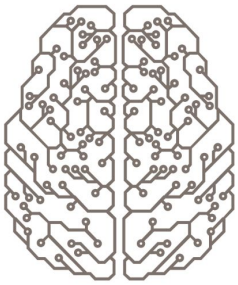
Image Processing for Medical Applications



ENGR-E 535 (3 CR)
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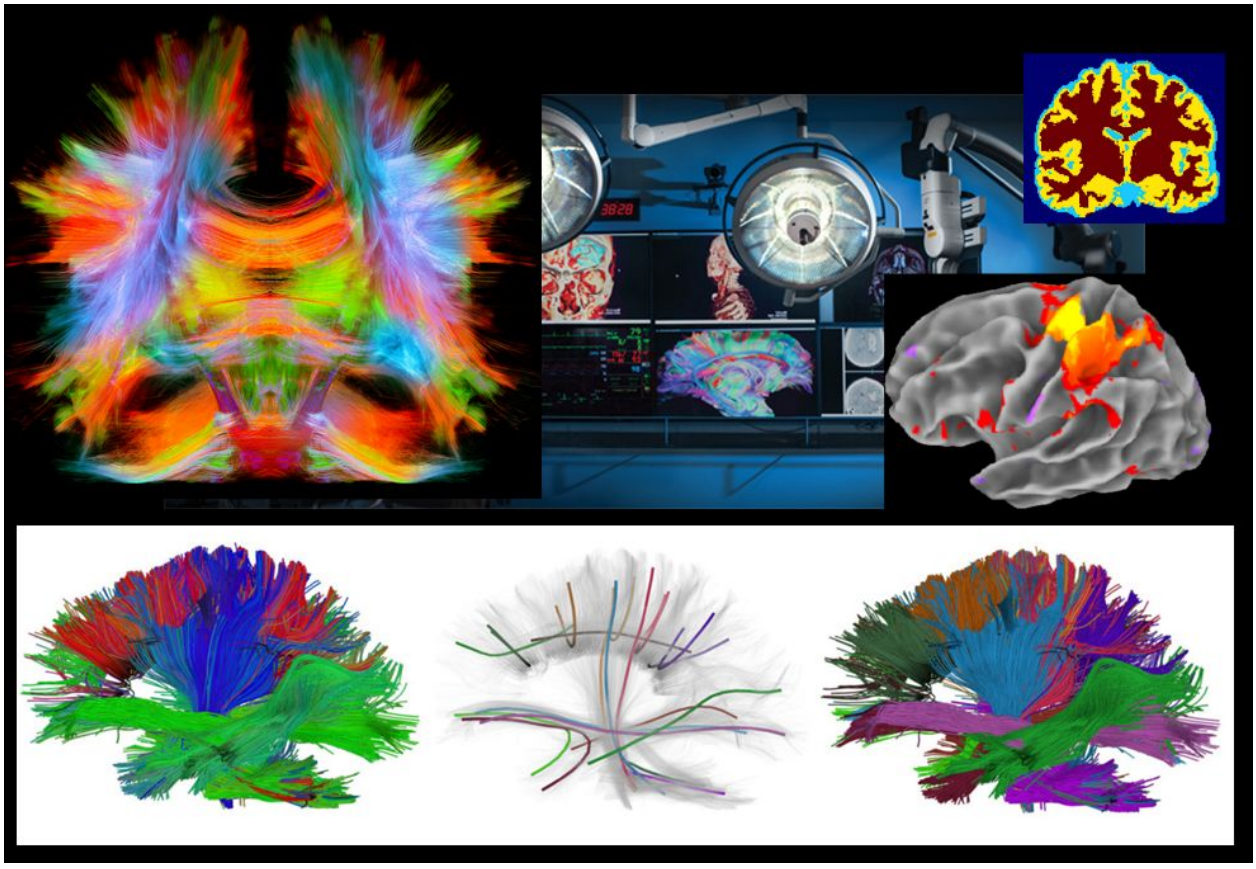

Spring 2018

DIPY

1. Course Title- not to exceed 30 characters
ENGR 535 - Image Processing for Medical Applications

2. Course Description
Learn how to build intelligent algorithms and software for medical imaging that can help medical doctors to treat their patients and researchers to understand how the body works. Students will be familiarized with algorithmic techniques such as tracking, denoising, warping, segmentation, model fitting, optimization and interactive visualization of medical datasets.

3. Course pre-requisites

This is a graduate course.
At least one programming course is required.
Linear algebra and calculus are also required.
Any machine learning or computer vision course would be helpful but not necessary.

4. Justification
Intelligent Systems Engineering is a new department and a new major at IU.

5. Course Content/ Topics covered

Weeks	Topic	Details and Activities	Assignments
1	Overview and definitions	Introductions and important definitions of medical imaging and neuroanatomy.	Homework1
2	Scientific computing	Introduction to Python for data analysis and image processing. 2D/3D/ND data processing intro.	Homework 2
4	Basic image processing	Fourier transform and other basic filters for images 2D/3D.	Homework 3
5	Denoising and Segmentation	Understand how to process simple structural images. Learn algorithms such as nonlocal denoising, volume segmentation and tissue classification.	Homework 4
6	Affine registration	Affine Registration.	Homework 5
7	Non-rigid registration	Warping and nonlinear Registration.	Homework 6
8	MRI Physics	Understand how the MRI signal is being generated.	
9	Diffusion MRI 1	Model fitting Spherical harmonics & deconvolution	Homework 7

9	Diffusion MRI 2	Analysis strategies	Homework 8
10	Tractography	Tracking generation algorithms and fast unsupervised segmentation.	
11	Reinforcement learning	Reinforcement Learning for tracking	
12	Functional Imaging	Signal processing from activation images	Homework 9
13	Supervised learning	Applied machine learning to functional MRI	
14	Invited talk 2	Detection of cardiac pulse from images	Homework 10
15	Invited talk 3	Microstuctural imaging	

6. Teaching and learning methods

Hands-on training with coding examples. Cool homeworks.

7. Representative bibliography

Garyfallidis, Eleftherios et al. DIPY, a library for the analysis of diffusion MRI data DIPY a library for diffusion MRI analysis, Frontiers 2014.
http://journal.frontiersin.org/article/10.3389/fninf.2014.00008/full

Jones, Derek K. Diffusion MRI. Oxford University Press, 2010.

Poldrack, Russell A., Jeanette A. Mumford, and Thomas E. Nichols. Handbook of functional MRI data analysis. Cambridge University Press, 2011.

Gonzalez and Woods, Digital Image Processing, 2017.

Trucco, Verri, Introductory Techniques, 1998.

Westbrook, MRI in Practice, 2011.
Huettel et al. Functional Magnetic Resonance imaging, 2008.

Bishop, Pattern Recognition and Machine learning, 2006.

McKinney, Python for data analysis, 2012.

Burger and Burge, Principles of digital image processing, 2009.

8. Student learning outcomes

When students complete this course, they should be able to:

- Know the mathematical and algorithmic tools for building intelligent algorithms for medical imaging applications
- Became an expert on building efficient and powerful algorithms for medical imaging.
- Become proficient with magnetic resonance imaging also known as MRI, currently the most powerful noninvasive technique for seeing inside the body and the brain.
- Be able to visualize and interact with high dimensional medical data.
- Be familiarized with a new powerful medical imaging software library called DIPY. Also get familiar with the common tools for data analysis in Python e.g. NUMPY.
- Be ready to work in companies like IBM, Philips and Siemens which are currently employ a great amount of engineers to deal with different problems of medical imaging.
- This is a data science relevant course and there is currently a large need in the market for experts in building medical imaging algorithms and analysis pipelines.

9. How graded (% papers, % participation, % exams, etc.)

Grade Item	**Percentage**
Projects + Homework	50%
Exams	50%