



Deep Learning for Healthcare

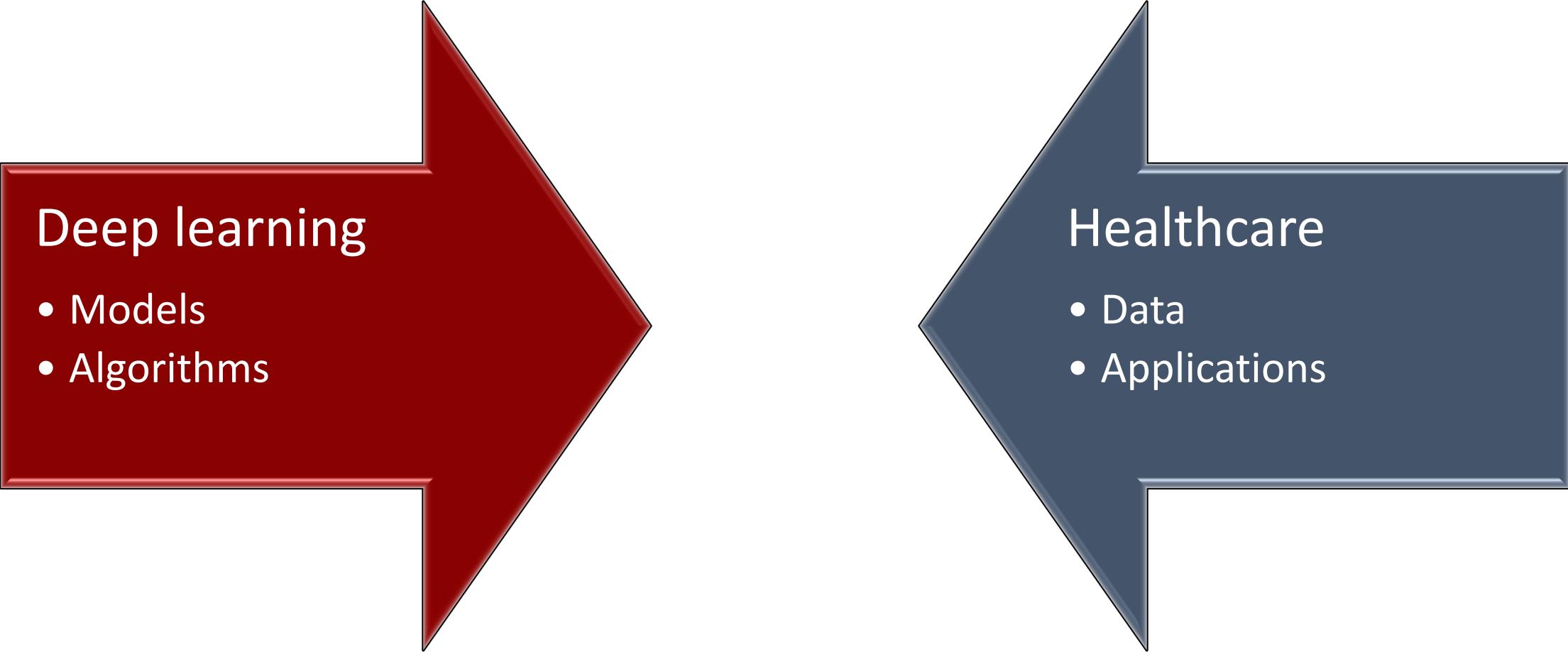
1. Introduction

Jimeng Sun

Outline: DL4health

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

Focus of DL4health



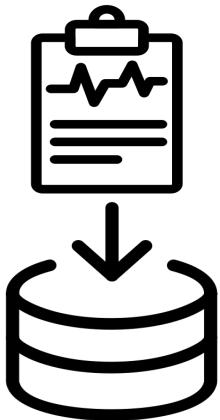
Deep learning

- Models
- Algorithms

Healthcare

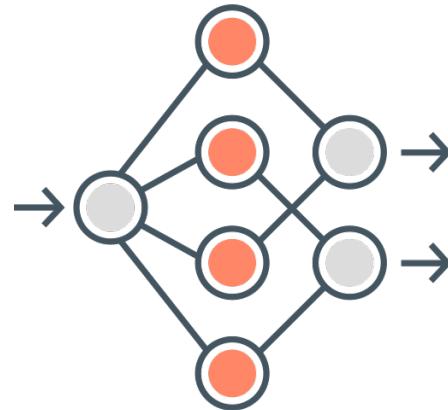
- Data
- Applications

After finishing this course, you can



Understand health data

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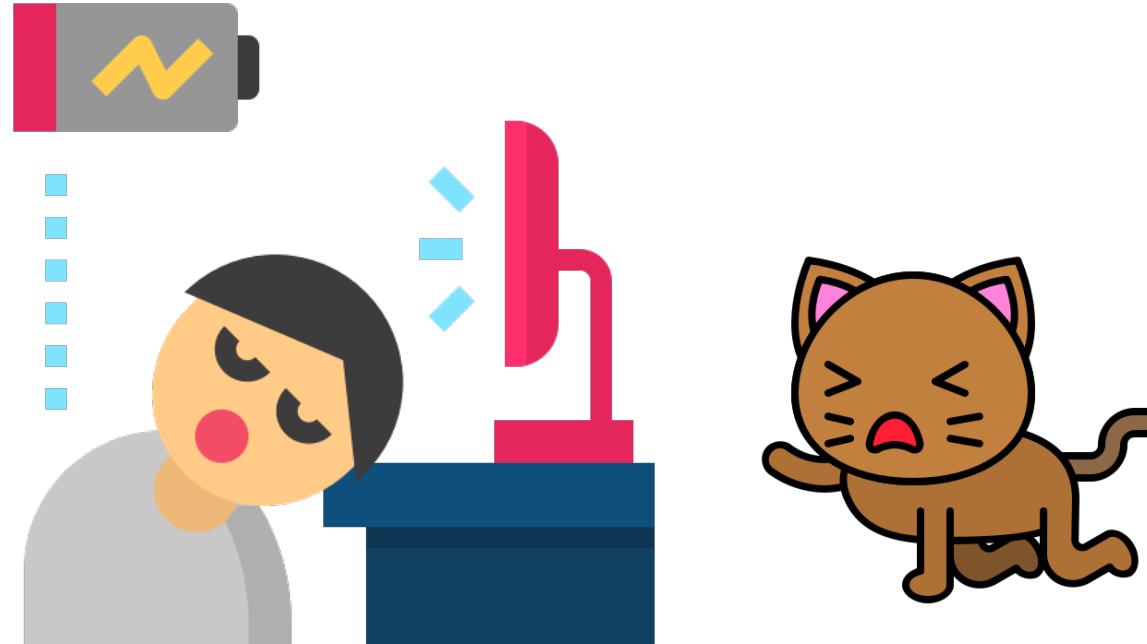
Apply deep learning models

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Health apps

Why should I care?



A large African elephant stands in a grassy savanna under a clear sky. The elephant's massive body, wrinkled skin, and long white tusks are clearly visible. It is positioned centrally, facing slightly towards the camera.

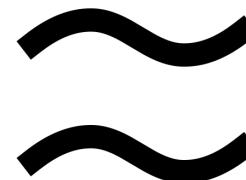
Healthcare is huge

US healthcare: The COST problem



US Healthcare spending in 2019

\$3.6 trillion



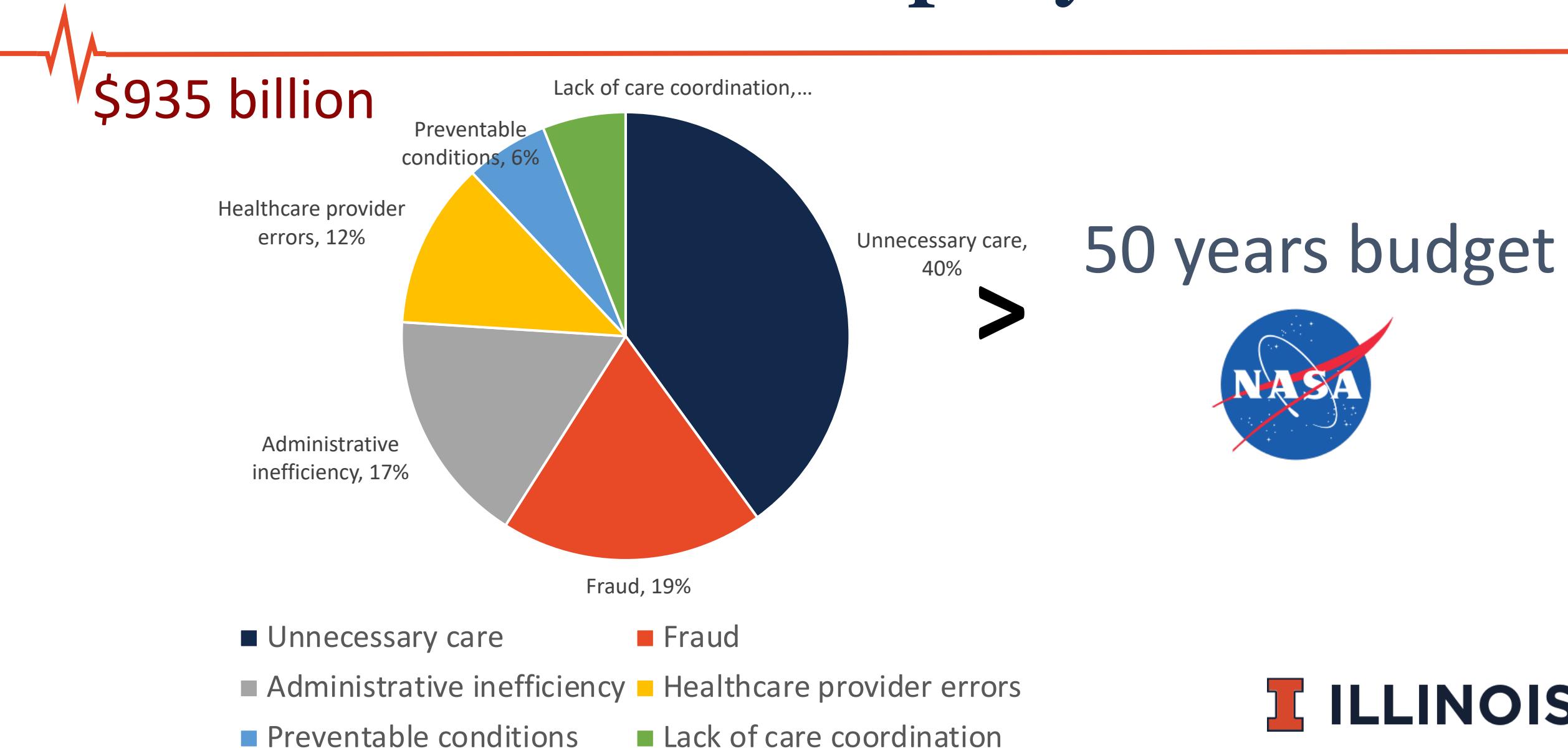
Google



amazon

Market cap of top 4 companies

US Healthcare Waste per year

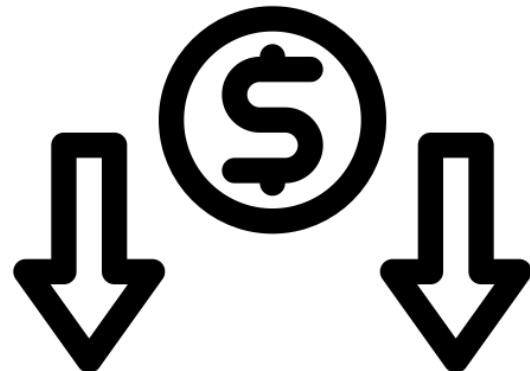


US Healthcare Quality Issue



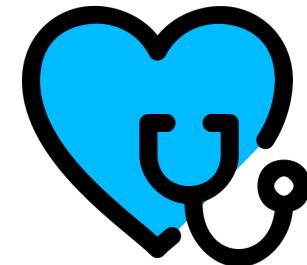
200K to 400K preventable death per year
Over 1000 per day

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

A large, realistic sculpture of a watermelon slice is positioned in a grassy park area. The sculpture is oriented horizontally, with its green rind on the right and a large wedge removed from the left side, revealing the red flesh and black seeds. It sits on a stand in front of a chain-link fence and some trees under a blue sky.

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

Real-time monitoring at ICU

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



Potential healthcare applications with deep learning

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

Diagnosis applications

- 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



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 to a number of hemorrhages (red spots) present.

Outcome prediction



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

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.

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

Public health applications

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

Roadmap

Preliminary

1. Intro
2. ML basics
3. Health data

Foundation

4. DNN
5. Embedding

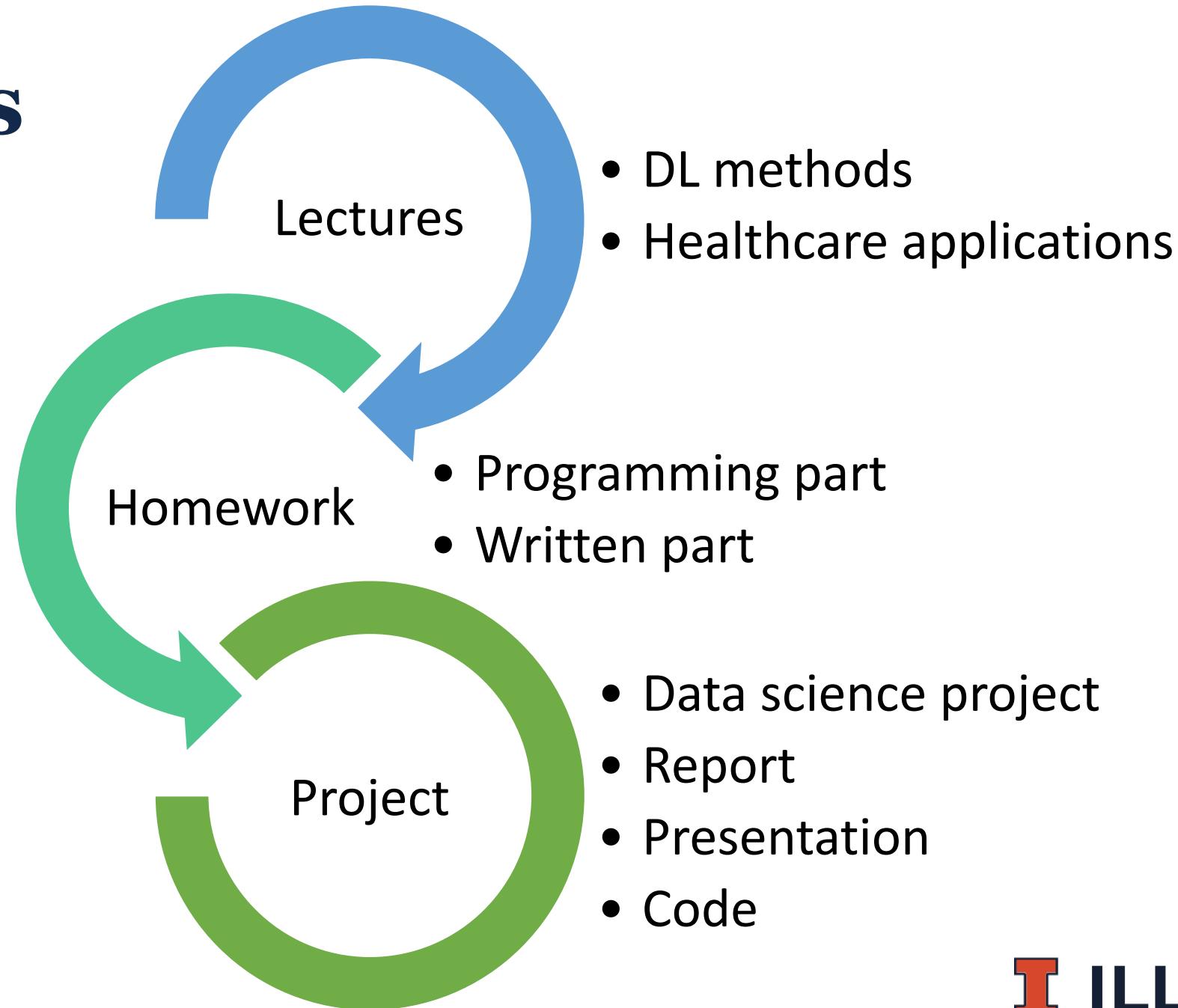
Classical models

6. CNN
7. RNN
8. Autoencoder

Modern models

9. Attention
10. Graph neural network
11. Memory network
12. Deep generative model

Activities



Resources

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