Brain Fiber Segmentation

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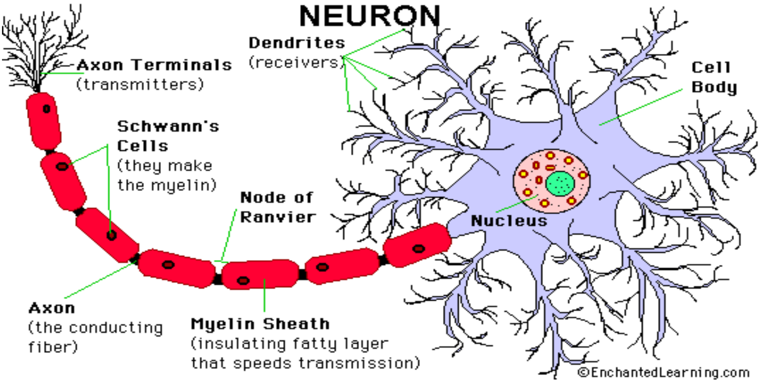
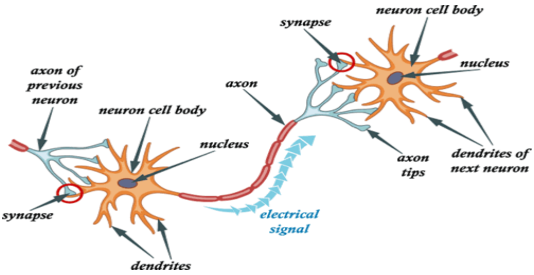
Introduction: Neuronal cell Structure



Introduction: Communication in Neurons

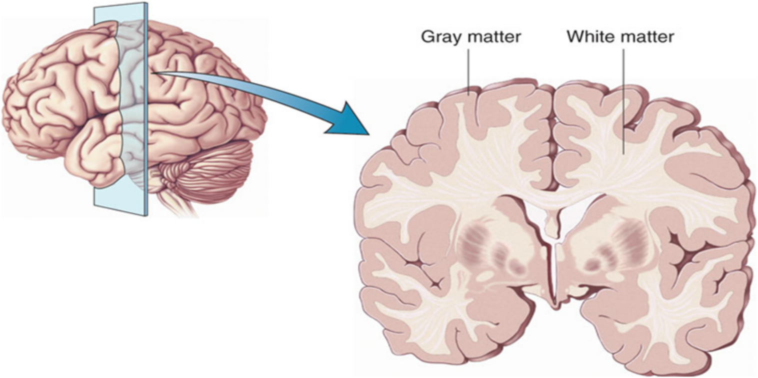


Here, Dendrites receives signals from other neurons, the cell body, which processes those signals and the axon, a long cable that reaches out and interacts with other neuron's dendrites. When different parts of the brain communicate and coordinate with each other, they send nerve impulses, which are electrical charges that travel down the axon of a neuron, eventually reaching the next neuron in the chain.

Introduction: Brain

- The brain contains more than 100 billion neurons that communicate with each other via axons for the formation of complex neural networks.
- In Brain, two kinds of tissue are there:
    - Grey matter,
    - White matter.

Introduction: Brain



- Grey matter, which has a pinkish-grey color in the living brain, contains the cell bodies, dendrites and axon terminals of neurons, so it is where all synapses are.
- White matter is made of axons connecting different parts of grey matter to each other.

Problem Statement and Long Term Goal

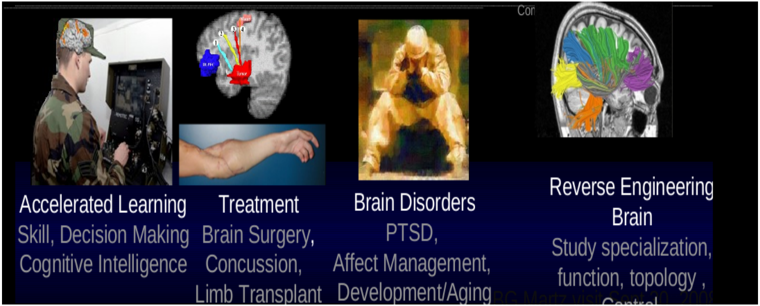
Problem Statement

Given the tractography data of a human brain, Segment it automatically into tracts having **"similar"** fibers which are anatomically meaningful.

Goal

Make a software, which will take tractography data of brain as input and gives "similar"fiber 3D model of brain and some useful information according to given application(like, for brain tumor operation, it will give us shortest path for cutting fibers to remove tumor.)

Motivation



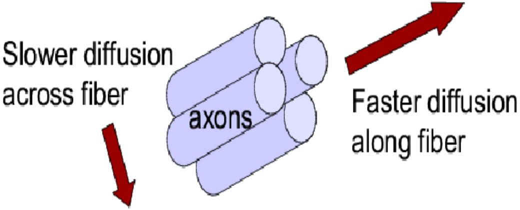
- To Study about the localization of specific tracks of fibers.
- Surgery planning with minimum damage to the fibers.

Background and Related Work

- White matter atlas creation, using group spectral clustering of tractography and Automatic Segmentation of Tractography from novel subjects by extending the spectral clustering solution, stored in the atlas, using the Nystrom Method. (Donnell-Westin, 2007)
- Treating image segmentation as a graph partitioning problem and proposing novel global criterion, the normalized cut, for segmenting the graph.(Shi and Malik, 2000)
- Proposing a nonparametric Bayesian framework to cluster white matter fiber tracts into bundles using a hierarchical Dirichlet Processes Mixture(HDPM) Model. (Wang-Eric-Westin, -)

Diffusion Tensor Imaging(DTI)

- It is important when a tissue, such as the neural axons of white matter in the brain has an internal anisotropy fibrous structure.
- Water will then diffuse more rapidly in the direction aligned with the internal structure, and more slowly as it moves perpendicular to the preferred direction.
- Tensors are used to model diffusion. Major eigen vectors of the tensor(Principle Directions) gives the fiber tract direction.



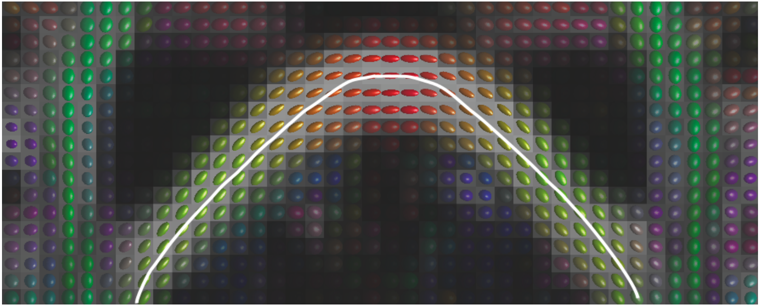
Tractography

wikipedia.org

In neuroscience, tractography is a 3D modeling technique used to visually represent neural tracts using data collected by diffusion tensor imaging (DTI).

- Streamline Tractography estimates white matter tract trajectories following the most likely tract direction. It locally chooses the most likely fiber trajectory.
- **DTI with Tractography gives us the white matter fiber orientation.**

Tractography



Preferred diffusion directions are shown as the long axes of diffusion ellipsoids.Here, red denotes left-right, green denotes back-front and blue up-down direction(out of the image plane). The white line shows the streamline obtained by connecting up a set of pixels based on their preferred directions and is an example of tractography.

Available data with us

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Initially, we have 3 brain's data as .trk file format.

- brain's data (classified) which is ground truth model for us.
- brain's data (Non-classified) which can be used for testing.

Data Format

The data is given in a file with .trk extension. Track(.trk) file is one single binary file, with the first 1000 bytes as the header and rest as the body. Some fields of header of track file are-

Name	Data-type	Bytes
id_string[6]	*char*	6
dim[3]	*short int*	6
voxel_size[3]	*float*	12
n_count	*int*	4
version	*int*	4
hdr_size	*int*	4

And the body part of the file contains "n_count" numbers of fibers as struct type and each struct of fiber contains **1.num_points**: number of points in that fiber, **2. 2D array** of num_point * 3, where each row displays x, y, z coordinates of points of that fiber.

Note

Here, we are using some name for particular things, which are mentioned below:

- Ground truth data - Brain1 data (classified)
- Class 0 - Grey Matter of Brain
- Classes of white matter fiber tracts:

Class no.	**Class Name**
Class1	Arcuate
Class2	Cingulum
Class3	Corticospinal
Class4	Forceps Major
Class5	Fornix
Class6	Inferior Occipitofrontal Fasciculus
Class7	Superior Longitudinal Fasciculus
Class8	Uncinate

Methodology

By observing ground truth data and fiber tracts' characteristics, we will develop some feature vector by which we can classify all the classes of white matter with good acuracy. After extracting features for classes, we will analyse this model using different classification algorithm and give the result as the best classification algorithm.

Methodology

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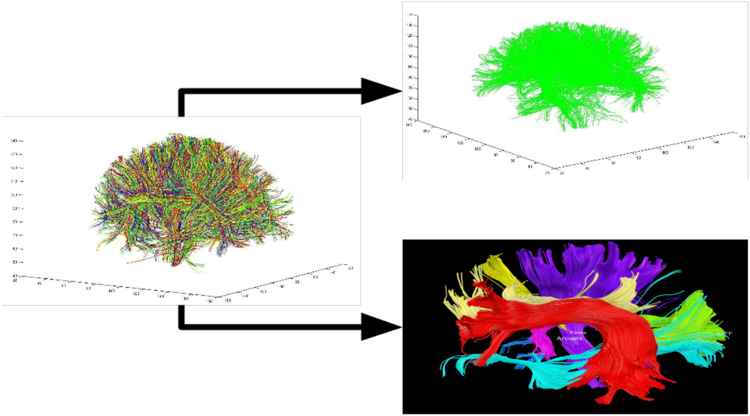


Result(1)

Class no.	Start-points Mean
Class1	(41.75930000,132.90225000,97.68317000)
Class2	(78.09513500,136.08315000,103.33668500)
Class3	(90.27637500,91.59677500,42.43649000)
Class4	(79.32306000,42.33381500,80.40204000)
Class5	(89.58828500,113.84820000,64.95563500)
Class6	(74.16783000,143.52725000,70.49763500)
Class7	(49.87368500,127.74495000,118.32490000)
Class8	(113.37985000,132.37805000,51.36863000)

Result(2)

Class no.	Start-points Standard deviation
Class1	(3.59007200,1.65377037,2.55151559)
Class2	(4.80101352,6.46182409,2.89388383)
Class3	(0.18937435,0.47351493,0.22717374)
Class4	(5.34165247,3.08654294,2.31996886)
Class5	(2.22060831,1.51108827,1.66560462)
Class6	(3.34551431,7.42975410,14.83555032)
Class7	(0.39485908,0.52277337,0.41652010)
Class8	(4.39531984,4.82689752,10.91509012)

Result(3)

Class no.	End-points Mean
Class1	(40.06050500,70.78955500,67.03863500)
Class2	(80.37367000,74.72157500,97.63405500)
Class3	(113.63880000,93.41260500,131.96160000)
Class4	(94.92560000,43.25754500,85.80602500)
Class5	(99.47859000,89.79473000,87.79484500)
Class6	(71.82542500,46.68512000,71.95375500)
Class7	(55.48636000,61.11233000,112.44245000)
Class8	(110.58140000,127.81460000,61.19712000)

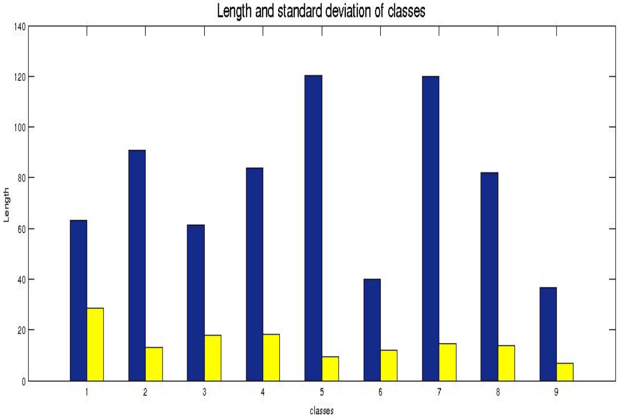
Result(4)

Class no.	End-points Standard deviation
Class1	(2.92963392,3.72654027,1.47660720)
Class2	(2.84154346,2.92655120,6.99558243)
Class3	(1.25299823,1.39776723,0.56241572)
Class4	(5.78067766,3.68521876,8.15535096)
Class5	(7.50444281,6.03372304,2.54777244)
Class6	(3.05448935,4.78675452,5.94266455)
Class7	(2.08037457,1.94918669,1.98636540)
Class8	(3.92595123,3.12721375,8.44942414)

Result(5)

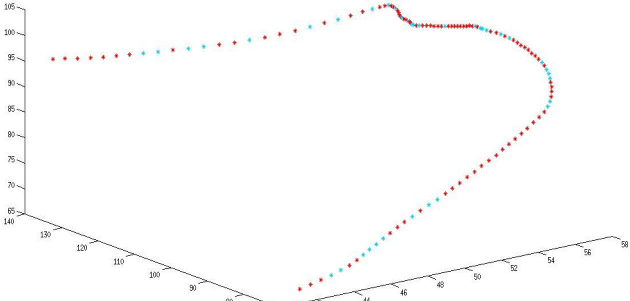
Class no.	Mean Length	Standard deviation
Class0	63.2312441493006	28.6485729787890
Class1	90.6890004417171	13.1847545751457
Class2	61.1771305385634	17.7718004108051
Class3	83.7487559847006	18.2878480190662
Class4	120.422320606324	9.34715491299375
Class5	39.9237420331200	11.8112475345795
Class6	119.862410788331	14.6056708300016
Class7	81.8378630440721	13.7995291380608
Class8	36.4855790683932	6.96950091496981

Result(6)

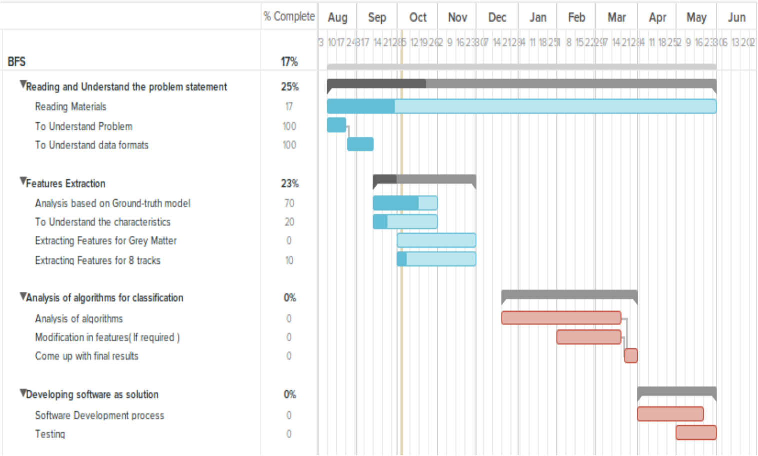

Length and standard deviation of classes
Length
classes
0
20
40
60
80
100
120
140
1
2
3
4
5
6
7
8
9

Working on

- Here, by observations we can say that above 105, we have only two classes eg. class-4 and class-6. So we can consider that point to classify this two class from rest of data.
- Also we are observing starting and ending points of classes as well as curvature points of classes for classification.



Gantt chart


% Complete
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
BFS 17%
Reading and Understand the problem statement 25%
Reading Materials 17
To Understand Problem 100
To Understand data formats 100
Features Extraction 23%
Analysis based on Ground-truth model 70
To Understand the characteristics 20
Extracting Features for Grey Matter 0
Extracting Features for 8 tracks 10
Analysis of algorithms for classification 0%
Analysis of algorithms 0
Modification in features(If required) 0
Come up with final results 0
Developing software as solution 0%
Software Development process 0
Testing 0

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Thank You