EEP 596: AI and Health Care || Lecture 9

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Logistics

- Mini Project 1 first deadline - Sunday, May 1

Logistics

- Mini Project 1 first deadline - Sunday, May 1
- Mini Project 1 second deadline - ~~Monday, May 2~~ Friday, May 6

Today

1. Cancer Study
2. Cancer Diagnosis
3. AI Methods for Cancer Diagnosis

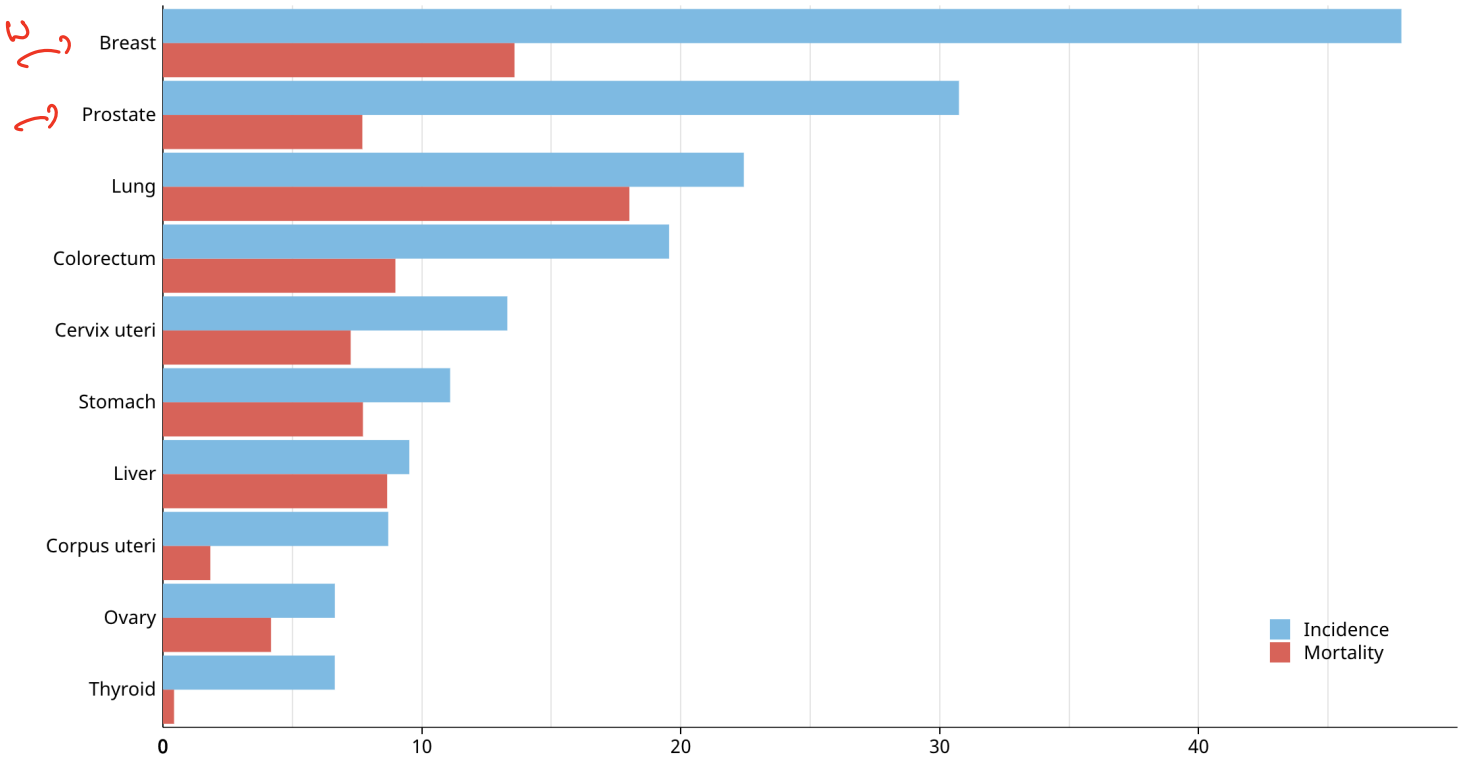
Cancer Statistics

US Cancer Statistics

Cancer Statistics

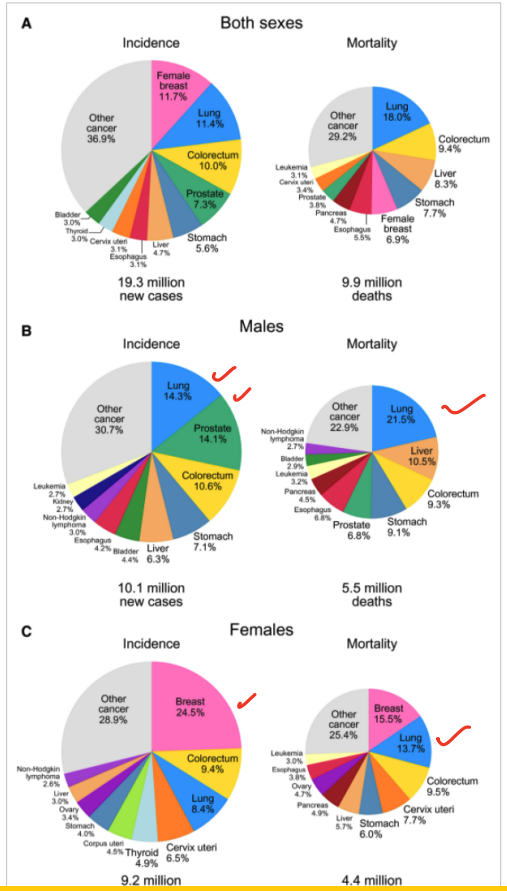
World wide stats 2021

Estimated age-standardized incidence and mortality rates (World) in 2020, worldwide, both sexes, all ages



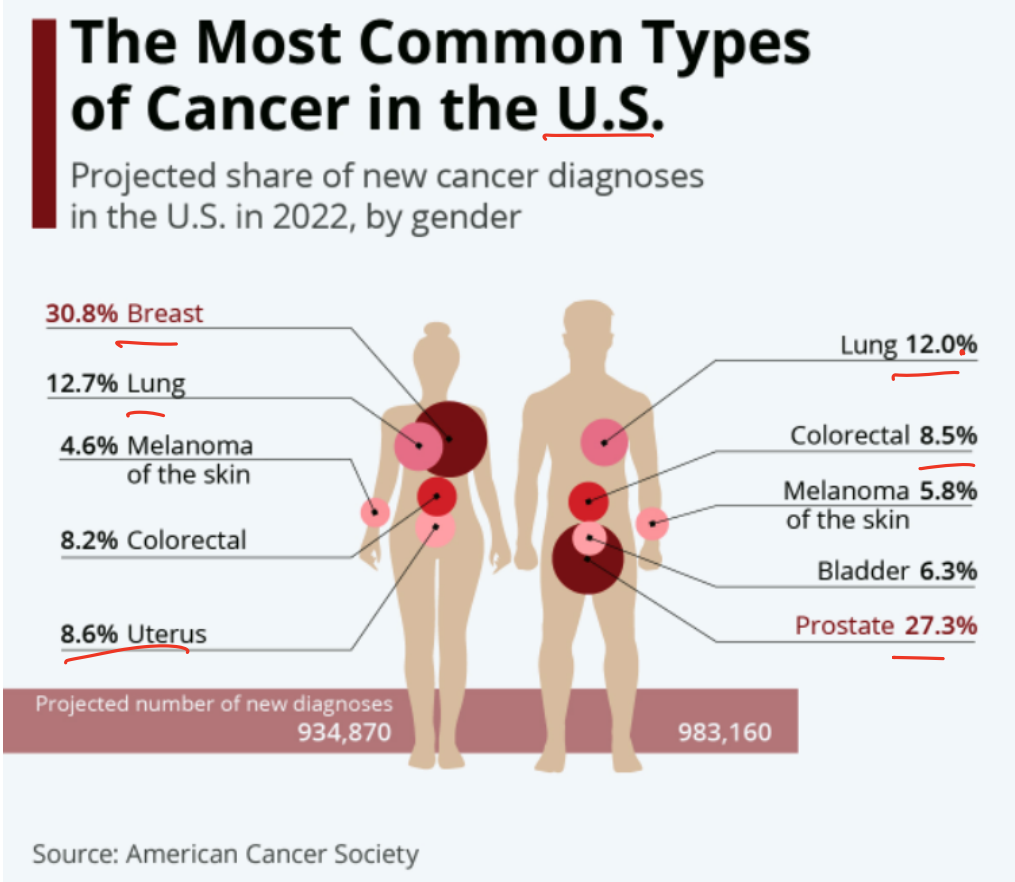
Cancer Statistics

World wide stats 2020



Cancer Statistics

By Gender 2022



Early Cancer Detection

1. 50 % of Lymphoma cancer (Lymphatic cancer) is detected at Stage 3 or 4!

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Early Cancer Detection

1. 50 % of Lymphoma cancer (Lymphatic cancer) is detected at Stage 3 or 4!
2. Early screening of patients with risk can lead to effective treatment
3. ML can help with risk assessment based on EHR, medical imaging data, test, etc

Early Cancer Detection

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Early Cancer Detection

1. Even in Breast Cancer, its not clear how to suggest patients for breast cancer screening
2. ML models can help with this
3. Screening ML models within Hospital workflows can automatically trigger a referral or diagnostics test - Hence speeding up treatment and recovery

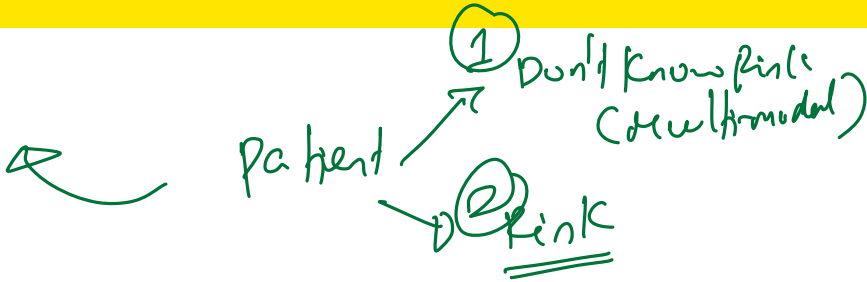
Time, Triggers, Notifications, Prioritization

Breakout 1

ML in cancer detection

Brainstorm how ML can support different parts of the early cancer detection pipeline for a typical patient at a hospital. What would be the data sources be used to train the ML model, and where in the pipeline would ML/AI help with speed ups in detection time - Think of a practical setting at a hospital you know of.

Data Sources



1. Multi-modal: Images, patient characteristics, etc
2. EHR given patient features and patient history
3. Radiology reports give medical imaging data
4. Digitized pathology slides (tissue samples imaged)

→ Referenced a survey paper

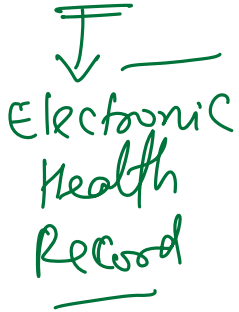
→ ? Blood chemistry profiles

Biopsy – Histopathology Report

ICE #1

Which parts of ML/AI can help with extracting information from EHR?

1. CNNs
2. NLP approaches
3. LSTMs
4. Auto Encoders



Digitized pathology slides

ML Approaches

1. ML for Radiology: Radiomics

ML Approaches

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2. Traditional ML

ML Approaches

1. ML for Radiology: Radiomics
2. Traditional ML
3. Deep Learning esp. for Imaging has seen 95% AUC for Breast cancer, Brain cancer, Lung cancer detection in literature

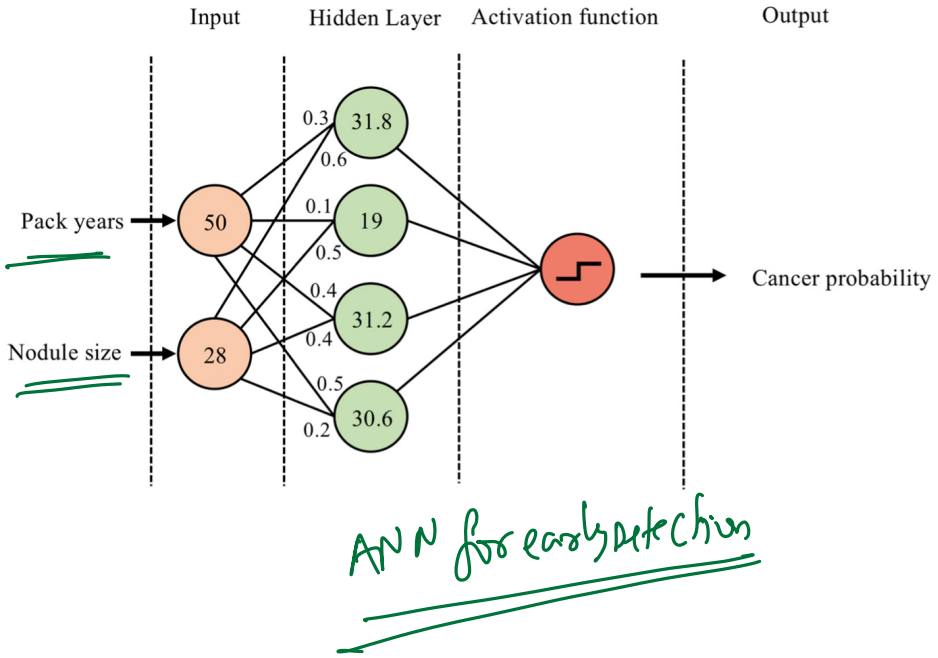
Early Cancer Detection

Table 1. Common supervised ML techniques with early diagnosis examples.

Model	Type	Description	Example
LR	R	Uses logistic function to predict categorical outcomes	Chhatwal et al. [13]
SVM	R, C	Constructs hyperplanes to maximise data separation	Zhang et al. [14]
NB	C	Utilises Bayesian probability including priors for classification	Olatunji et al. [15]
RF	R, C	Ensembles predictions of random decision trees	Xiao et al. [16]
XGB	R, C	As RF, but sequential errors minimised by gradient descent	Liew et al. [17]
ANN	R, C	Multiplies input by weights and biases to predict outcome	Muhammad [18]
CNN	R, C	Uses kernels to detect image features	Suh [19]

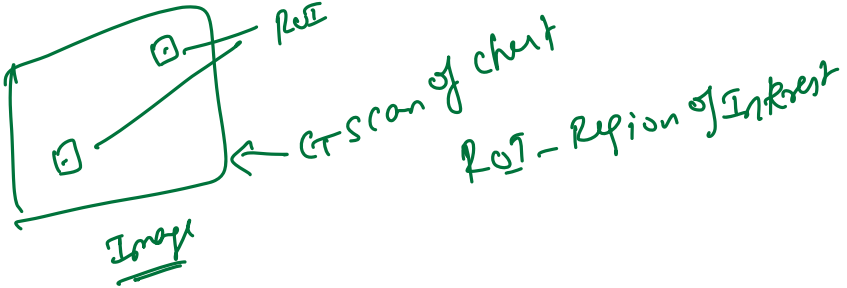
Abbreviations: R: regression, C: classification, LR: logistic regression, SVM: support vector machine, NB: naïve Bayes, RF: random forest, XGB: extreme gradient boosting, ANN: artificial neural network, CNN: convolutional neural network.

Early Cancer Detection (Lung cancer)



ANN for early detection

Early Cancer Detection



Traditional Machine Learning		Deep Learning
Requires ROI segmentation	⟷	ROI segmentation optional
Features are pre-specified		Features generated by model
Features are easily quantified		Features difficult to quantify
Computationally less intensive		Computationally more intensive
May perform better on small datasets		May perform better on large datasets

Early Cancer Detection

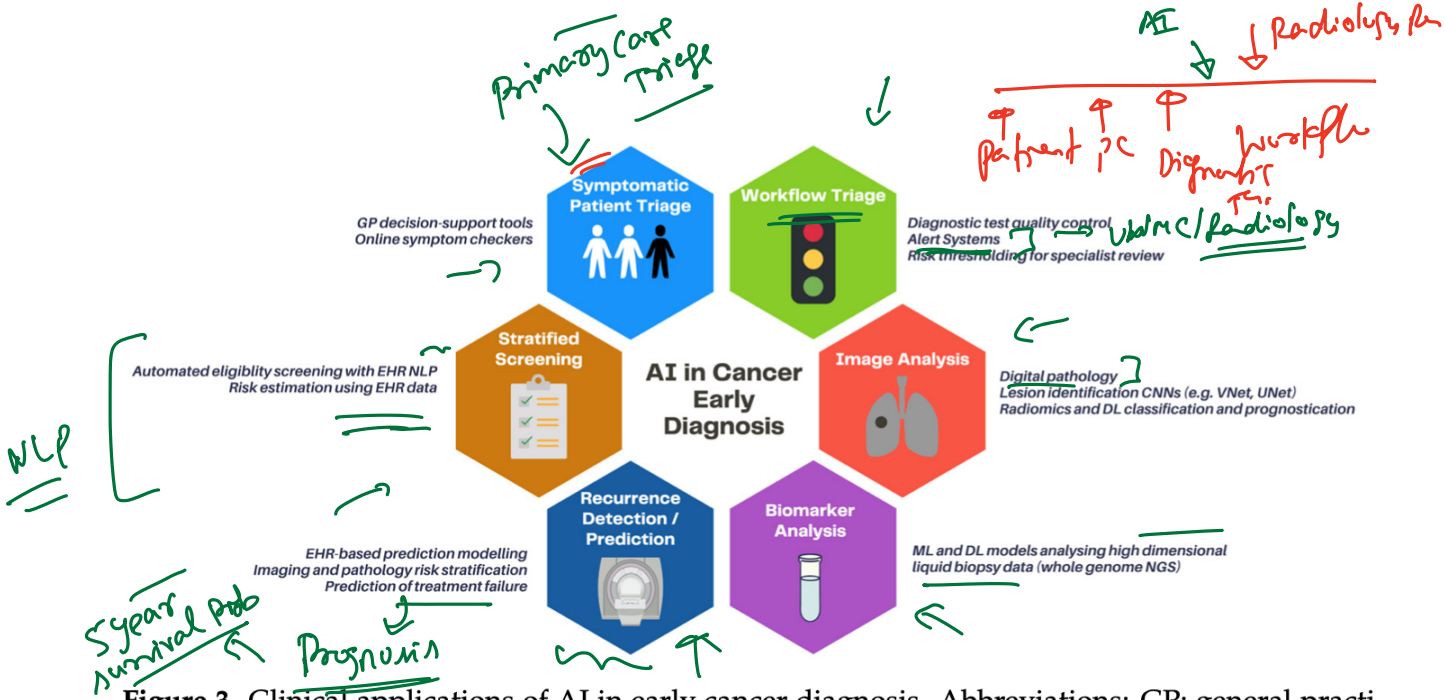


Figure 3. Clinical applications of AI in early cancer diagnosis. Abbreviations: GP: general practitioner, NLP: natural language processing, EHR: electronic healthcare record, ML: machine learning, DL: deep learning, NGS: next-generation sequencing.

Early Cancer Detection

AI + Radiologist In the Loop Model

↳ workflow optimization

Figure 4. Example diagnostic triage pipeline. The AI model assigns a risk group to each examination, as well as a confidence estimate, and scans that are either high risk or have low diagnostic confidence are escalated for specialist review. CT images taken from the public LUNGx dataset [97].

Triages

1. A study showed symptomatic triages from primary care can increase cancer-detection by 6% (based on a decision support tool)
2. One study over 1 MM mammograms over 500k women showed that AI based risk scores less than 60% can be safely triaged for no radiologist review!

Saving Time + Prioritizing Risky Mammograms

Threshold based Trigger → Integrate into workflow!

Early Cancer Detection

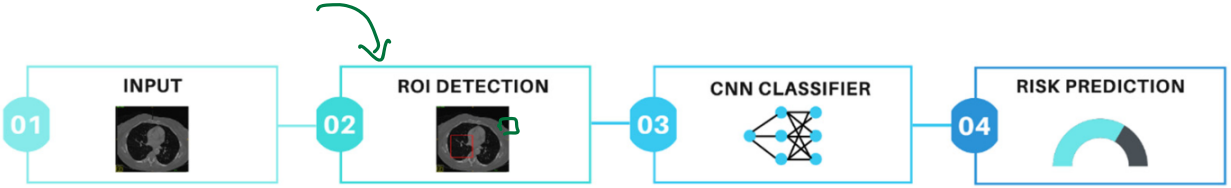
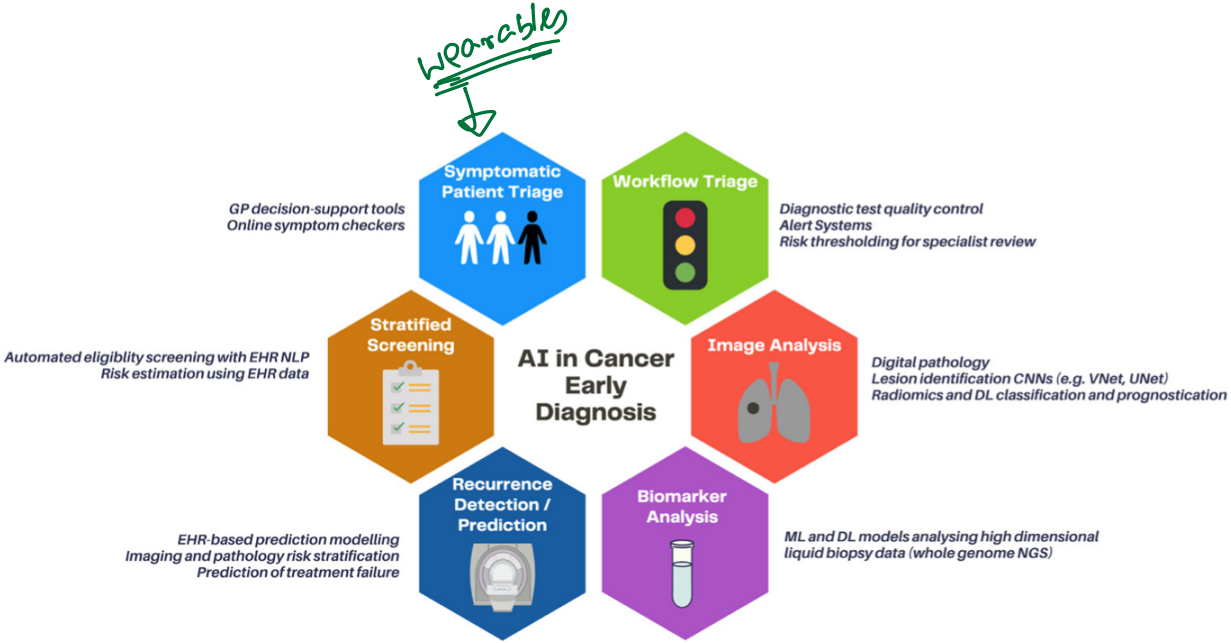


Figure 5. Example of an 'end to end' cancer detection pipeline. 1: A whole CT volume is used as input into the model. 2: A region detection architecture (such as UNet) is used to identify a sub-volume and assign a bounding-box ROI. 3: The volume encompassed by the ROI is input into a classification CNN (such as InceptionNet) to learn patterns associated with the outcome variable. 4: A risk prediction of malignancy is output. Abbreviations: ROI: region of interest, CNN: convolutional neural network. CT images taken from the public LUNGx dataset [97].

Imaging

95% AUC Comparable to Radiologist Detection performance!

Early Cancer Detection



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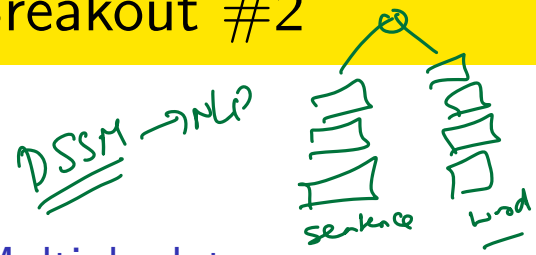
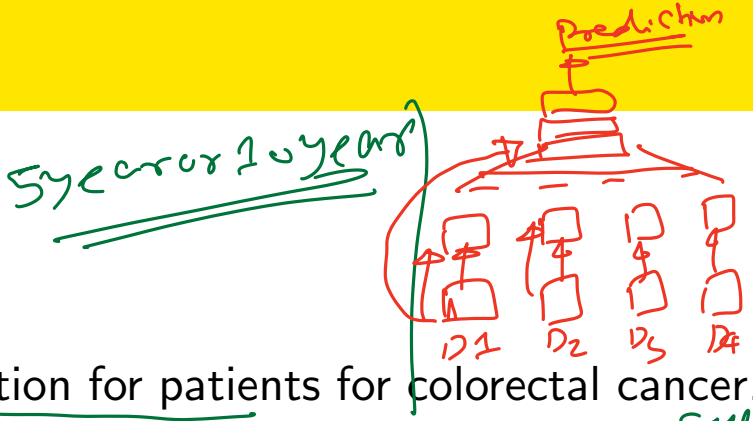
Breakout #2

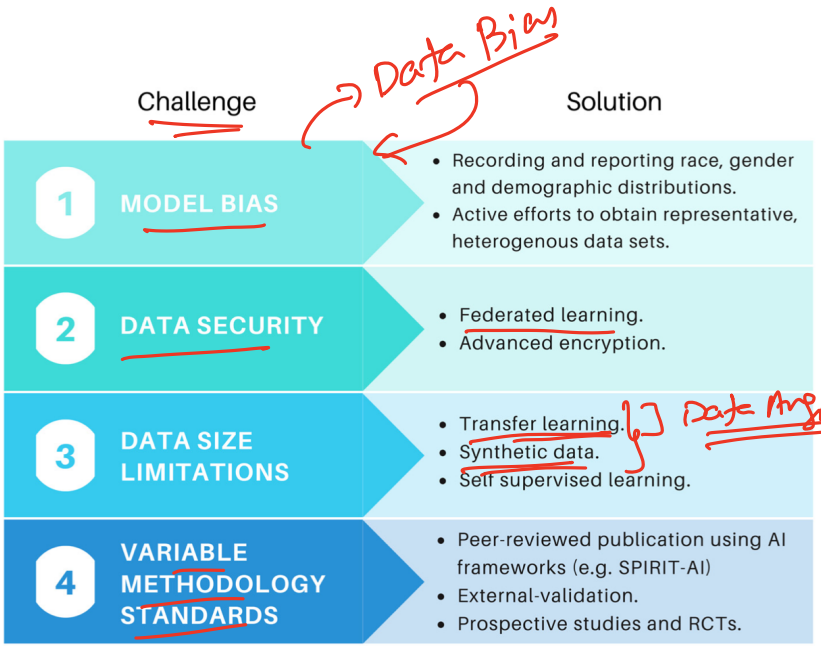




Multiple data sources

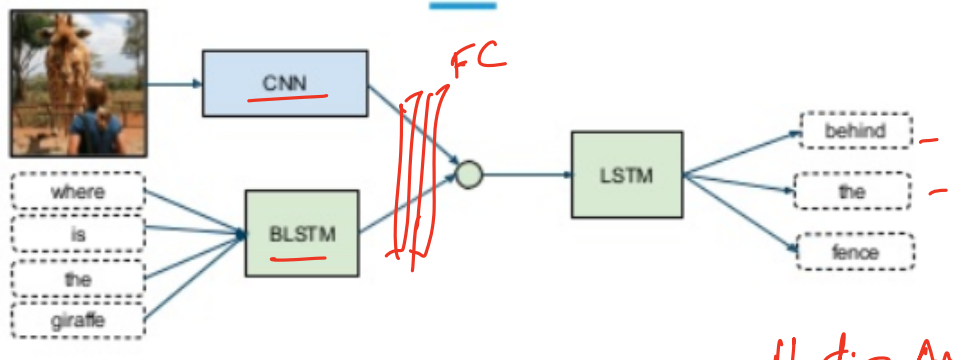
Let's say we want to do risk stratification for patients for colorectal cancer. We have access to histopathology reports (including blood chemistry - EMR Wbc, Rbc, Platelets, sodium, potassium levels, etc) and also digital pathology images (biopsy tissue samples). We also have access to recent CT scans from the abdomen/lower-abdomen region. A typical cancer diagnostics would require getting all these tests done and then going to a Oncologist for a diagnosis. Think of a ML model architecture that can extract information from all these different data sources for risk stratification of colorectal cancer.

Early Cancer Detection



Multi-model architecture

Multiple Modes of Data → Multi-Modal



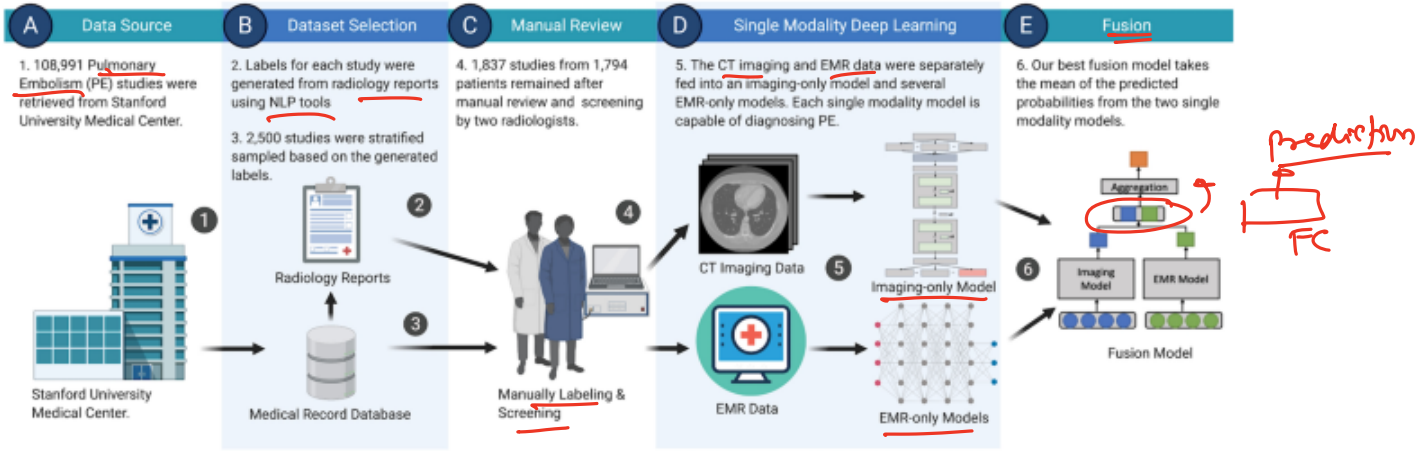
Image

Text

Inputs:- Image, question

output:- Answer (text)

Multi-model architecture



References

1. The Role of Artificial Intelligence in Early Cancer Diagnosis. Hunter et al. 2022
2. US Cancer Statistics