Image Processing for Medical Applications

ENGR-E 535 (3 CR)
Prof. Eleftherios Garyfallidis
Intelligent Systems Engineering
Indiana University

Spring 2018
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

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

Hands-on training with coding examples. Cool homeworks.

### 7. Representative bibliography


Westbrook, MRI in Practice, 2011.


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.)

<table>
<thead>
<tr>
<th>Grade Item</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Projects + Homework</td>
<td>50%</td>
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<tr>
<td>Exams</td>
<td>50%</td>
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</table>