_DIR@/TestSuit
          <Image Type="T2" Filename="@BRAINSCut_SOURCE_DIR@/TestSuit
          <Mask Type="mask1"  Filename="@BRAINSCut_SOURCE_DIR@/TestS
          <Registration
            SubjToAtlasRegistrationFilename="[BRAINSCutOutputDir]/Su
            AtlasToSubjRegistrationFilename="[BRAINSCutOutputDir]/At
            AtlasBinaryFilename="na"
            SubjectBinaryFilename="na"
            ID="BSpline"
            />
        </DataSet>
```

Use these type image

BRAINSCut **Process**
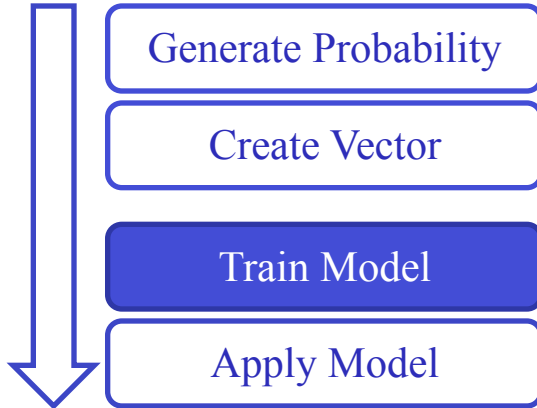
Generate Probability

Create Vector
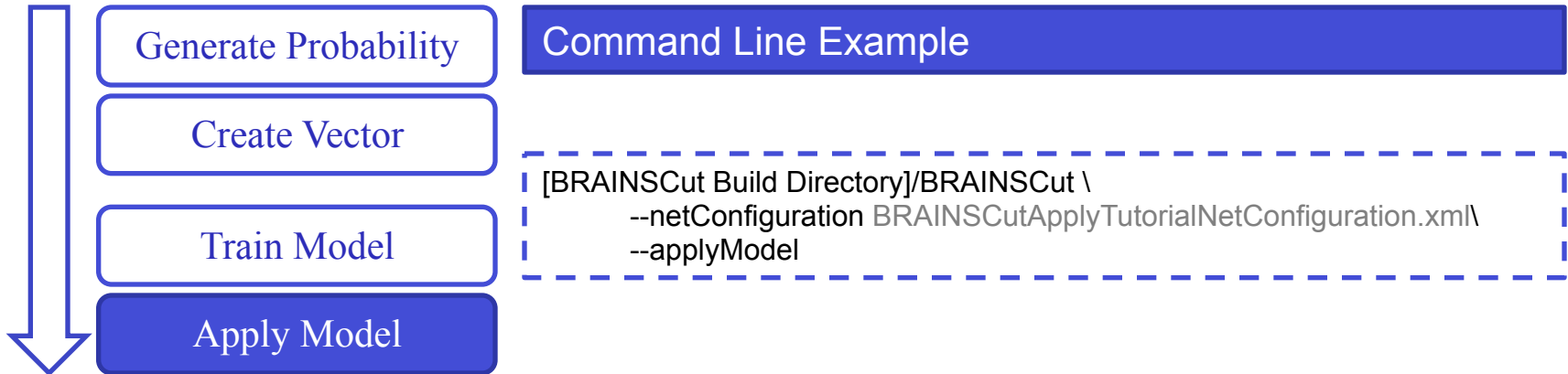
Train Model

Apply Model

Command Line Example

[BRAINSCut Build Directory]/BRAINSCut \
      --netConfiguration BRAINSCutGeneralTutorialNetConfiguration.xml \
      --trainModel

After creating training vector set, BRAINSCut will train for your ROI. The figure below shows the architecture of BRAINSCut.

Input Layer

Hidden Layer

Output Layer

BRAINSCut **Process**

| Generate Probability |
| Create Vector |
| Train Model |
| **Apply Model** |

Command Line Example

```
[BRAINSCut Build Directory]/BRAINSCut \
        --netConfiguration BRAINSCutApplyTutorialNetConfiguration.xml\
        --applyModel
```
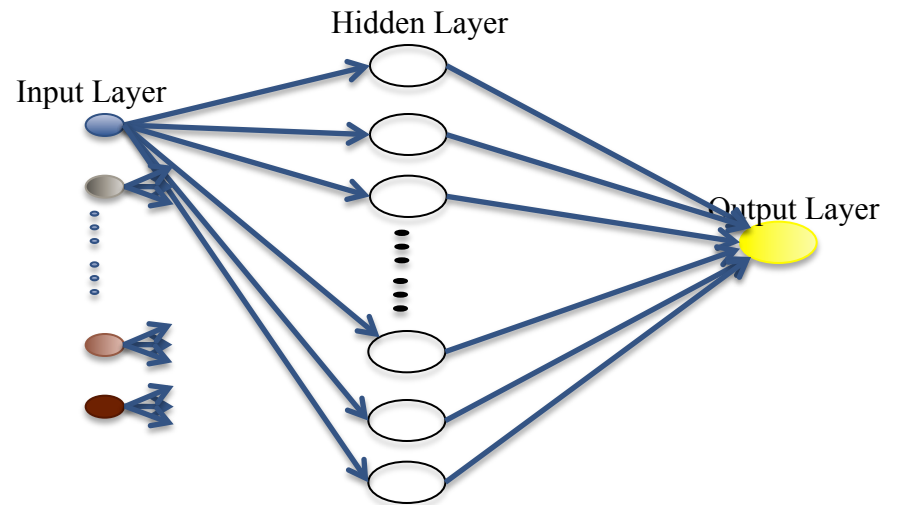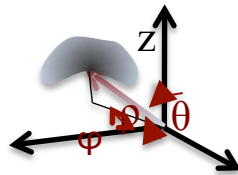
Now, it is time to apply our trained data set. Since trained model from previous section could be quite ugly, please open up the BRAINSCutApplyTutorialNetConfiguration.xml file. The file includes finely trained ANN model for Caudate and Putamen for now. For other structures we are working on and will be updated as soon as we get.

By doing above line, segmentation output will be generated as in the directory specified at the net configuration file. In this tutorial example, the result file would go into the same directory as BRAINSCutOutputDir.

BRAINSCut **Results – Scan3**

```
<DataSet Name="Scan3"  Type="Apply"
    OutputDir="[BRAINSCutOutputDir]/MaskOutputDir">
  <Image Type="T1" Filename="[BRAINSCutInputDir]/BRAINSCutTutorialDataSet/scan3T1.nii.gz"/>
  <Image Type="T2" Filename="[BRAINSCutInputDir]/BRAINSCutTutorialDataSet/scan3T2.nii.gz"/>
  <Image Type="SG" Filename="[BRAINSCutInputDir]/BRAINSCutTutorialDataSet/scan3SG.nii.gz"/>
  <Mask Type="right_caudate"   Filename="[BRAINSCutOutputDir]/scan3Mask1.nii.gz"/>
  <Registration
    SubjToAtlasRegistrationFilename="[BRAINSCutOutputDir]/SubjectToAtlasScan3.mat"
    AtlasToSubjRegistrationFilename="[BRAINSCutOutputDir]/AtlasToSubjectScan3.mat"
    AtlasBinaryFilename="NA"
    SubjectBinaryFilename="NA"
    ID="BSpline"
    />
</DataSet>
```

If Mask Type is given for Apply data type, the segmentation result will be stored as it specified in the Mask Type. Otherwise it will use the location where specified in the OutputDir section of DataSet.

Right Picture: Caudate Segmentation Surface model generated from BRAINSCut Result
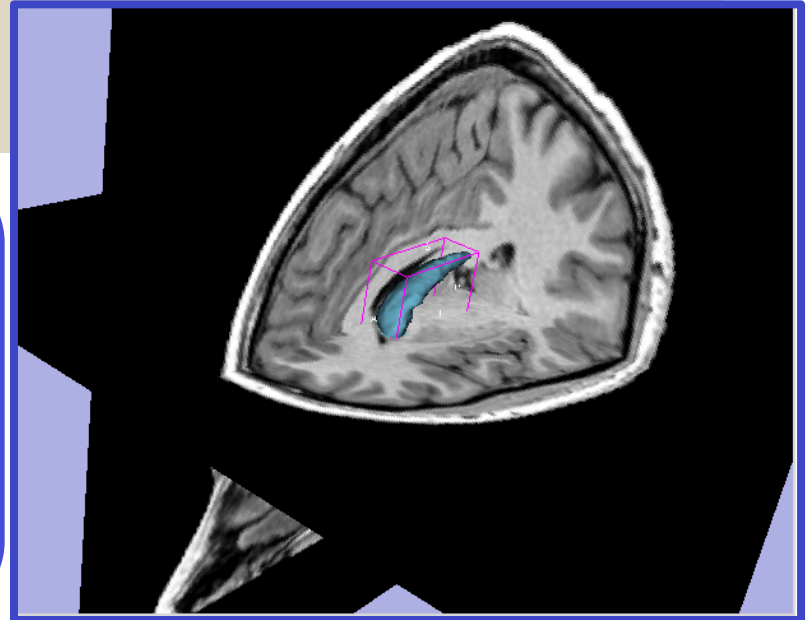
Conclusion

- Segmentation of subcortical structure could be constructed solely by *BRAINSCut*, and this tutorial briefly introduced how to do segmentation process with provided software.

- The example includes only Caudate for now, and others will be shortly updated.

- For more questions, please send e-mail to

  - Regina Kim: eunyoung-kim at uiowa dot edu

  or

  - Prof. Hans Johnson: hans-johnson at uiowa dot edu

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