1. Introduction

Jimeng Sun

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Outline: DL4health

- Overview
- Health data science
- Health applications with deep learning
- Deep learning topics in this course

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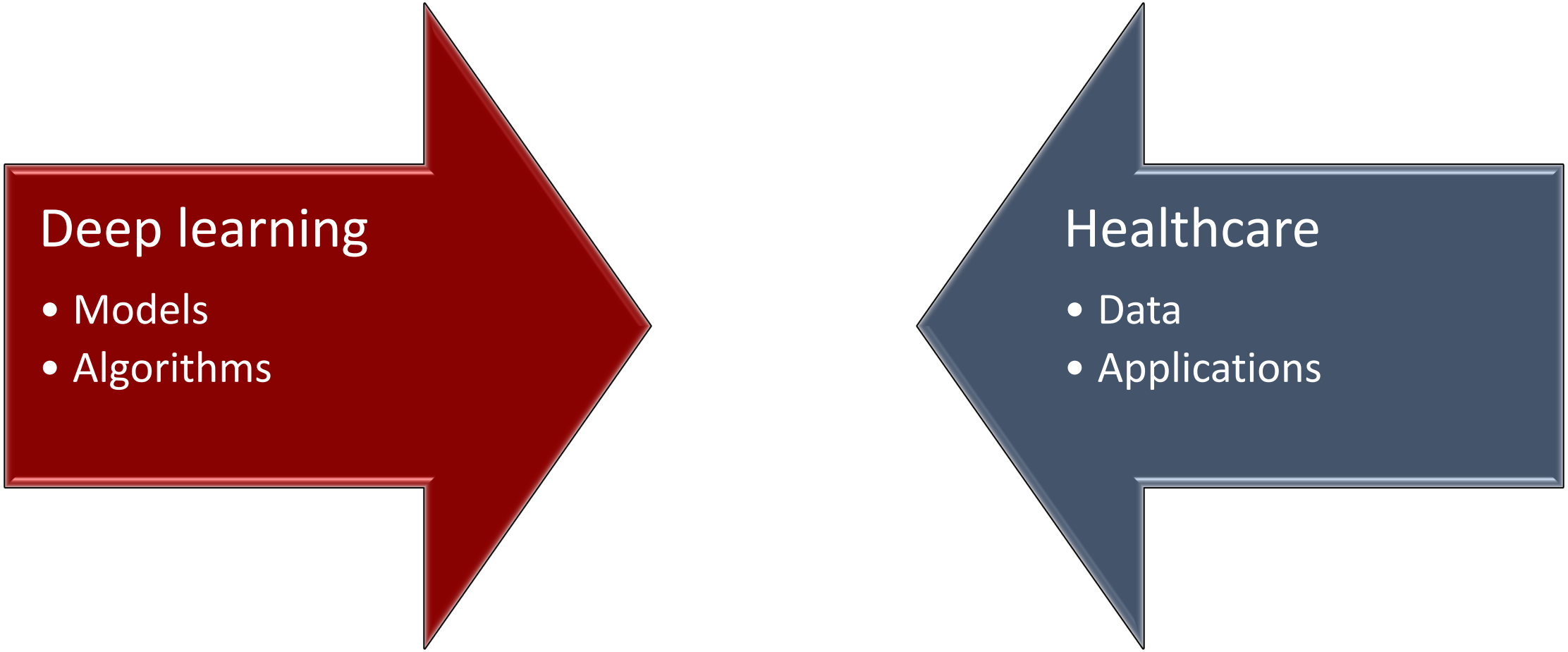
Focus of DL4health



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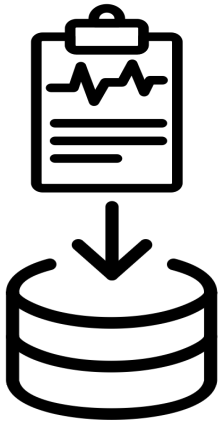
After finishing this course, you can



Understand health data

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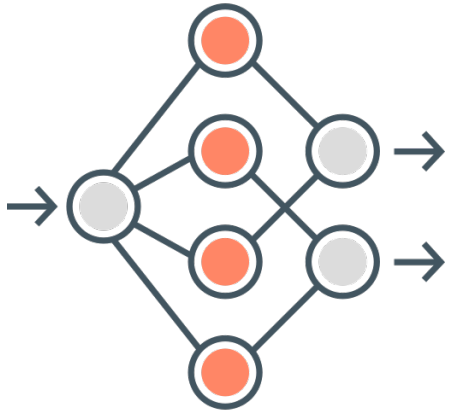

Apply deep learning models

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Health apps

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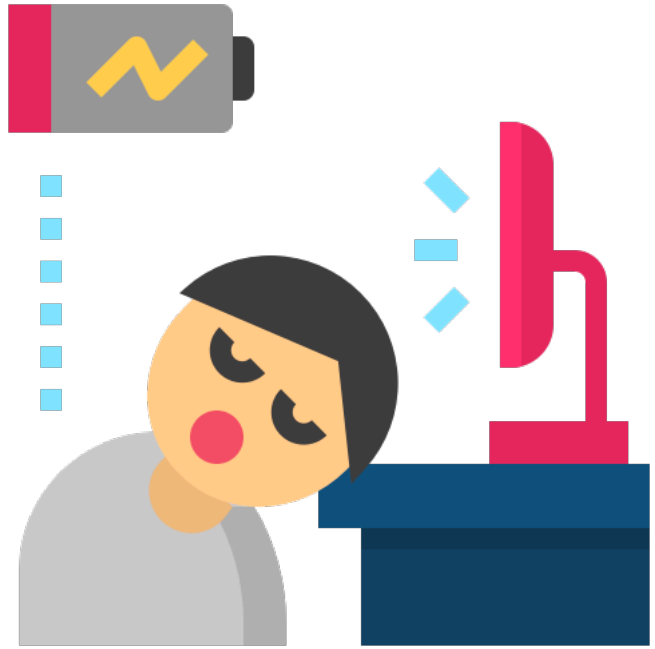
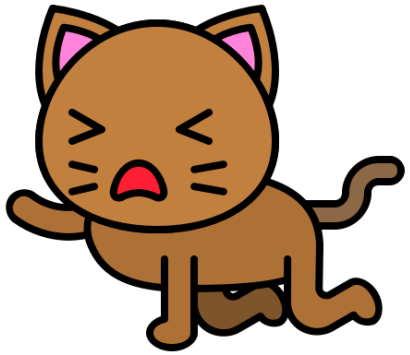
Why should I care?





Healthcare is huge

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US healthcare: The COST problem

US Healthcare spending in 2019

$3.6 trillion

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Market cap of top 4 companies

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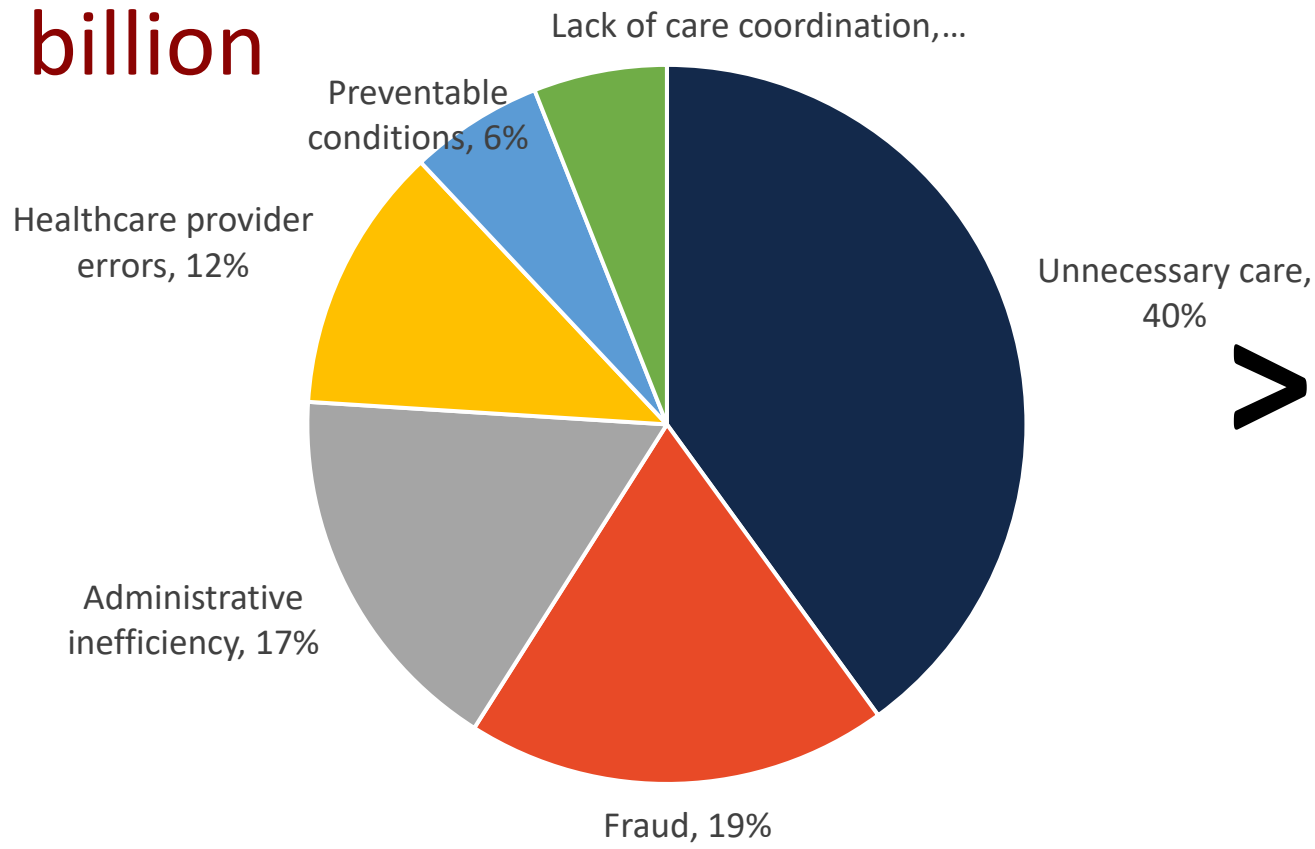
US Healthcare Waste per year

$935 billion



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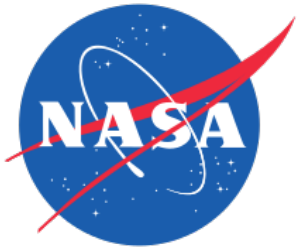
50 years budget



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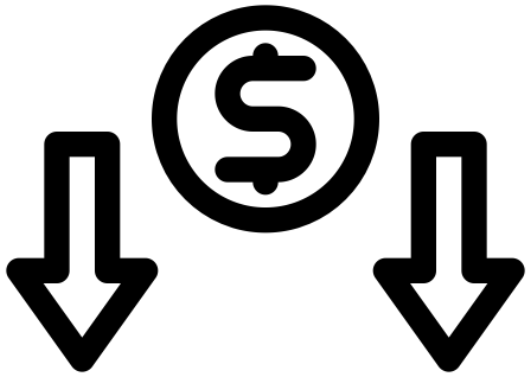
US Healthcare Quality Issue

200K to 400K preventable death per year

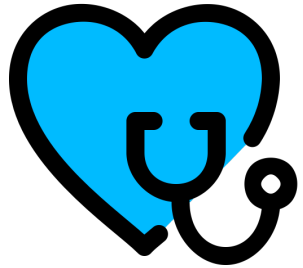
Over 1000 per day

Hope: data science ➔ low cost, better quality



Lower cost

- Early detection and prevention
  - E.g., heart failure onset prediction
- Utilization analysis
  - to identify and remove waste



Better care

- Inpatient care improvement
  - Sepsis detection
- Home monitoring
  - Sleep monitoring at home

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Health data is big

Big data in healthcare

Volume

- Genomic data
- Medical imaging

Variety

- Electronic health records
- Medical knowledge base

Velocity

- Real-time monitoring in ICU
- mHealth

Veracity

- Noises are everywhere
  - Missing data, errors in the data, false alarms

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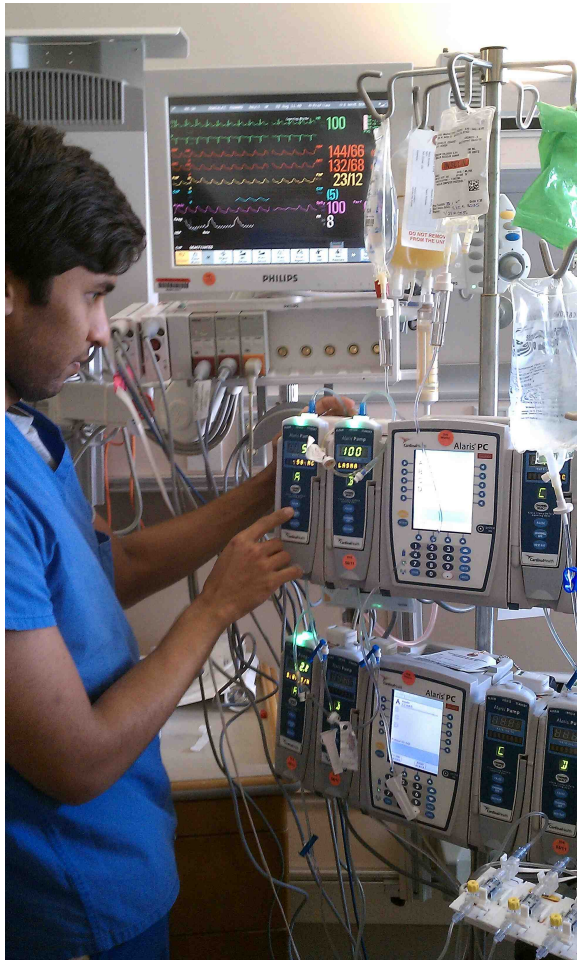
Real-time monitoring at ICU

- Arterial blood pressure
- Central venous pressure (CVP)
- Temperature
- Heart rate
- ECG
- Drug dispensing measures



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Potential healthcare applications with deep learning

- Diagnosis
- Outcome
- Treatment
- Insurance
- Drug discovery
- Public health

Diagnosis applications

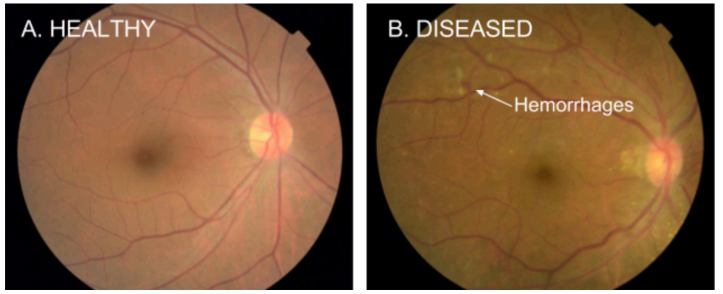

Figure 1. Examples of retinal fundus photographs that are taken to screen for DR. The image on the left is of a healthy retina (A), whereas the image on the right is a retina with referable diabetic retinopathy (B) due a number of hemorrhages (red spots) present.

- Medical imaging analysis

- Early detection of diseases
  - Choi, Edward, Andy Schuetz, Walter F. Stewart, and Jimeng Sun. 2017. "Using Recurrent Neural Network Models for Early Detection of Heart Failure Onset." *Journal of the American Medical Informatics Association: JAMIA* 24 (2): 361–70.
- Triaging

Image credit: https://ai.googleblog.com/2016/11/deep-learning-for-detection-of-diabetic.html

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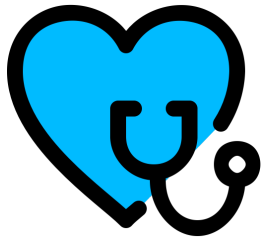
Outcome prediction



- Readmission prediction
- Length of stay prediction
- Mortality prediction
- Sepsis prediction

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Treatment recommendation

- Drug drug interaction detection
  - Huang, K., C. Xiao, T. N. Hoang, L. M. Glass, and Jimeng Sun. 2019. “CASTER: Predicting Drug Interactions with Chemical Substructure Representation.” *arXiv Preprint arXiv*. https://arxiv.org/abs/1911.06446.

- Treatment combination recommendation
  - Shang, Junyuan, Cao Xiao, Tengfei Ma, Hongyan Li, and Jimeng Sun. 2018. “GAMENet: Graph Augmented MEmory Networks for Recommending Medication Combination.” *arXiv [cs.AI]*. arXiv. http://arxiv.org/abs/1809.01852.
  - Zhang, Yutao, Robert Chen, Jie Tang, Walter F. Stewart, and Jimeng Sun. 2017. “LEAP: Learning to Prescribe Effective and Safe Treatment Combinations for Multimorbidity.” In *Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 1315–24. ACM.

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Insurance applications

- Fraud detection
- Cost estimation

Drug discovery and development

- Molecule property prediction

- Molecule generation
  - Fu, Tianfan, Cao Xiao, and Jimeng Sun. 2020. “CORE: Automatic Molecule Optimization Using Copy & Refine Strategy.” *AAAI*
- Clinical trial recruitment
  - Biswal et al. 2020. “Doctor2Vec: Dynamic Doctor Representation Learning for Clinical Trial Recruitment.” *AAAI*
  - Gao et al. 2020. COMPOSE: Cross-Modal Pseudo-Siamese Network for Patient Trial Matching KDD

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Public health applications

- Epidemiology models
  - Predicting COVID19 cases at different locations
  - Predicting hospitalization
  - Predicting death

Roadmap

Preliminary	Foundation	Classical models	Modern models
1. Intro	4. DNN	6. CNN	9. Attention
2. ML basics	5. Embedding	7. RNN	10. Graph neural network
3. Health data		8. Autoencoder	11. Memory network
			12. Deep generative model

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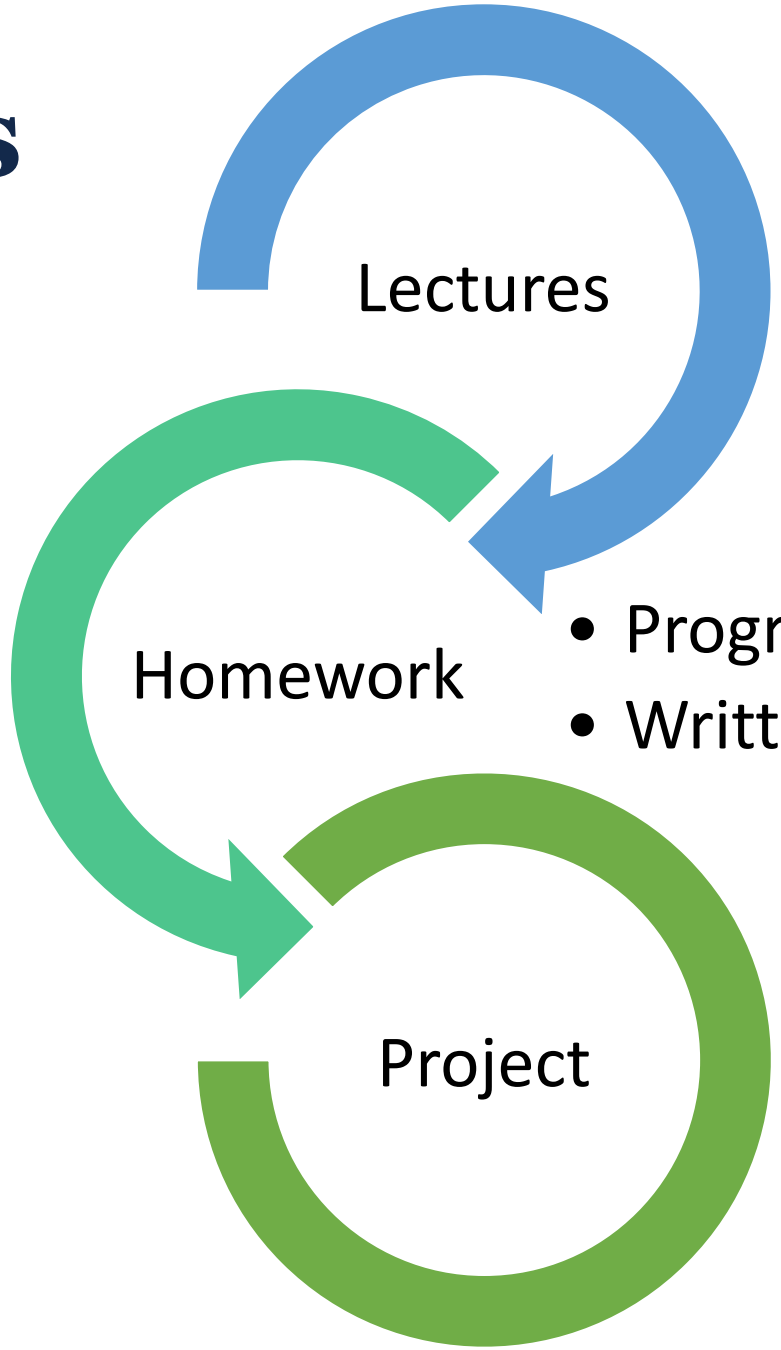
Activities



- DL methods
- Healthcare applications

- Programming part
- Written part

- Data science project
- Report
- Presentation
- Code

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Resources

- Textbook: Deep learning for healthcare
- Lecture video and slides
- Online labs

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