

# Machine Learning in Imaging

BME 590L  
Roarke Horstmeyer

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](https://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

The screenshot shows the Slack interface for the 'Deep Imaging' workspace. On the left, there's a sidebar with sections for 'Channels', 'Direct Messages', and 'Apps'. The 'Channels' section lists '# bme590-general', '# general', '# homework' (which is selected and highlighted in green), and '# random'. The 'Direct Messages' section shows conversations with 'slackbot', 'roarke.horstmeyer (you)', 'Kevin Zhou', 'Ouwen Huang', and 'Ouwen Huang, Ke...'. The 'Apps' section has a '+' button. The main area shows the '#homework' channel. It has 8 messages, 0 attachments, and 0 reactions. There's a search bar and a 'Save Your Account' button. Below the channel header, there's a message from 'roarke.horstmeyer' at 4:56 PM joining the channel. At the bottom, there's a message input field with '+ Message #homework' and reaction icons.

# Github

The screenshot shows the GitHub repository page for 'BME-590-Medical-Imaging'. The top navigation bar includes links for 'GitHub, Inc. [US]' and the repository URL. It also shows 'VMBR Archive link', 'track-blacker', 'Caltech G. Scholar', 'Outline', 'Duke Research Fu...', and 'Scihub\_ck'. The repository summary states: 'This repository is used for Duke BME 590 medical imaging course taught in Spring 2019.' Key statistics shown are 2 commits, 1 branch, 0 releases, 1 contributor, and an MIT license. A dropdown menu shows 'Branch: master'. There are two commits listed: 'Ouwen Homework 0' (latest commit) and 'homework/homework\_0'. The commit details are as follows:

File	Message	Time
Ouwen Homework 0	Latest commit e0c38d7 a day ago	a day ago
homework/homework_0	Homework 0	a day ago
session/session_0	Homework 0	a day ago
.gitignore	Homework 0	a day ago
LICENSE	Initial commit	a day ago
README.md	Initial commit	a day ago

The repository title 'BME-590-Medical-Imaging' is displayed prominently, along with the same descriptive text as the summary.

## 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%

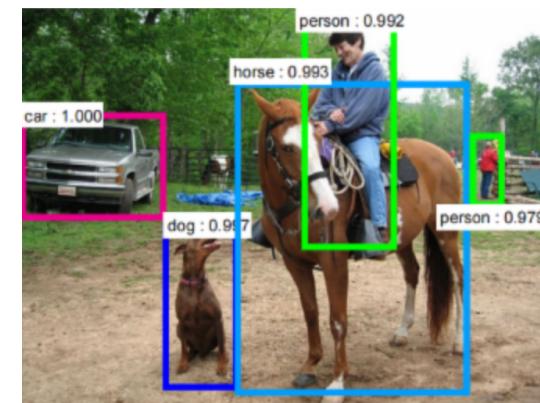
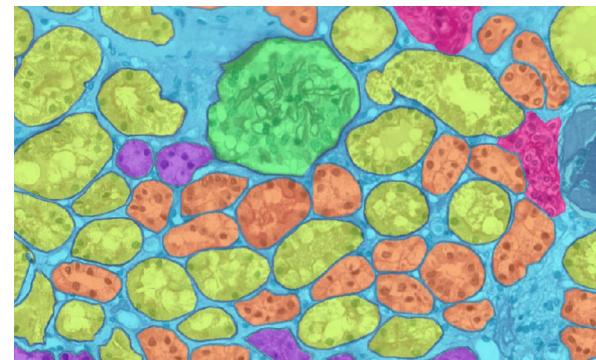
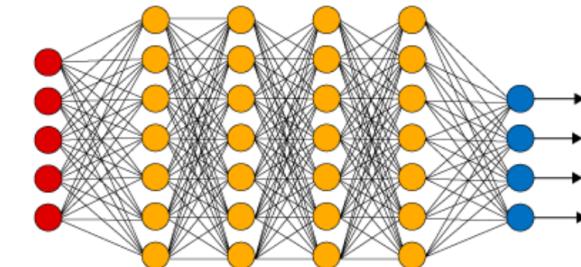
# What is this class about?



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

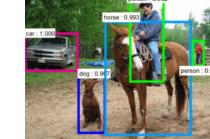
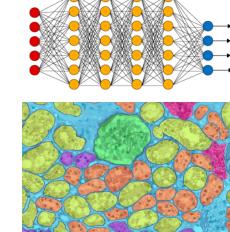


Nearly all new advances enabled by deep neural networks

# What is this class about?

We will figure out  
what is going to be  
right here

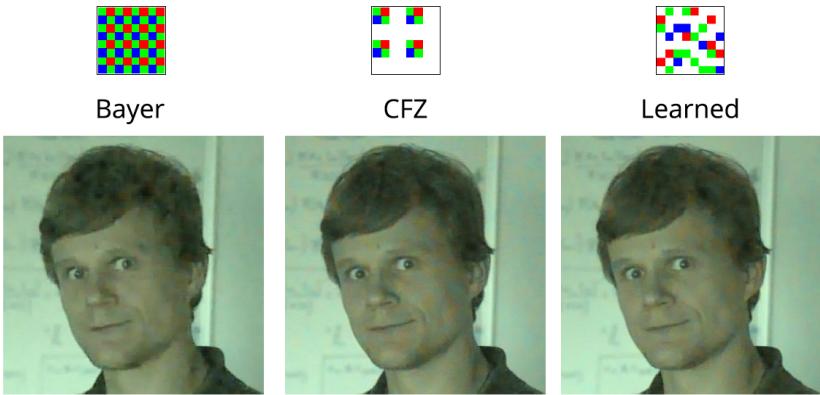
Computer-  
centered hardware  
+ software



Human-centered hardware design

Computer-centered software design

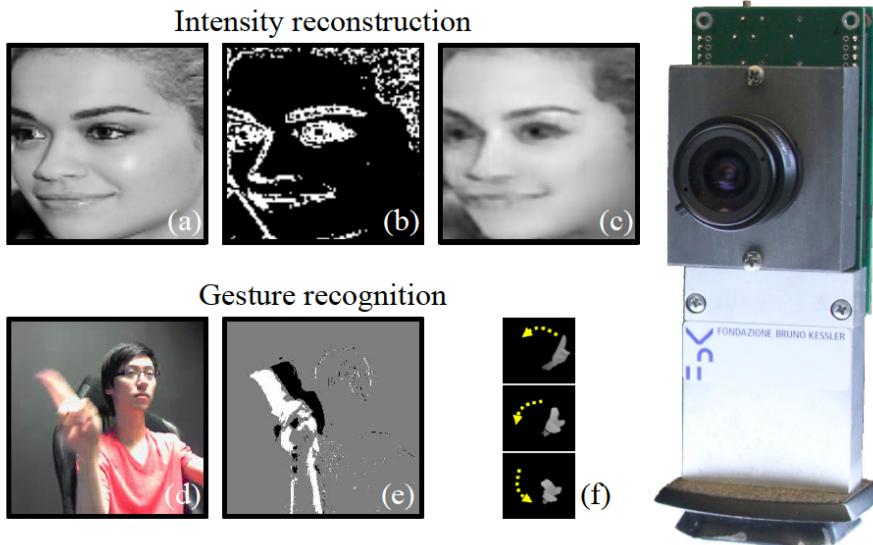
# Some examples of computer-centered hardware?



A. Chakrabarti

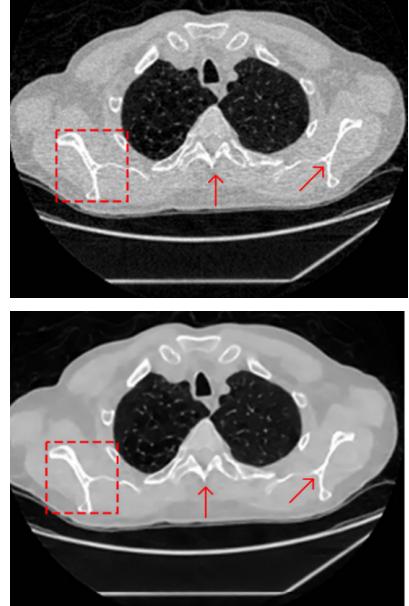


Butterfly

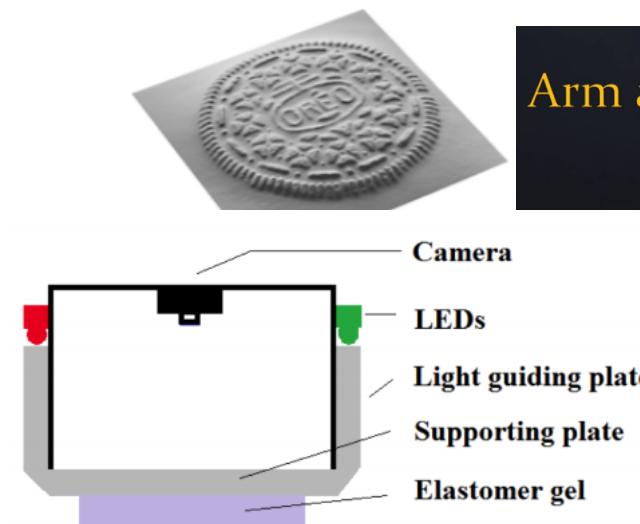
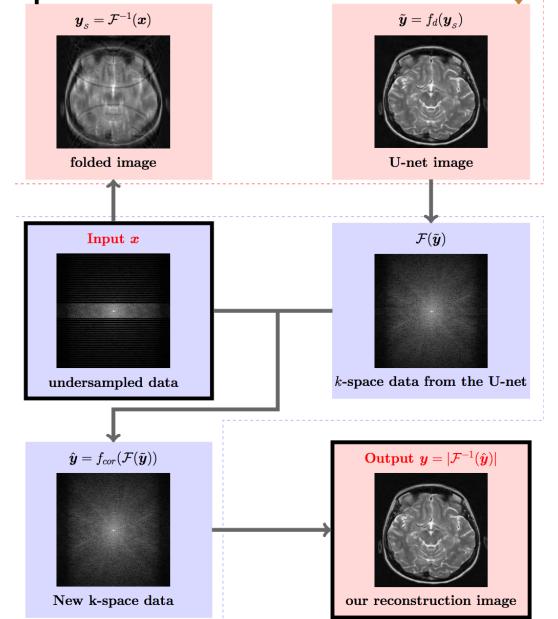


Nvidia

Low-dose CT – Chen et al.



Under-sampled MRI – Hyun et al.



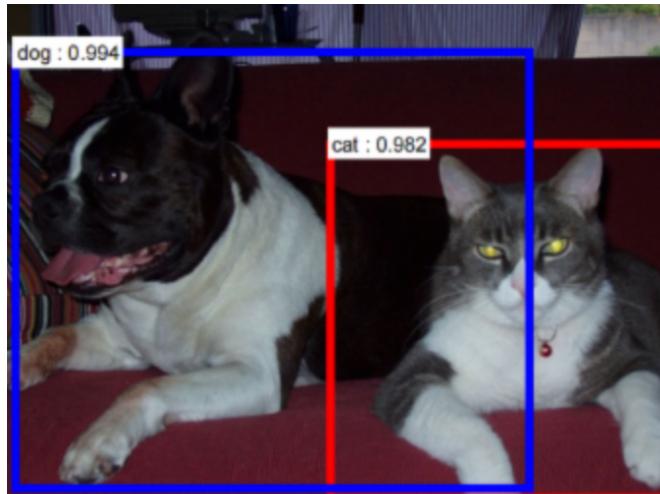
[https://youtu.be/BIW\\_jq3dOEE](https://youtu.be/BIW_jq3dOEE)

## 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 networks & 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

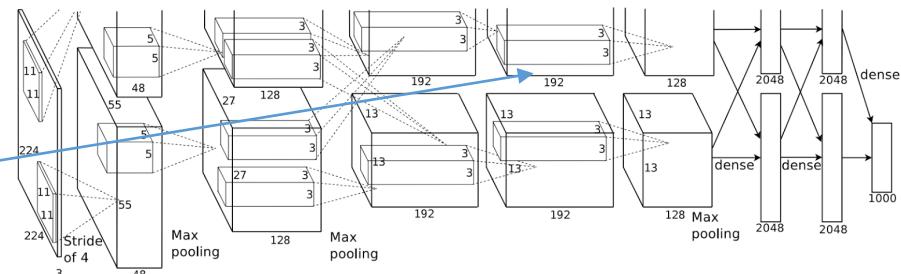
# What is this class *not* about?

“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 want to really understand this one operation here



“I want to program something to make cool pictures like this”

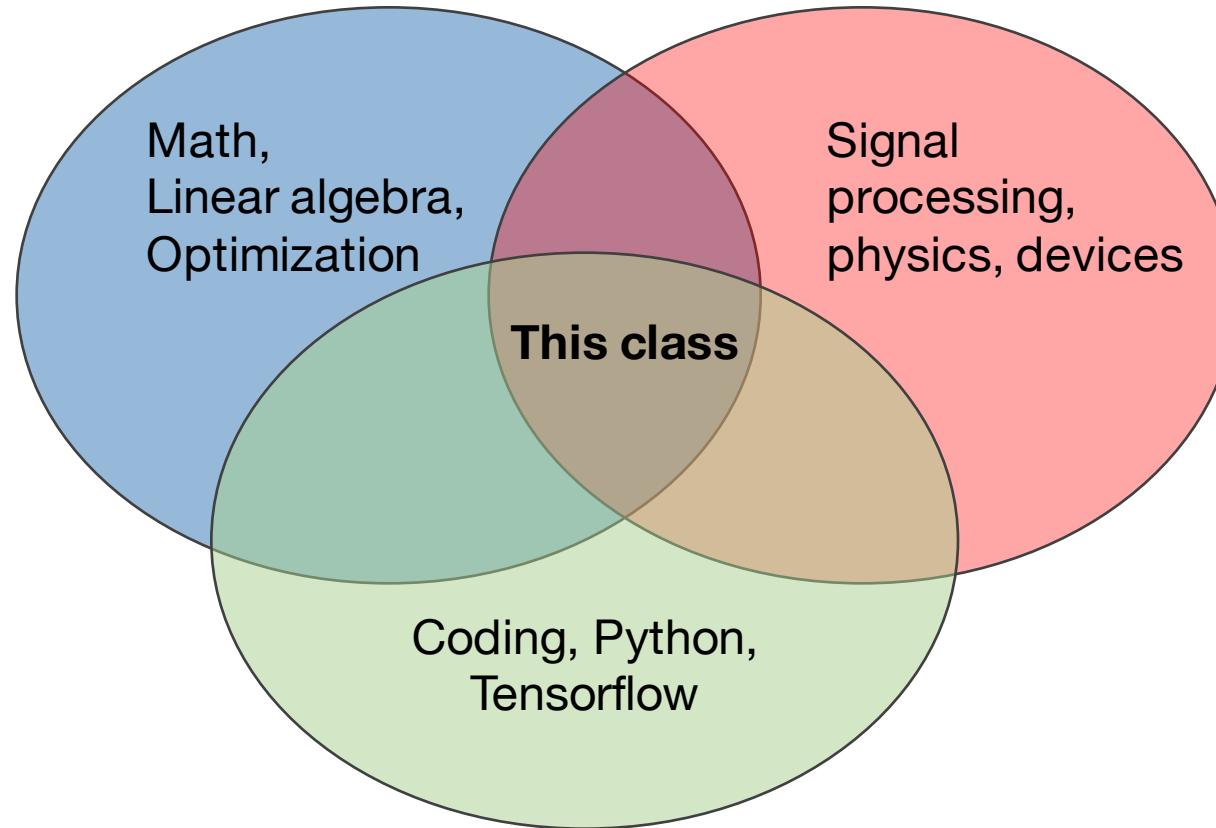


“I’d like an in-depth explanation of how my (fill-in-the-blank) imaging system works”

# 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