# DIPY: Correlation Tensor we Magnetic Resonance Imaging

## About Me:

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## Background

I am currently a 3rd-year B.Tech. student of Dayananda Sagar College of Engineering,Bangalore, Karnataka India. I am pursuing a B.Tech. in Computer Science and Engineering. I expect to graduate in 2024.
I am interested in Machine Learning, and have taken multiple DL and ML specialization courses on coursera .
As a requirement for my project, I read that the knowledge of diffusional MRI would be a plus. Thus, I've read several articles and research papers to get familiarized with the concept of diffusional MRI. I've also watched several videos on Youtube as well.
For my project specifically, I've reviewed the existing code of some diffusion MRI techniques that are already implemented in the open source software Diffusion in Python (DIPY) and which will be relevant for the project, namely the code and tutorials for Diffusion Tensor Imaging (dti.py, example-reconst-dti) and for Diffusion Kurtosis Imaging (dki.py,, example-reconst-dki). Understanding this code is important for the project since the diffusion MRI technique that I intend to implement will have to follow a similar architecture and will use some features from this code. I've also read the research papers: Diffusion Tensor Imaging and Diffusional Kurtosis Imaging.
Since the amount of information I had to take in was very large, I ended up making notes for it. This is the link to my notes.

## Contributions

Issue: #1073 = PR: #2749 ,I suggested a new feature: __getitem__

# Project Information

## Sub-org name: DIPY

## Abstract

The goal of DIPY is to facilitate the development and dissemination of reference procedures for advanced methods for dMRI data analysis, making it easier for researchers and medical professionals to gain insights from these complex data sets.

Implementing a module for "Correlation-Tensor Magnetic Resonance Imaging" (CT-MRI) in DIPY will be of great interest for researchers and clinicians who use MRI techniques. CT-MRI is a diffusion MRI method based on advanced diffusion encoding sequences, which shows advantages in characterizing healthy and pathological brain alteration when compared with more conventional diffusion MRI techniques.
Currently, DIPY mainly provides modules for diffusion MRI techniques for conventional diffusion acquisition. These included modules for "Diffusional Kurtosis Imaging" and "Diffusion Tensor Imaging" analysis. However, while recent studies show that advanced diffusion acquisitions provide unique information about tissue microstructure (e.g. Henriques et al., 2021), DIPY still provides limited modules to process this type of diffusion MRI data. . By implementing the module for CT-MRI, I could contribute to filling a gap in the functionality of DIPYand expanding its capabilities. This will make DIPY a more complete and useful tool for a wider range of researchers and clinicians who use MRI data.

## Detailed Description

The project can be divided into three main parts:

1. Building CT-MRI module (cti module).
2. Adding tests for the cti module.
3. Creating a tutorial for the cti module.

**1.Building CT-MRI module (cti module).**

The implementation of a CT-MRI module in DIPY can greatly enhance the capabilities of the software for researchers and doctors. Currently, DIPY has modules for Diffusion Tensor Imaging (DTI) and Diffusional Kurtosis Imaging (DKI) that are widely used by the medical community. Adding a CT-MRI module will further aid in the diagnosis of various neurological disorders (e.g. Ischemic Stroke, Alves et al. 2022), and allowing for a more comprehensive understanding of microstructural properties of neural tissues (Henriques et al., 2021; Novello et al., 2022).
To create this module, I'll first start with preprocessing of data, which in this case would basically require denoising and masking of data. Then I'd start with some basic tutorials and then implement features based on that. The CT-MRI will be built in a similar architecture than previous DTI and DKI modules. To avoid duplicating the code of features that are in common to DTI/DKI, CT-MRI class objects will be built as a class child of DKI class objects (i.e. class inheritance will be used). All code will be well documented, cited and written using PEP8 coding standards.

The implementation of the module will also involve writing the necessary algorithms and scripts to process data, ensuring that the software functions accurately and efficiently.

**2. Adding tests for the cti module.**
The addition of tests for the CT-MRI module (cti module) is crucial to ensuring the accuracy and reliability of the module. These tests will verify the functionality of the module.
The tests will also ensure that the module integrates seamlessly with the rest of the software and complies with DIPY's coding standards.
I intend on creating some tests along with the development of the features in the module.
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**3. Creating a tutorial for the cti module:**
Creating a tutorial for the CT-MRI module is essential to enable researchers and doctors to understand the capabilities and usage of the module.
The tutorial will include a brief introduction to the module, its applications in the medical field, and the methodology used in its implementation. The tutorial will also provide examples of how to use the module with sample data, demonstrating its functionalities and the expected results.

## Weekly Timeline

| Week | Work |
|---|---|
| May 4 - May 28 | Community Bonding Period<br><br>● Discuss with mentors about the project<br>● Read through research papers related to CT-MRI.<br>● Understand parts of the DIPY codebase related to this project. |
| (Week1 - Week2)<br><br>May29 - June12 | Adapt DKI simulations for CT-MRI. This will help me in getting familiarized with data requirements for CT-MRI. CT-MRI simulations will be the base for CT-MRI tests and modules. |
| (Week3 - Week6)<br><br>June13 - July10 | Implementing the first version of the CT-MRI module using class inheritance from previous DKI modules.<br><br>In DIPY, reconstruction of diffusion MRI techniques are based on two different class objects: one defining the model and another for data fitting. Therefore, in these weeks the following will be done:<br><br>1) CT-MRI model class with be defined from inheritance of the general ReconstModel from dipy.reconst.base, while CT-MRI fitting class will be defined from inheritance of the DiffusionKurtosisFit from dipy.reconst.dki to capture all the attributes that are in common between CT-MRI and DKI.<br><br>2) For CT-MRI fitting functions, I will be generalizing the previous DTI/DKI fitting functions in dipy.reconst.dti to be compatible with CT-MRI. This will also require the definition of a design_matrix for CT-MRI.<br><br>3) Implement CT-MRI unique features, according to their papers (c.f. Henriques et al., 2020; Henriques et al., 2021). |

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| July14 | MidTerm Evaluation |
| (Week7-Week10)<br><br>July11 - August6 | Improve CT-MRI implementations according to the feedback from DIPY contributors given in github. Make sure that all lines of code are being covered by tests that will be based on the CT-MRI simulation functions that were built on the two first weeks of the project. Namely, the following aspects have to be tested:<br><br>1) Fitted tensor parameters will have to match the ground truth values used to produce the synthetic diffusion-weighted signals in both single voxel and multi voxels cases.<br>2) Making sure that all previous DTI/DKI tests are running with no issue after generalizing their fitting procedures to be compatible with CT-MRI.<br>3) New attributes of CT-MRI fitting class objects will have to match the predicted values from the ground truth parameters of the simulations. |
| Week11 - Week12<br><br>August7 September 4 | Finishing up with the tutorial showing how to run CT-MRI in real diffusion MRI data<br><br>Tying any open loose ends. |
| September 5 | Phase 1 evaluation deadline |
| | Final work report<br>● Write the final work report. |
| November 13 | Final Work Report Deadline |

## Commitments:

- DIPY is the only organization that I'm applying to.
- Although I'd have classes, I assure you that I'll work on DIPY for at least 5 hours everyday.

- I will be having my final exams in early July, for 2 weeks, during which period I won't be very active. But I have arranged for a buffer period in my schedule so I'll stay on track.
- I don't have any other commitments or summer plans during the GSoC period. In case something comes up, I'll make sure to inform my mentors as soon as possible.
- I look forward to working on more interesting projects at Dipy, being part of the community and mentoring future contributors after my GSoC.

## Communication:

- I will always be available through email
- I will be regularly communicating with my mentors about my progress in the project, or about any issues that I may encounter.
- I'm also planning to write weekly blog posts about my progress and the things I learnt about the project.
- I would also be happy to join any discussions/video calls during daytime.