Machine Learning in Imaging

BME 590L
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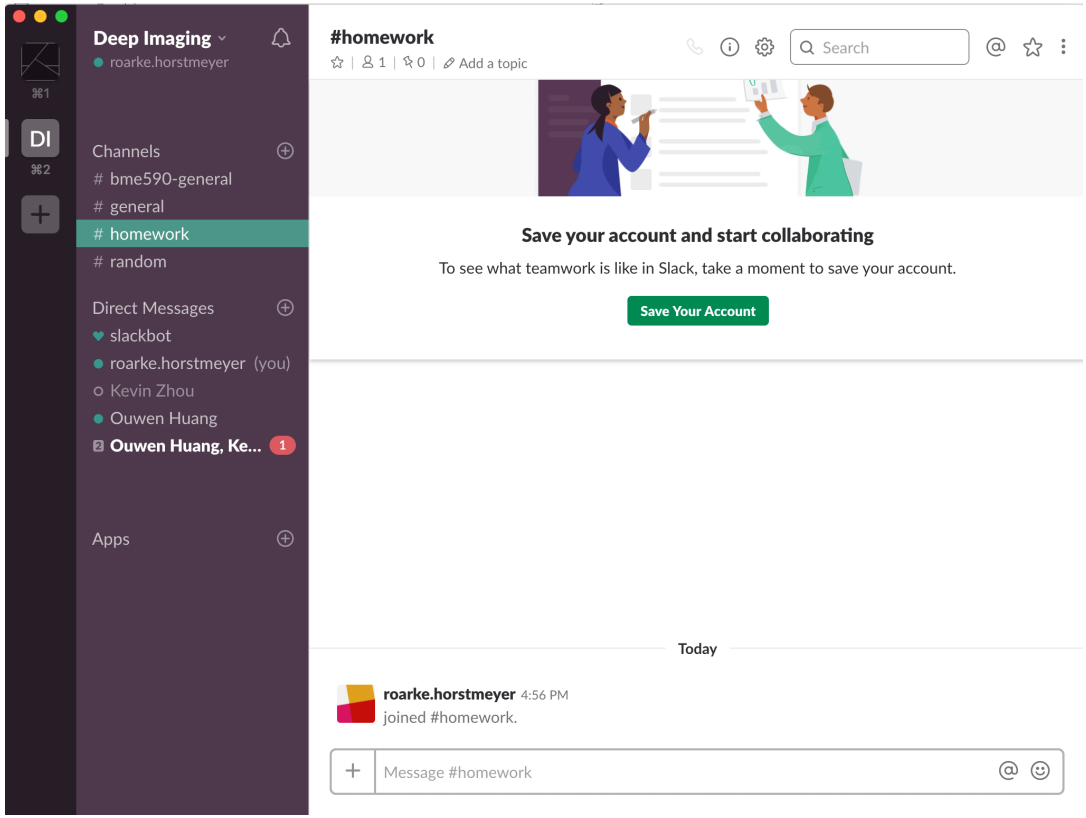
Lecture 0: Class outline and motivation

- Go over class logistics
  - See syllabus

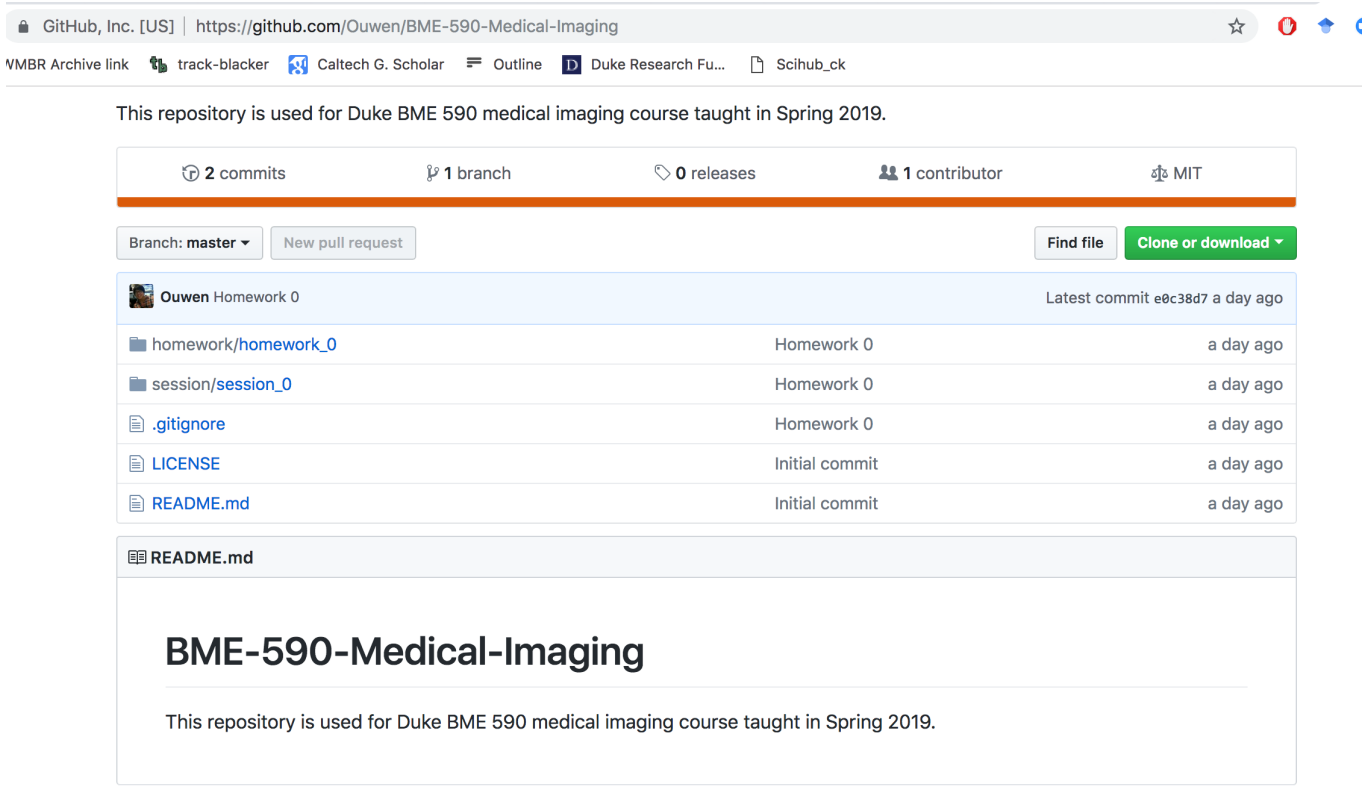
Organizational stuff

- Sign-up sheet for non-enrolled students -> permission number
- Slack channel: deepimaging.slack.com
- Homeworks will be posted on Slack (and Github)
- Homeworks will be a mix between “hand-written” problems and code
- “Hand-written” problems can be written up and turned in at class
- Coding assignments will be shared via Github
- Code should be written up with Jupyter notebooks
- Coding assignments should be submitted via Github
- (Typed “hand-written” problems can also be submitted via Github)

Slack



Github



Organizational stuff – Lab Sessions

- Monday and Wednesday 4:55pm-6pm
- Please bring your laptop to the lab sessions (I assume you have one, if not please come speak with me)
- Try your best to show up to the lab session that you signed up for, but you can attend alternate (or both!) if you really have a conflict
- First lab sections will go over basics of code setup (NumPy/SciPy, Jupyter, Github)
- Then we'll get into classification & Tensorflow, also homework help
- Please fill out survey and try out Jupyter/Github on your machines before lab sections next week

Organizational stuff - Grading

- 5 homework assignments, 2-3 short quizzes, 1 final project
- -20%/day for late homework
- Final project is important, mostly for you!
- Participation: come to lecture & lab & office hours if needed, self-scored
- Collaboration encouraged, but please write up your *own code* and *own solutions*

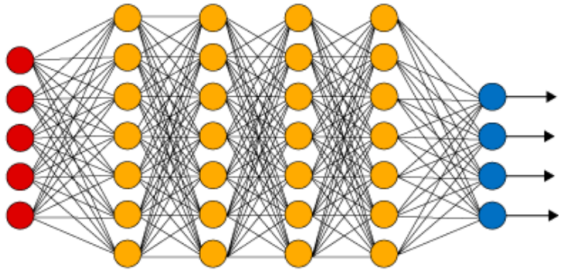
Grading:
Homework: 40%
Quizzes: 15%
Project proposal: 5%
Final project: 35%
Participation: 5%

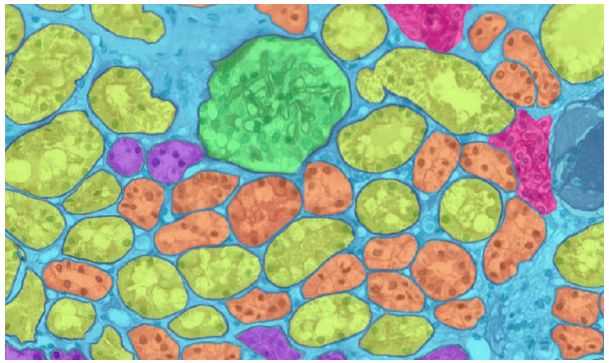
What is this class about?

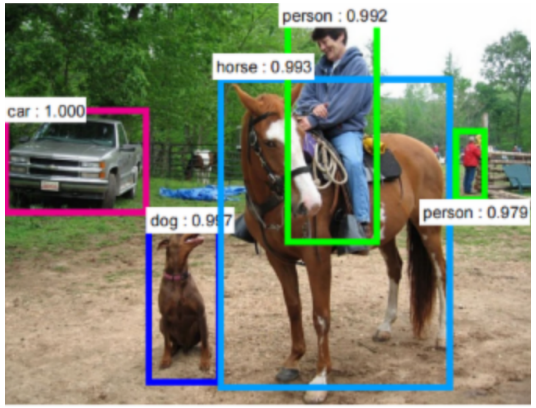
Historically, hardware has been optimized to create images for humans

What is this class about?

Over the last 10 years, computers have become “really good” at automatically processing image data





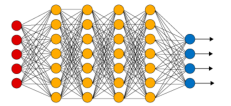


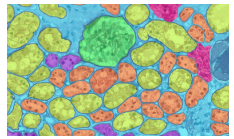
Nearly all new advances enabled by deep neural networks

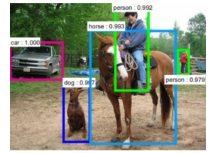
What is this class about?

We will figure out what is going to be right here

Computer-
centered hardware
+ software



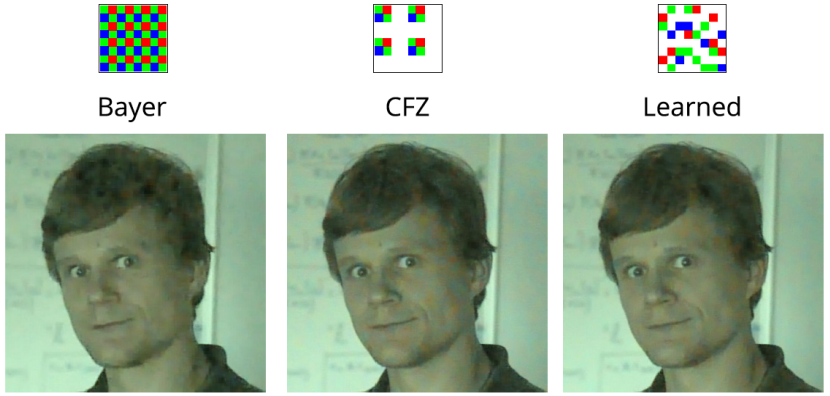




Human-centered hardware design

Computer-centered software design

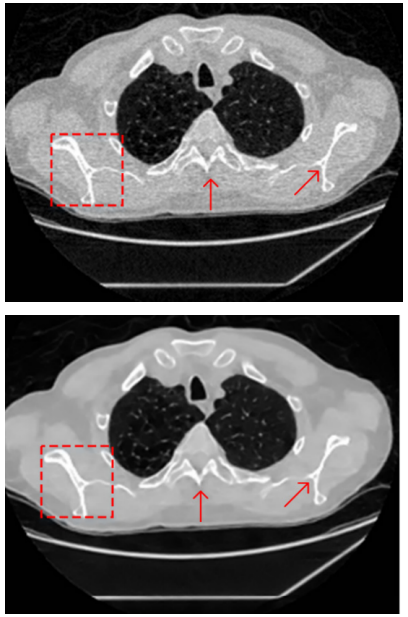
Some examples of computer-centered hardware?



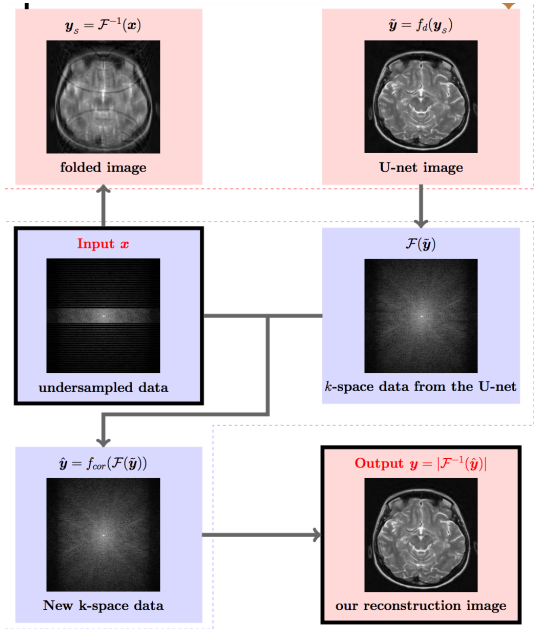
A. Chakrabarti

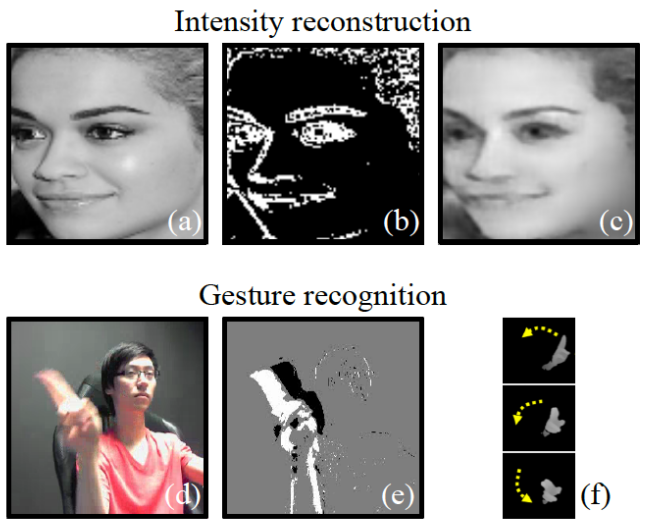
Butterfly

Low-dose CT – Chen et al.

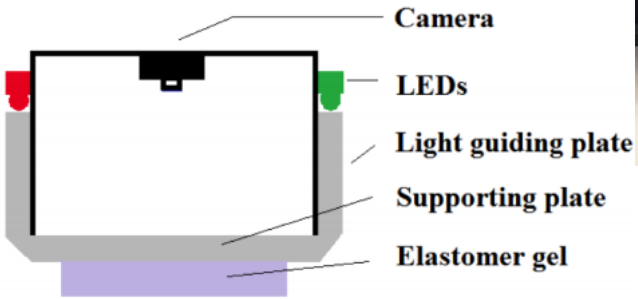


Under-sampled MRI – Hyun et al.





Nvidia



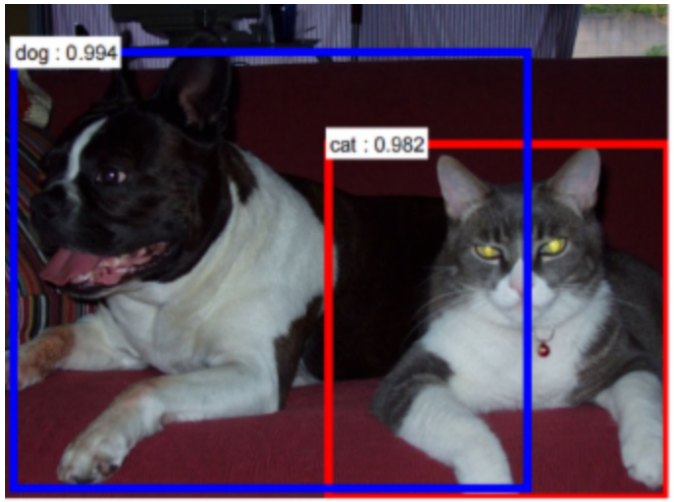
https://youtu.be/BIW_jq3dOEE

General layout for this class:

- Here is what I plan to cover:
  - Fundamental concepts behind machine learning
  - Current methods in machine learning for image analysis
    - Deep neural neworks & CNN's
    - Classification, segmentation, detection, super-resolution
  - How to model *simplified* imaging systems (cameras, microscopes, ultrasound, CT, etc.)
  - How to optimize imaging system hardware with machine learning

What is this class *not* about?

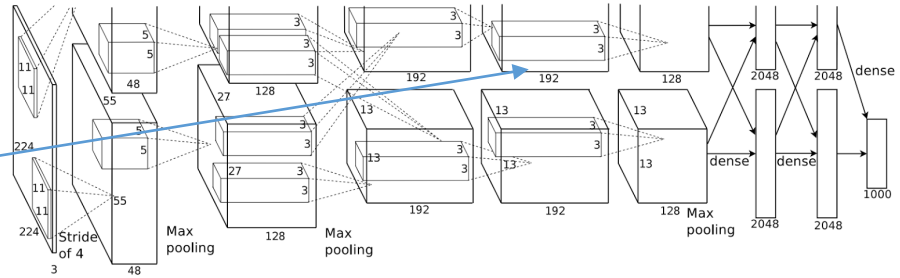
"I want to get this score from 0.982 up to 0.999"



"Can we create a comprehensive mathematical framework to understand how deep learning algorithms work?"

"I'd like an in-depth explanation of how my (fill-in-the-blank) imaging system works"

"I want to really understand this one operation here"



"I want to program something to make cool pictures like this"

What do I need to know about beforehand to succeed in this class?

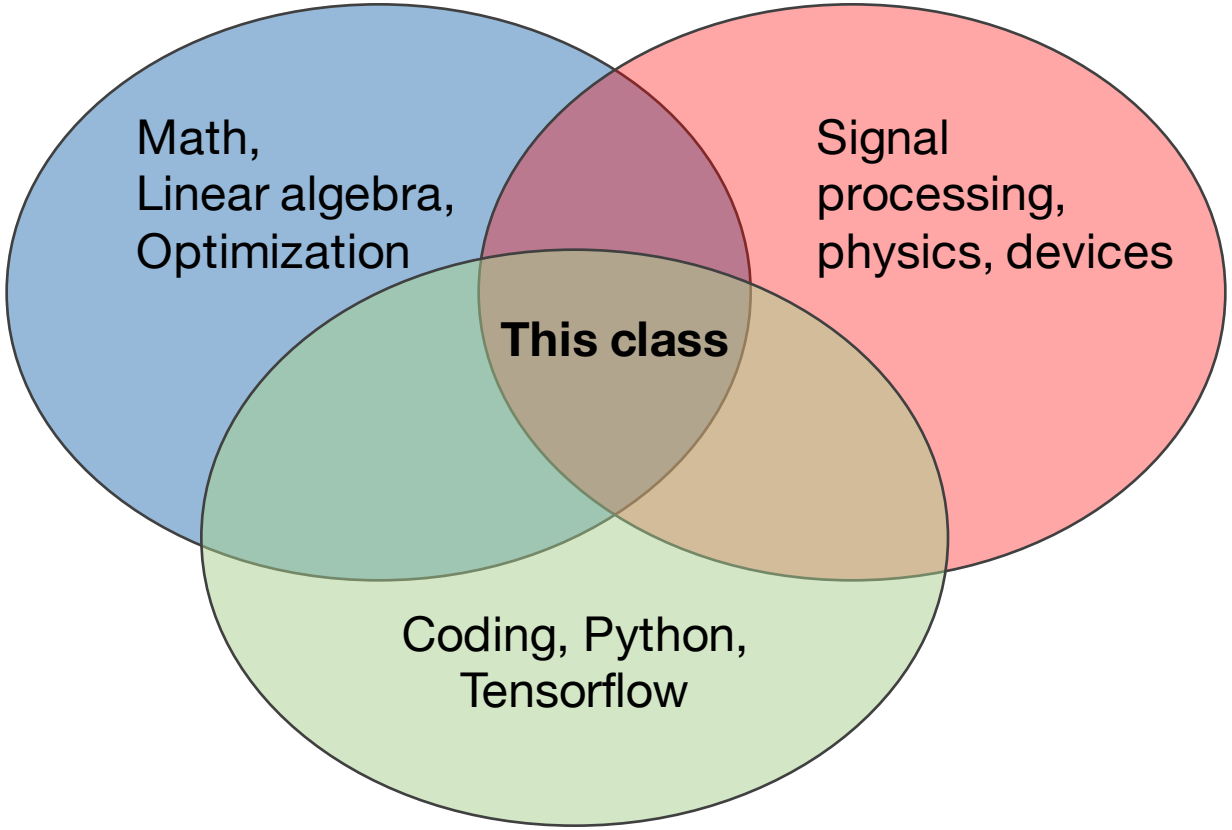
- Python coding experience ideally, but MATLAB programming experience will probably be ok

- Linear algebra & Calculus
  - Vector/matrix operations
  - Matrix inversion, pseudo-inverse
  - Gradients, partial derivatives

- Signal processing
  - Complex-valued signals
  - Fourier transforms
  - Convolutions

- Optimization
  - Differences between Linear, convex, non-linear optimization
  - Gradient descent

This class is interdisciplinary (by design)



- We will move fast
- We will jump between subjects I assume most have had “some” exposure to
- End goal: Meaningful project with Tensorflow
- This is a first …

What should I expect to gain from this class?

- Comfort with general mathematical principles behind machine learning
- Comfort with how to simply model generalized imaging systems (math and simulation)
- Ability to program in Python and Tensorflow
- Hands on experience with current “deep” ML algorithms (convolutional neural networks, GANs maybe)
- An ability to reason thought architecture choices for deep CNNs
- Coding experience with adding imaging system hardware optimization into a CNN or other NN structure