# Object Segmentation for Lung CT Scans

## Capstone Project

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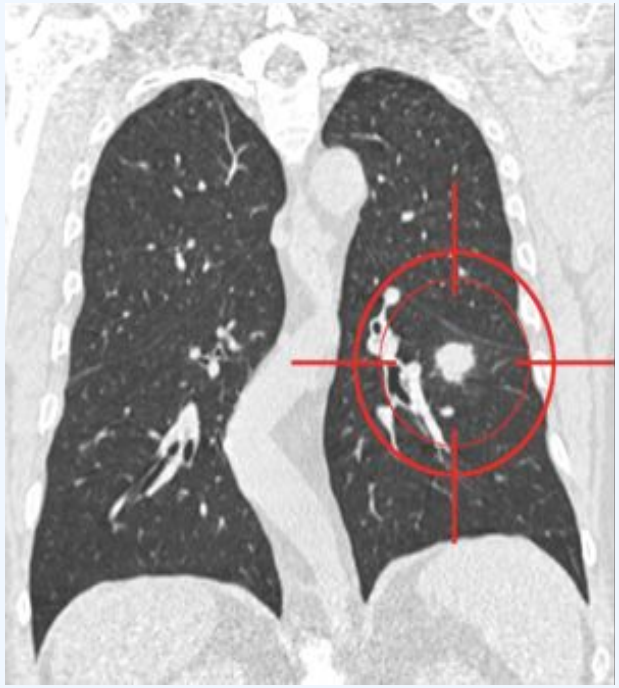


# 01

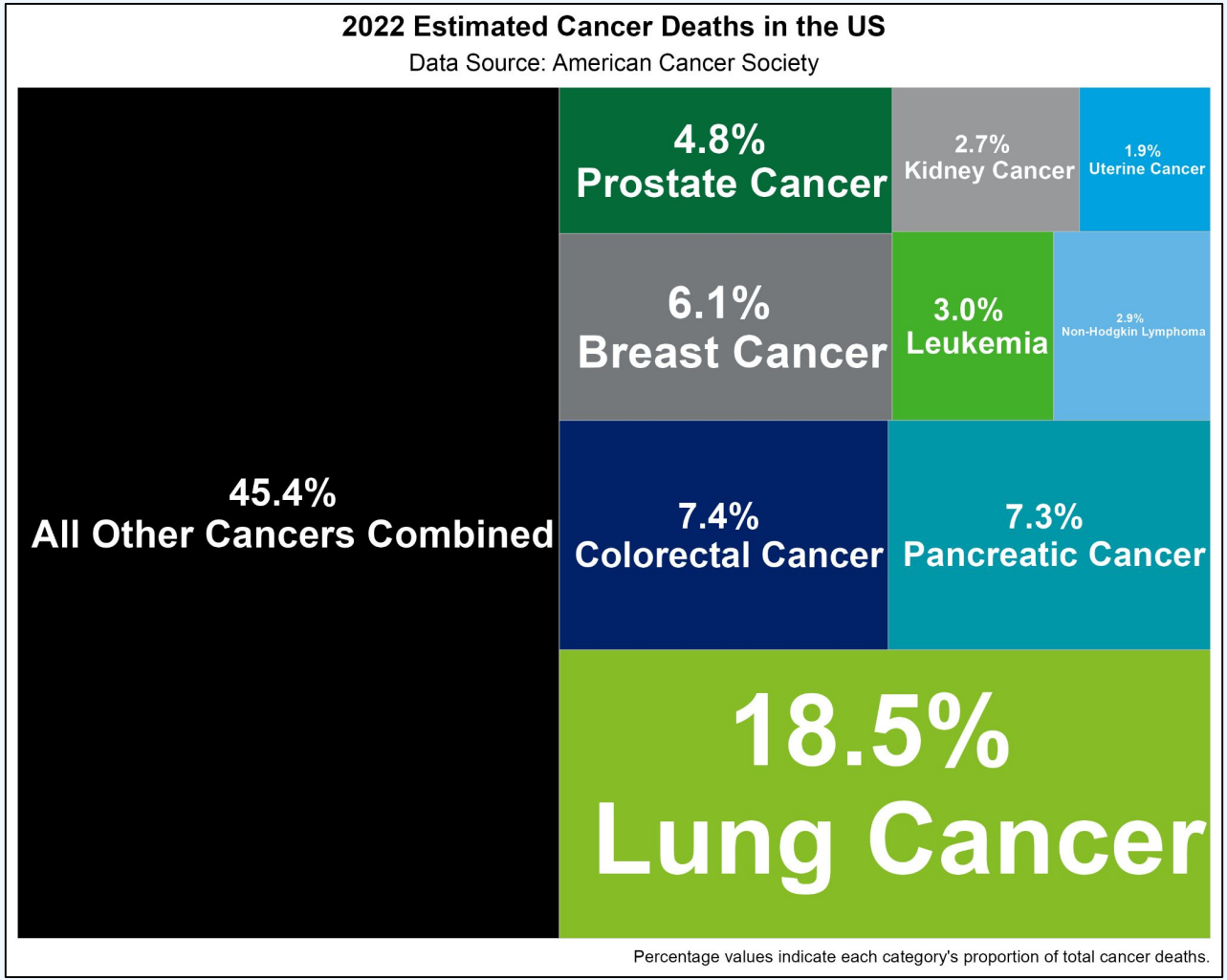
# Introduction

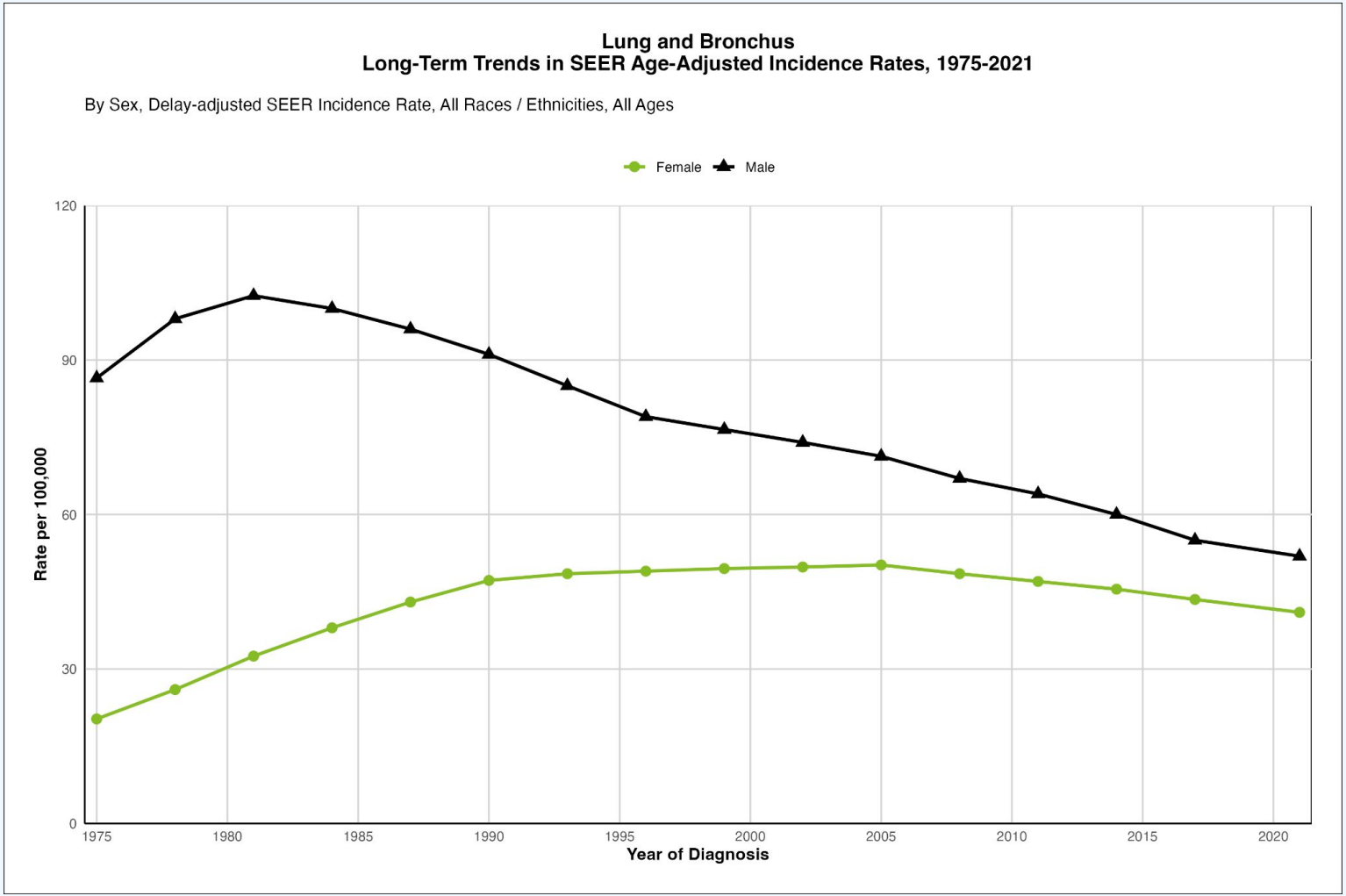
# Total U.S. Cancer Deaths: 748,440

2022 Estimated Cancer Deaths:
https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2021.html

# U.S. Lung Cancer Deaths: 131,880

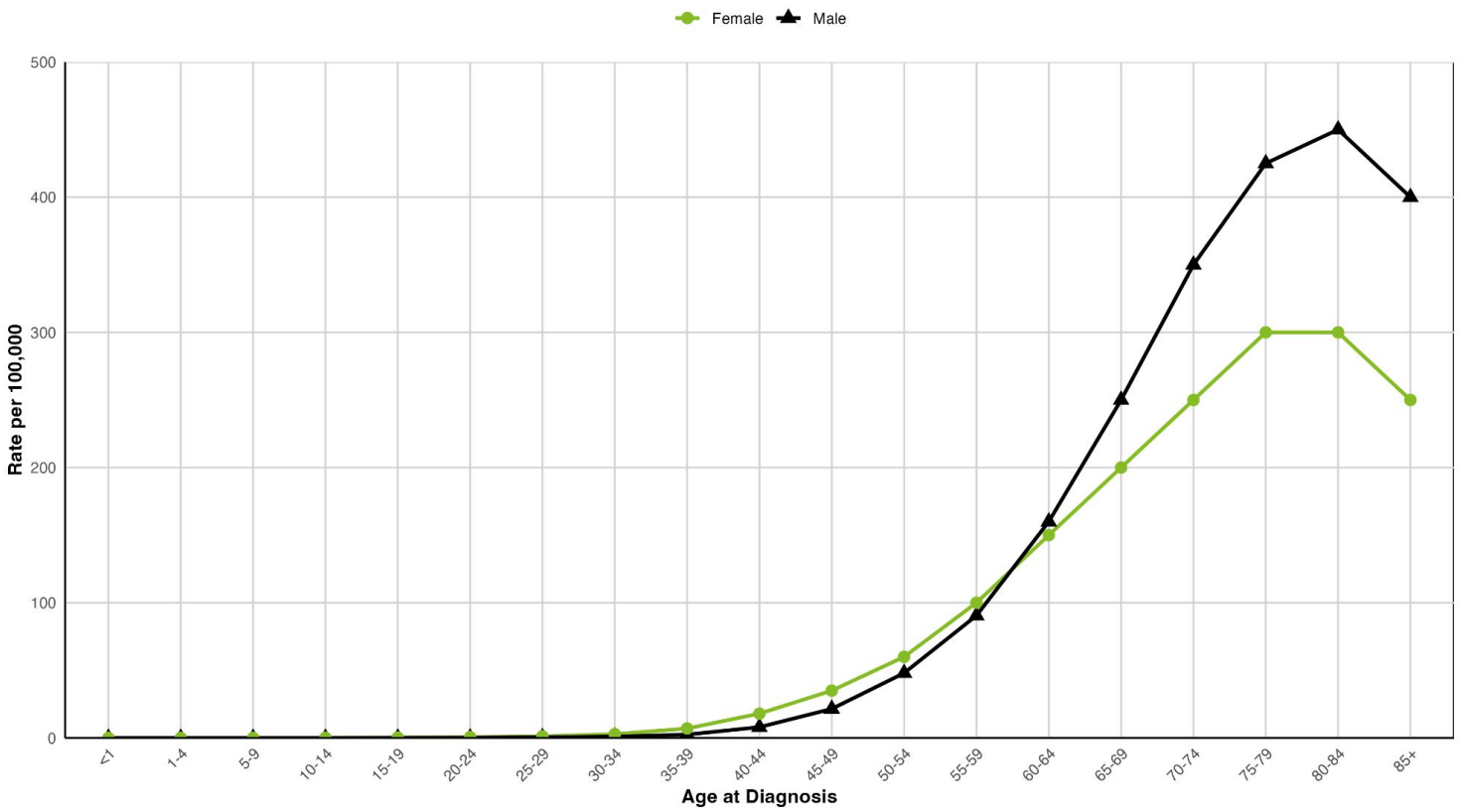
2022 Estimated Cancer Deaths:
https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2021.html


2022 Estimated Cancer Deaths in the US
Data Source: American Cancer Society
45.4%
All Other Cancers Combined
4.8%
Prostate Cancer
2.7%
Kidney Cancer
1.9%
Uterine Cancer
6.1%
Breast Cancer
3.0%
Leukemia
2.9%
Non-Hodgkin Lymphoma
7.4%
Colorectal Cancer
7.3%
Pancreatic Cancer
18.5%
Lung Cancer
Percentage values indicate each category's proportion of total cancer deaths.


Lung and Bronchus
Long-Term Trends in SEER Age-Adjusted Incidence Rates, 1975-2021
By Sex, Delay-adjusted SEER Incidence Rate, All Races / Ethnicities, All Ages
Female
Male
120
90
60
30
0
Rate per 100,000
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year of Diagnosis

**Lung and Bronchus**
**SEER Incidence Rates by Age at Diagnosis, 2017-2021**

By Sex, Delay-adjusted SEER Incidence Rate, All Races / Ethnicities



# Vocabulary for Cancer Staging Detection

### 1. Localized

The cancer is localized and hasn't spread beyond its origin.

### 2. Regional

The cancer has spread beyond the original organ, potentially affecting nearby tissues, structures, or lymph nodes.

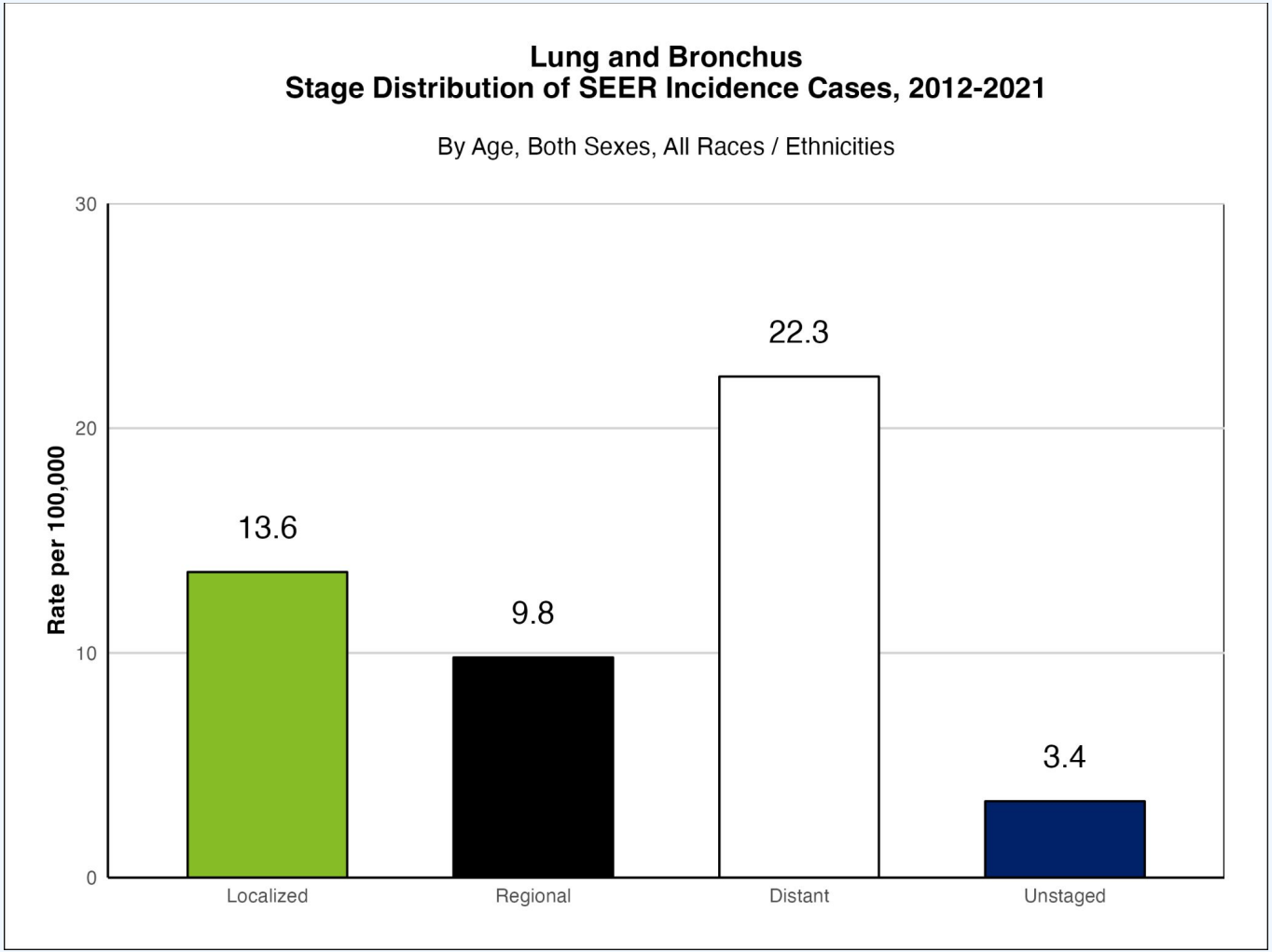
### 3. Distant (Metastatic)

The cancer has metastasized beyond regional organs or lymph nodes.

### 4. Unstaged

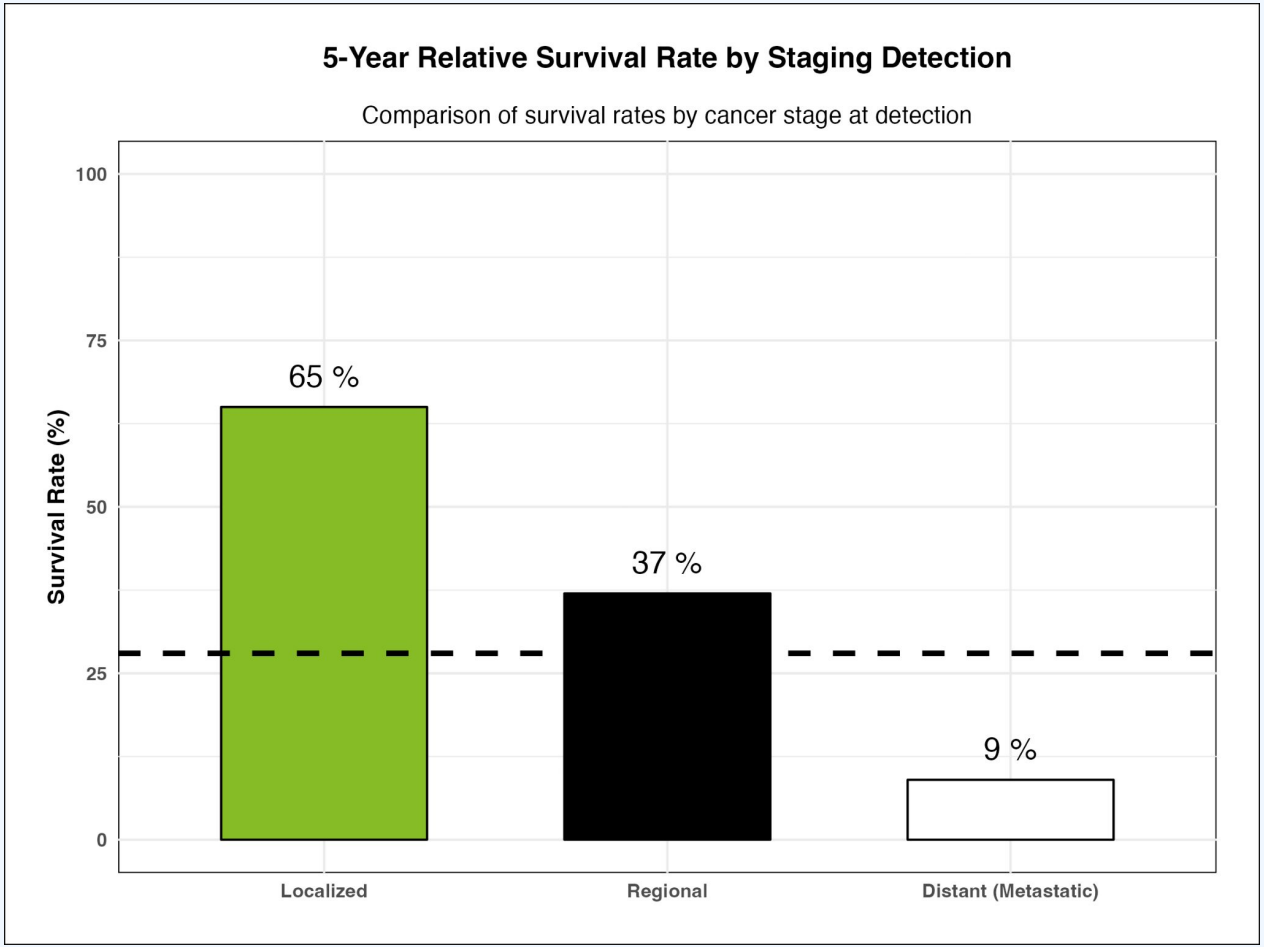
Insufficient data prevents definitive cancer staging, possibly due to incomplete testing or diagnostic limitations.

https://www.cdc.gov/cancer/uscs/technical_notes/stat_methods/stage-at-diagnosis.htm


Lung and Bronchus
Stage Distribution of SEER Incidence Cases, 2012-2021
By Age, Both Sexes, All Races / Ethnicities
Rate per 100,000
30
20
10
0
13.6
9.8
22.3
3.4
Localized
Regional
Distant
Unstaged

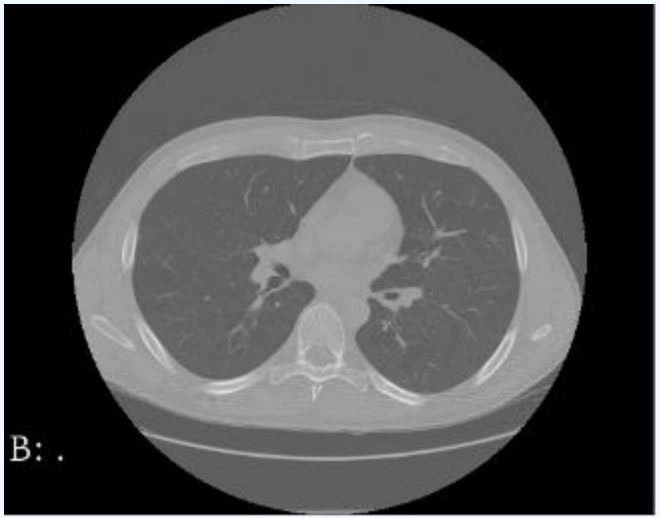
# 13.7%
# Misdiagnosis Rate

Citation: Armato III, AE, McLennan, G, Bélanger, Y, et al. (2011). Diagnosis of Subsolid Nodules by Anatomic Pathologists on Low-Dose CT Scans in the National Lung Screening Trial. Journal of Thoracic Oncology, 6(4), 737-745.




https://www.cancer.org/cancer/types/lung-cancer/detection-diagnosis-staging/survival-rates.html

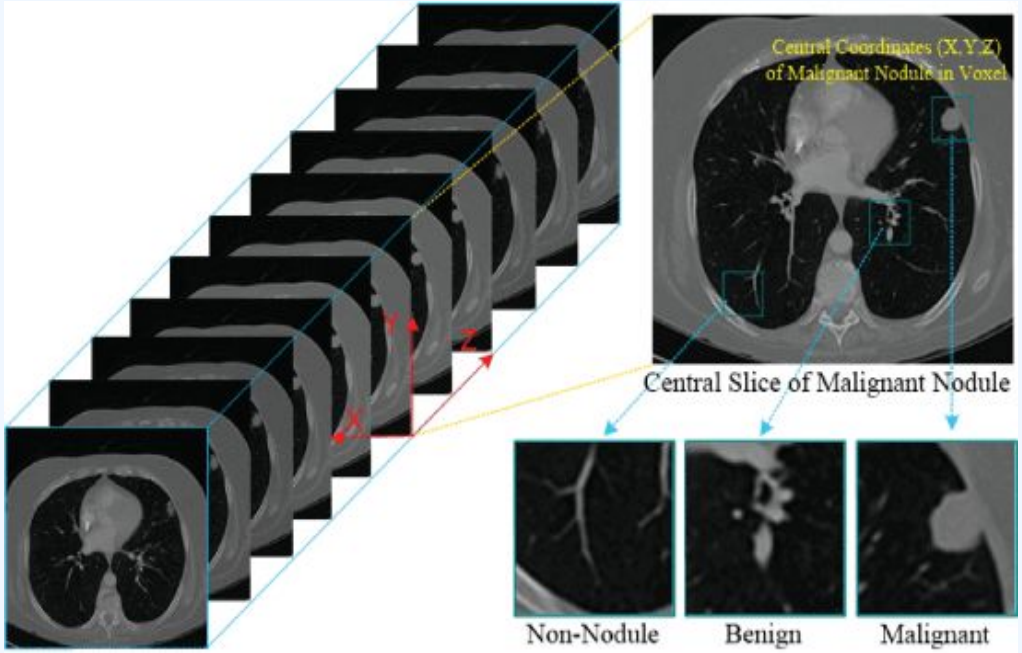
# Early Detection Will Save Lives!




# 02

# Dataset Breakdown

# Dataset

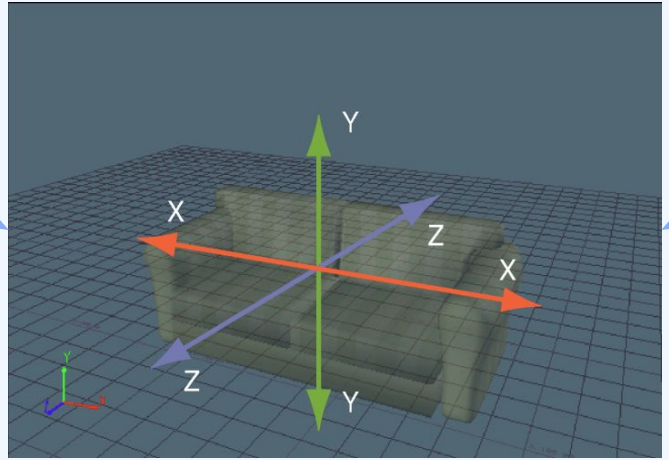


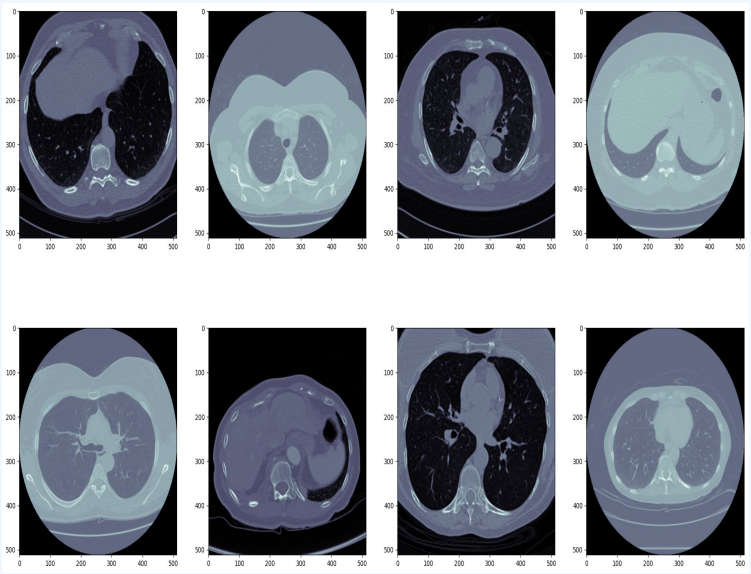

## Our .RAW Data

- *888 CT Scans.*
- *CT images are stored in MetaImage(mhd/raw)*
- *Each .mhd file is stored with a separate .raw binary file for the pixel data.*

# Dataset

| *File Name* | *X Coordinate* | *Y Coordinate* | *Z Coordinate* | *Diameter (mm)* |
|---|---|---|---|---|
| 0 | -129.7 | -175.3 | -298.4 | 5.65 |
| 1 | 103.8 | -211.9 | -277.1 | 4.22 |
| 2 | 69.6 | -140.9 | 876.4 | 5.79 |





# 03

# Lung Segmentation

# Preprocessing

**Start**

**Read mhd**

**A.** Produce Images from numerical data

**B.** *(SimpleITK library employed)*

2

**Image Process**

**A.** C.L.A.H.E. algorithm to balance the contrast

**B.** K Means clustering to group bright and dark pixels separately

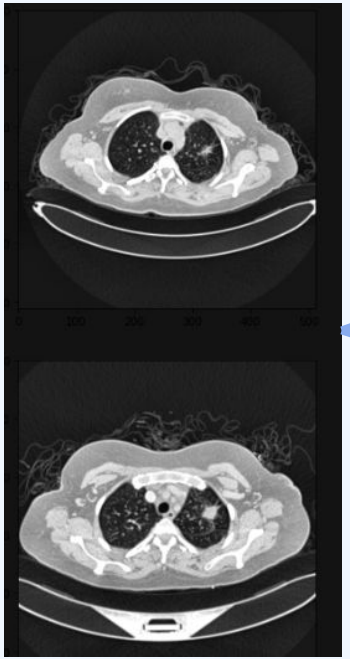
3

**Mask**

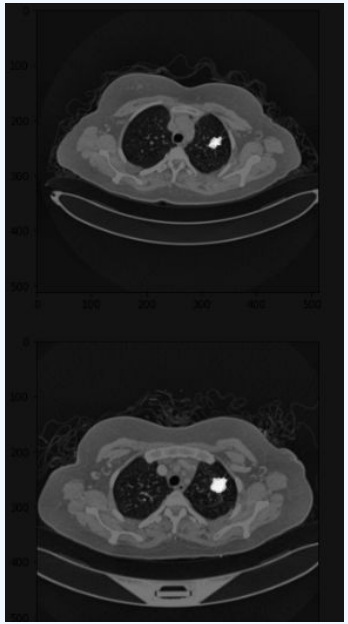
**A.** Apply mask to isolate region of interest

# Image Preprocessing - *C.L.A.H.E.*

CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION



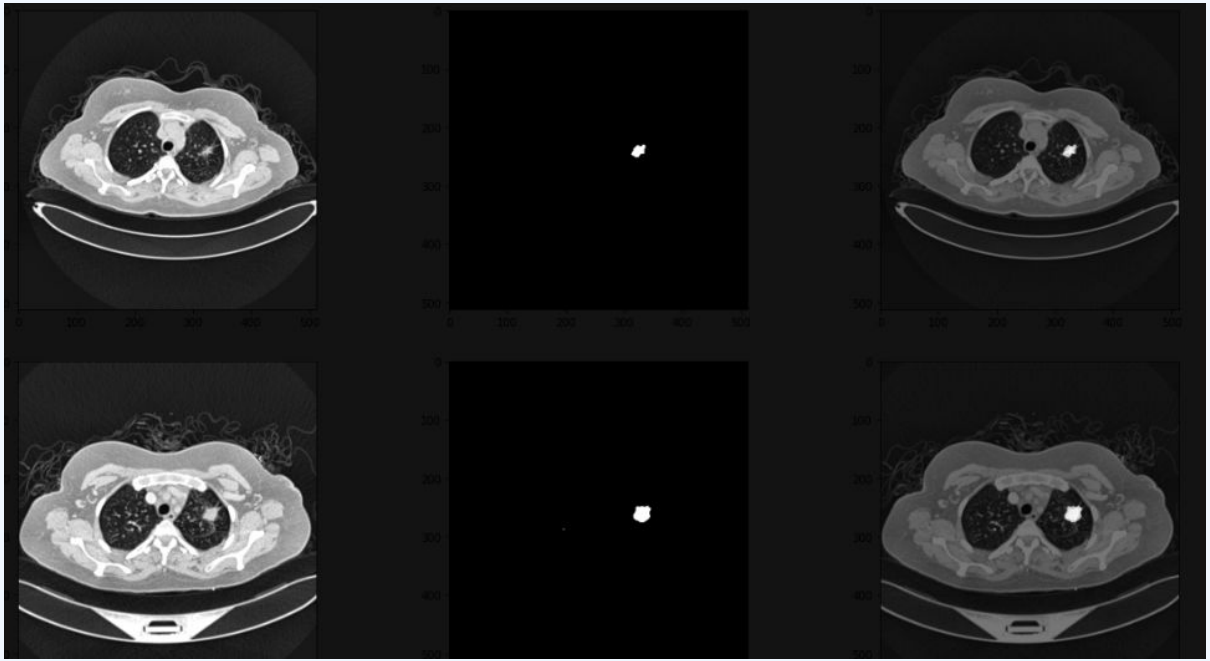
*We're applying a Threshold*



# Image Preprocessing - *Masking*

- C.L.A.H.E.
  - *Preprocessing the images has made the darks darker and the lights lighter*
  - *The difference between dark and light is much sharper*
- Masking
  - *We can now trust the computer to reliably isolate what's important from what isn't*
  - *and it will do so with a much greater accuracy*

# Image Preprocessing - *Results*



| Original | Masked Object | C.L.A.H.E. Object |
|---|---|---|

# File Preprocessing

**Start**

**Read mhd**

**A.** Produce Images from the numerical data

**B.** *(SimpleITK library employed)*

**Image Process**

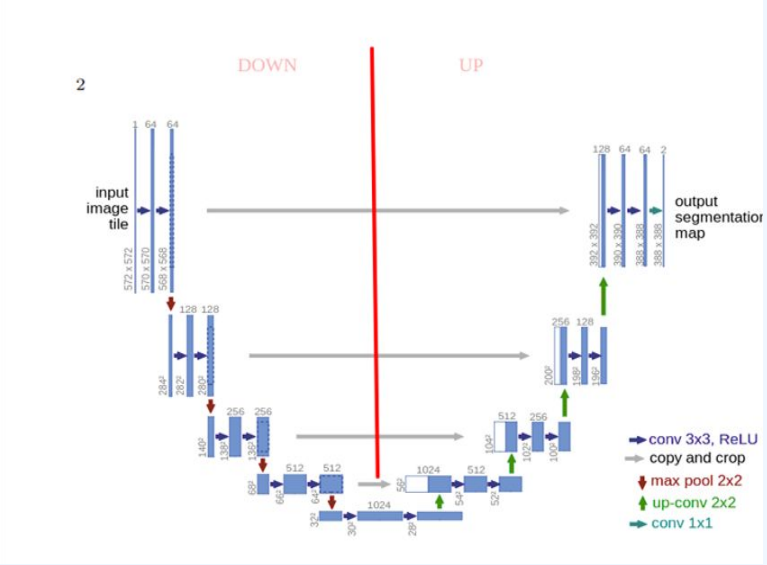
**A.** CLAHE algorithm to balance the contrast

**B.** Kmeans clustering to group bright and dark pixels separately

**Mask**

**A.** Apply mask

**B.** Region of interest is now isolated



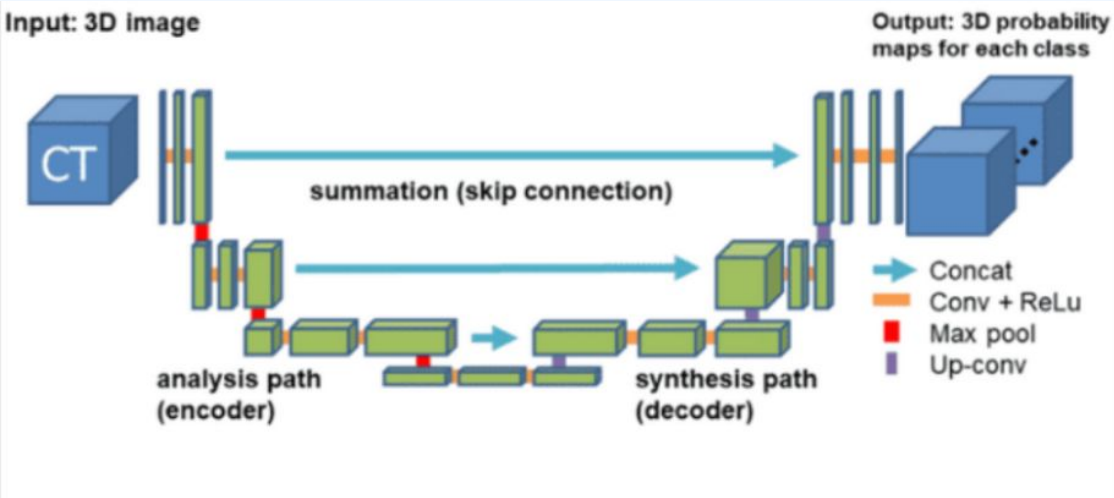

# 04

# CNN Architecture

# Intro to CNN (Convolutional Neural Network)

- Introduction
  - CNNs: Advanced algorithm for processing structured visual data.
- Key Features
  - Leverage layers for automatic feature extraction, inspired by human visual system.
- Why CNNs?
  - Vital for tasks like image classification, object detection, and medical image analysis.
- U-net Architecture
  - Specialized CNN architecture for precise image segmentation

# 2D UNet CNN architecture




- Encoder-decoder deep learning model with skip connection
- Feature extraction
- Reconstruct spatial information using unsamping and concatenation
- Connect encoder and decoder layers

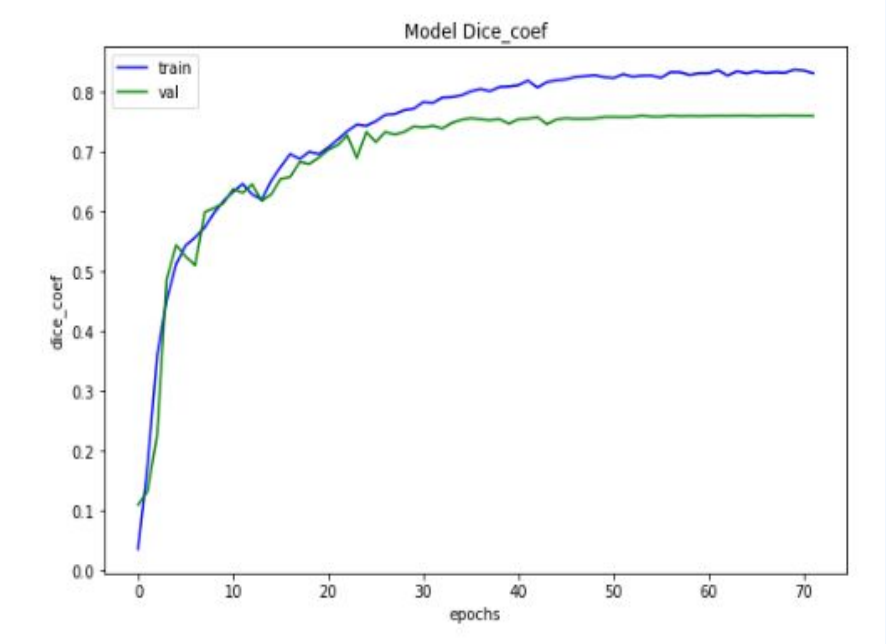
# Training Process

- Data processing
  - Preprocess CT scans and annotations for input to the network
- Loss Function
  - Employ Dice coefficient loss to measure the discrepancy between predicted and actual segmentation labels.
- Optimization
  - To Adjust the network's parameters to minimize the loss function

# 05

# Result

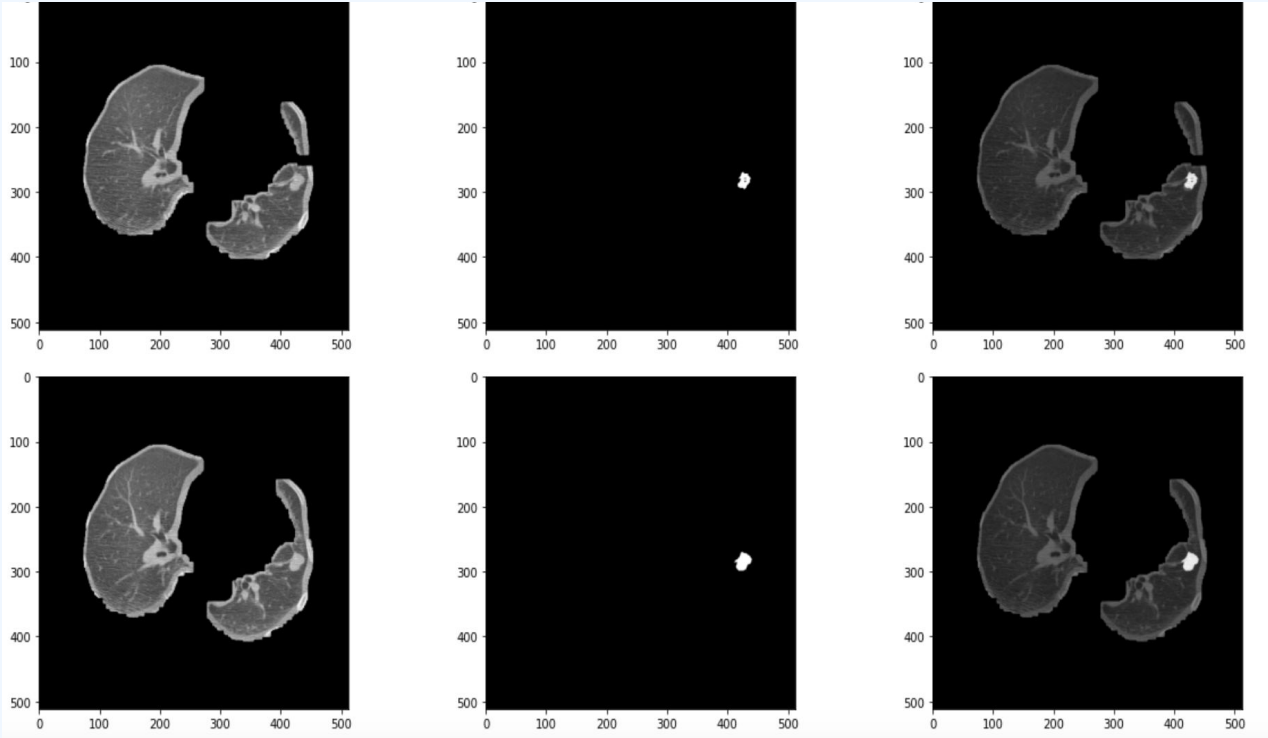
# Project Impact



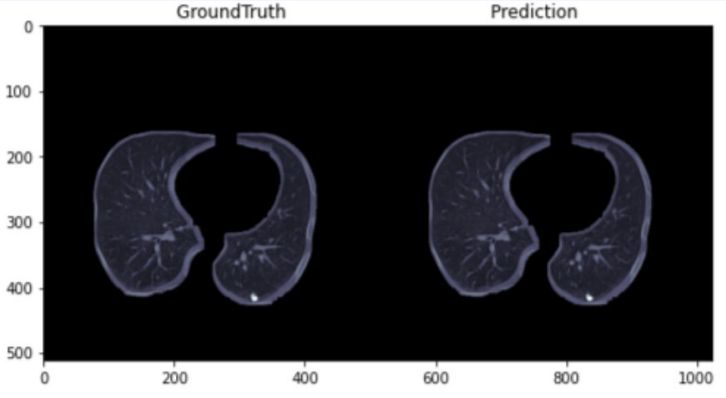

- Leveraging the CT scans of 888 patients cases with annotated lesions
- The average score of the model performance is 0.83 on the training dataset
  - A score of 1 indicates perfect
  - A score of 0 indicates no overlap

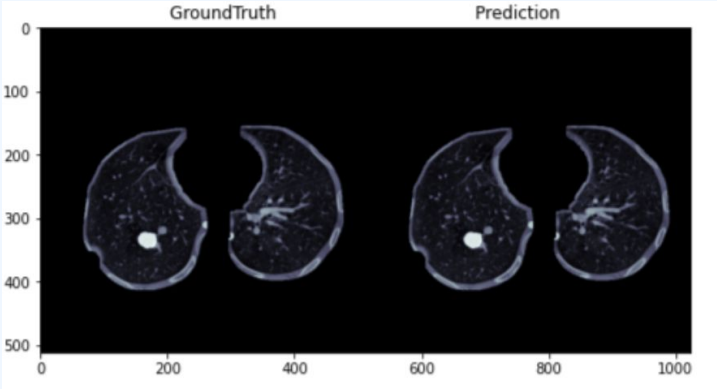
Dice coefficient : $$\frac{2 \times (|Y_{\text{true}} \cap Y_{\text{pred}}| + 1)}{|Y_{\text{true}}| + |Y_{\text{pred}}| + 1}$$

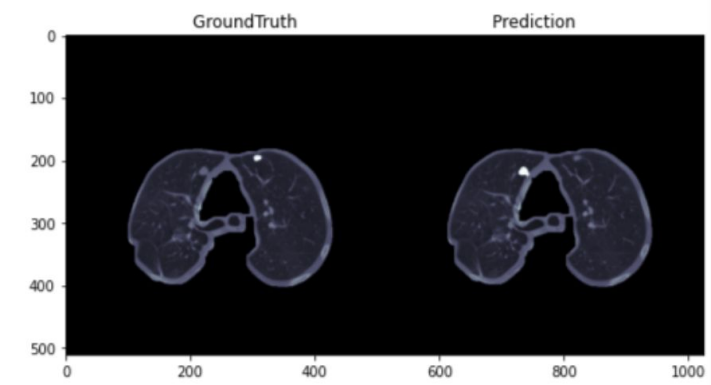
# Original vs. Masked

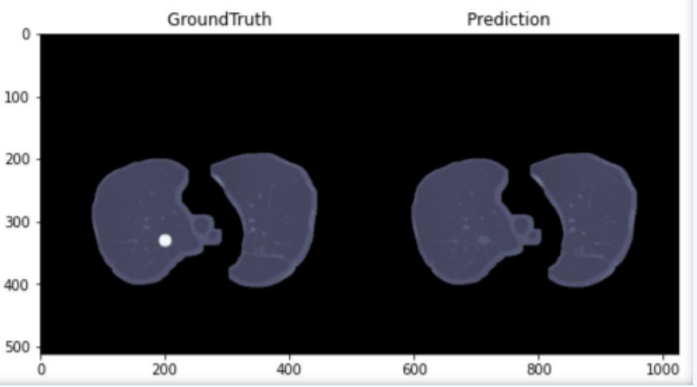


# Prediction


GroundTruth
Prediction
0
100
200
300
400
500
0
200
400
600
800
1000


GroundTruth
Prediction
0
100
200
300
400
500
0
200
400
600
800
1000


GroundTruth
Prediction
0
100
200
300
400
500
0
200
400
600
800
1000

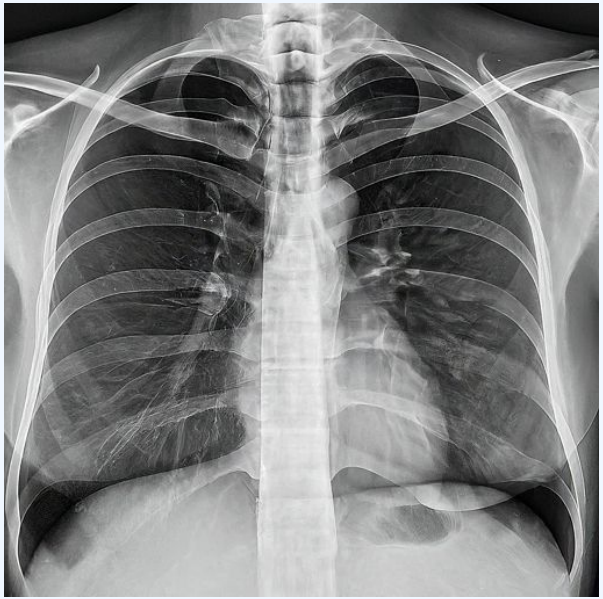

GroundTruth
Prediction
0
100
200
300
400
500
0
200
400
600
800
1000

# 06

# Conclusion

# Clinical Significance

- Early Detection : Enable earlier diagnosis and treatment of lung cancer
- Impact on Patient Care
  - Enhanced accuracy and reliability
  - Reduce the risk of misdiagnosis
- Cost-effectiveness by reducing manual interpretation
- Future Prospects



# Thanks

Do you have any questions?