Introduction to Biomedical Imaging

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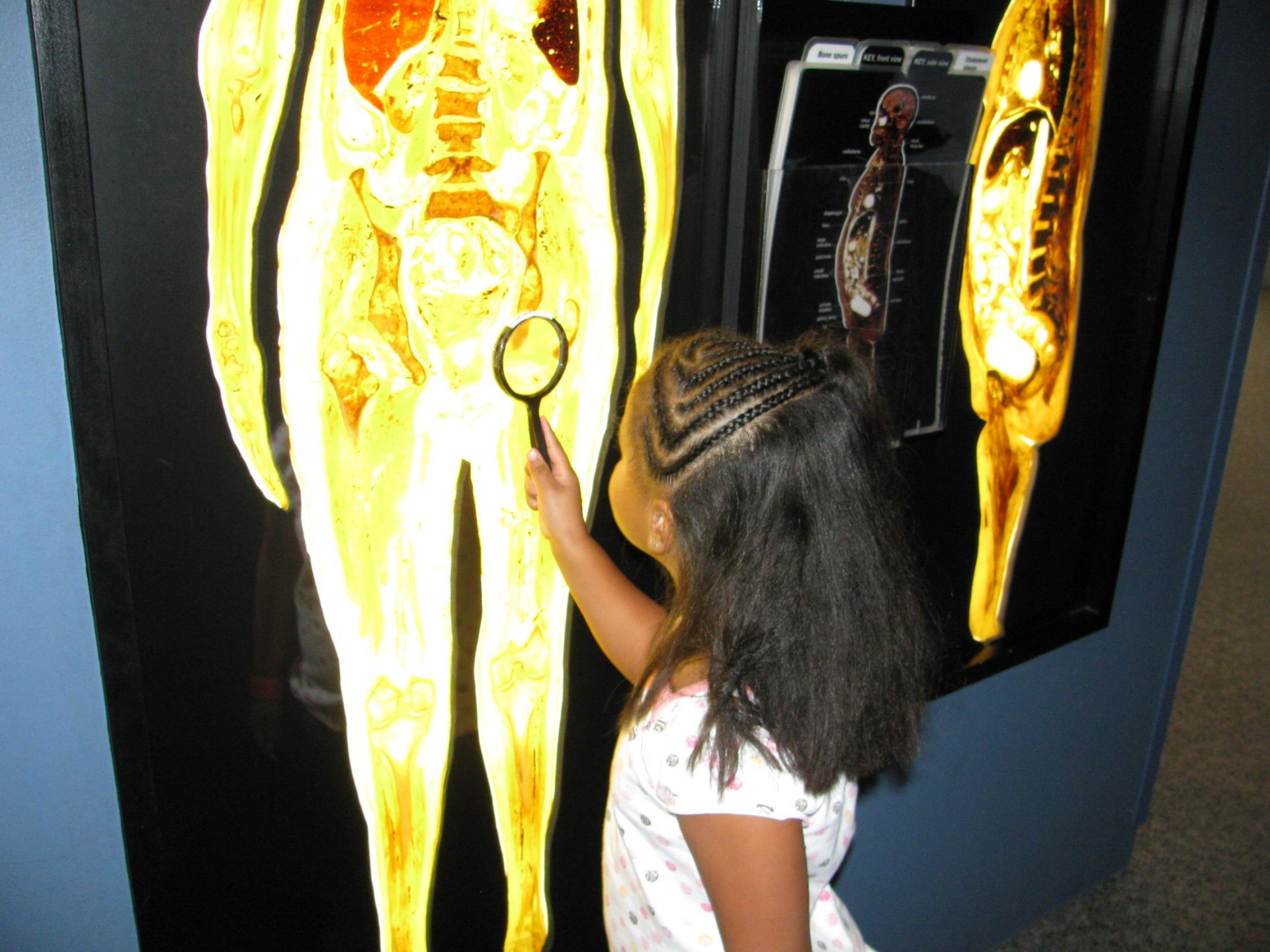
What we learned

- Imaging Informatics
- Imaging basics
- Imaging modalities
- PACS and its core functions
- DICOM


PIZZA
PAPA JOHNS
Mejores Ingredientes. Mejor Pizza.
Delivery
243-1070

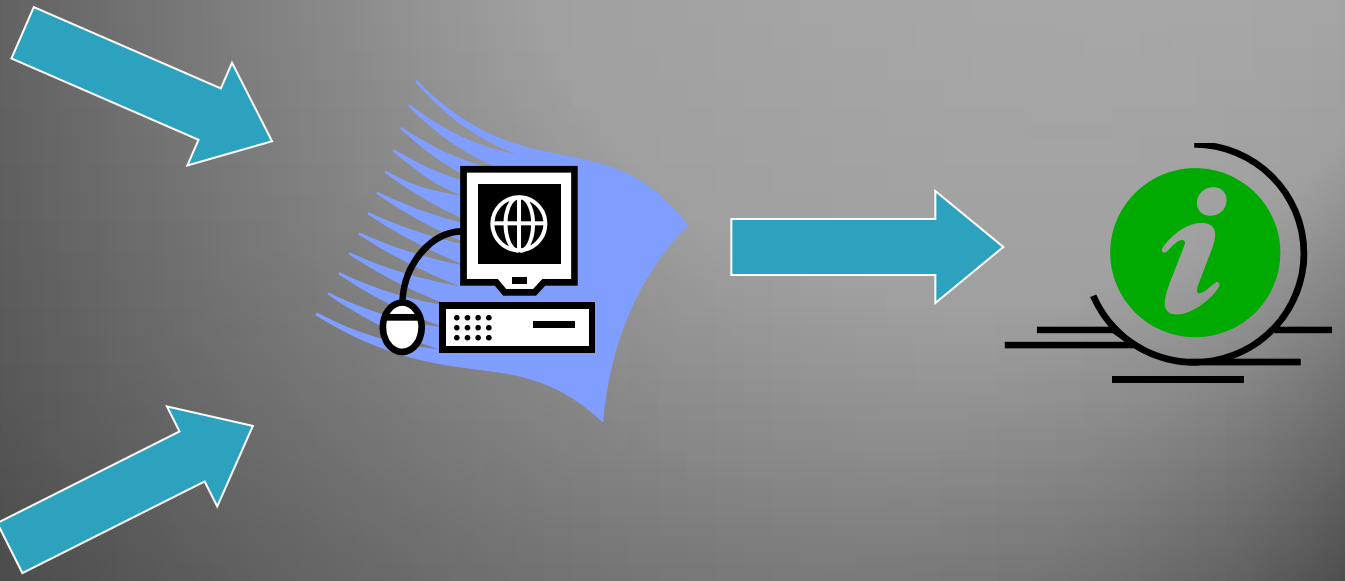

Delivery
24-7-10


R

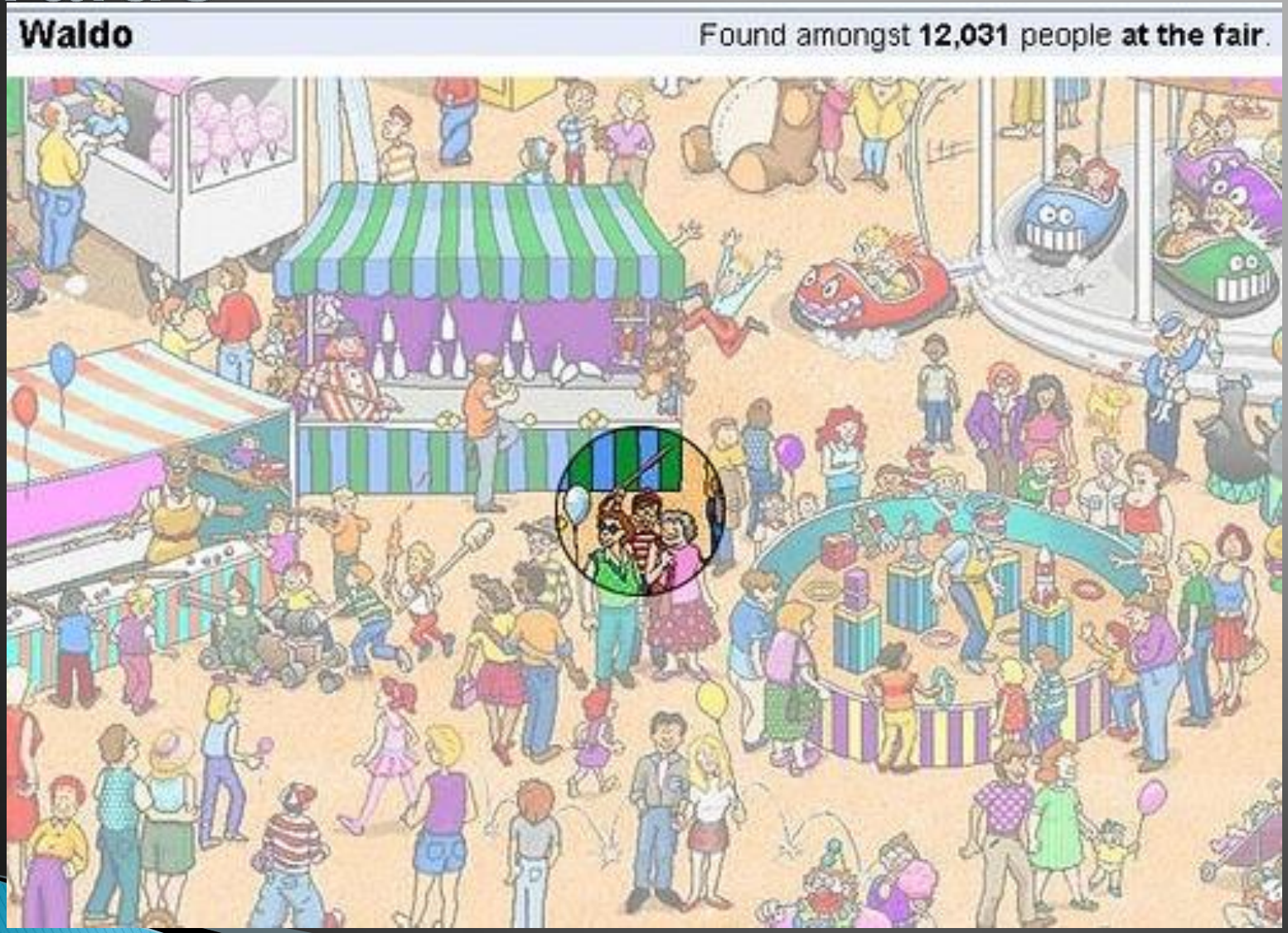


Where's Waldo?

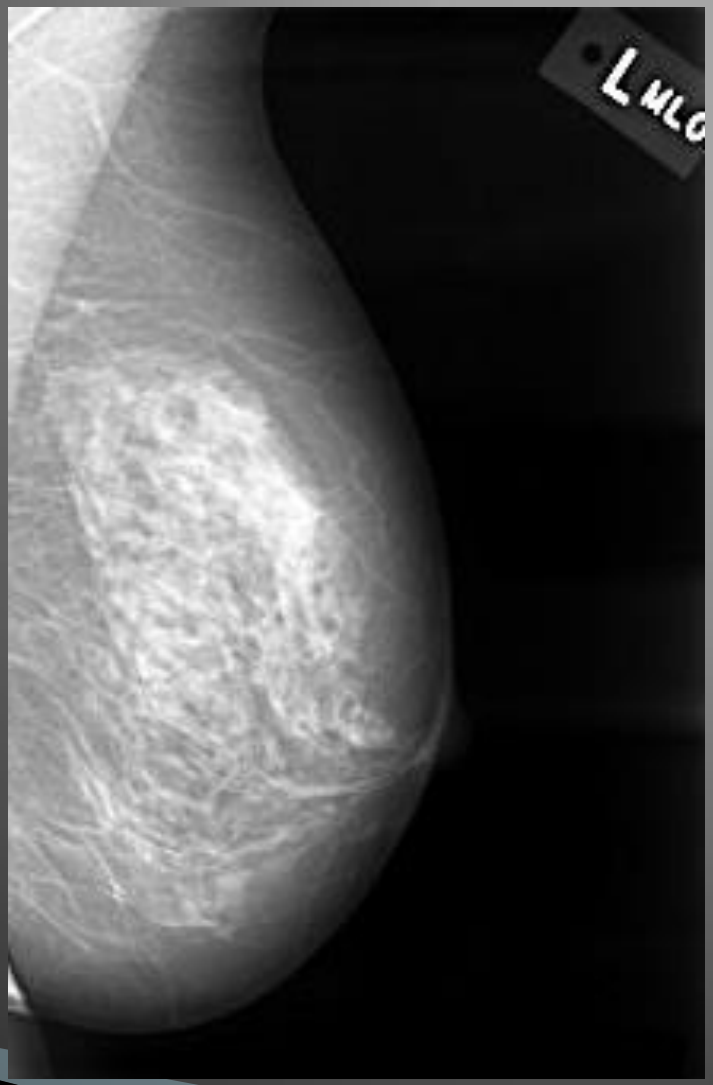
Computer-aided Detection



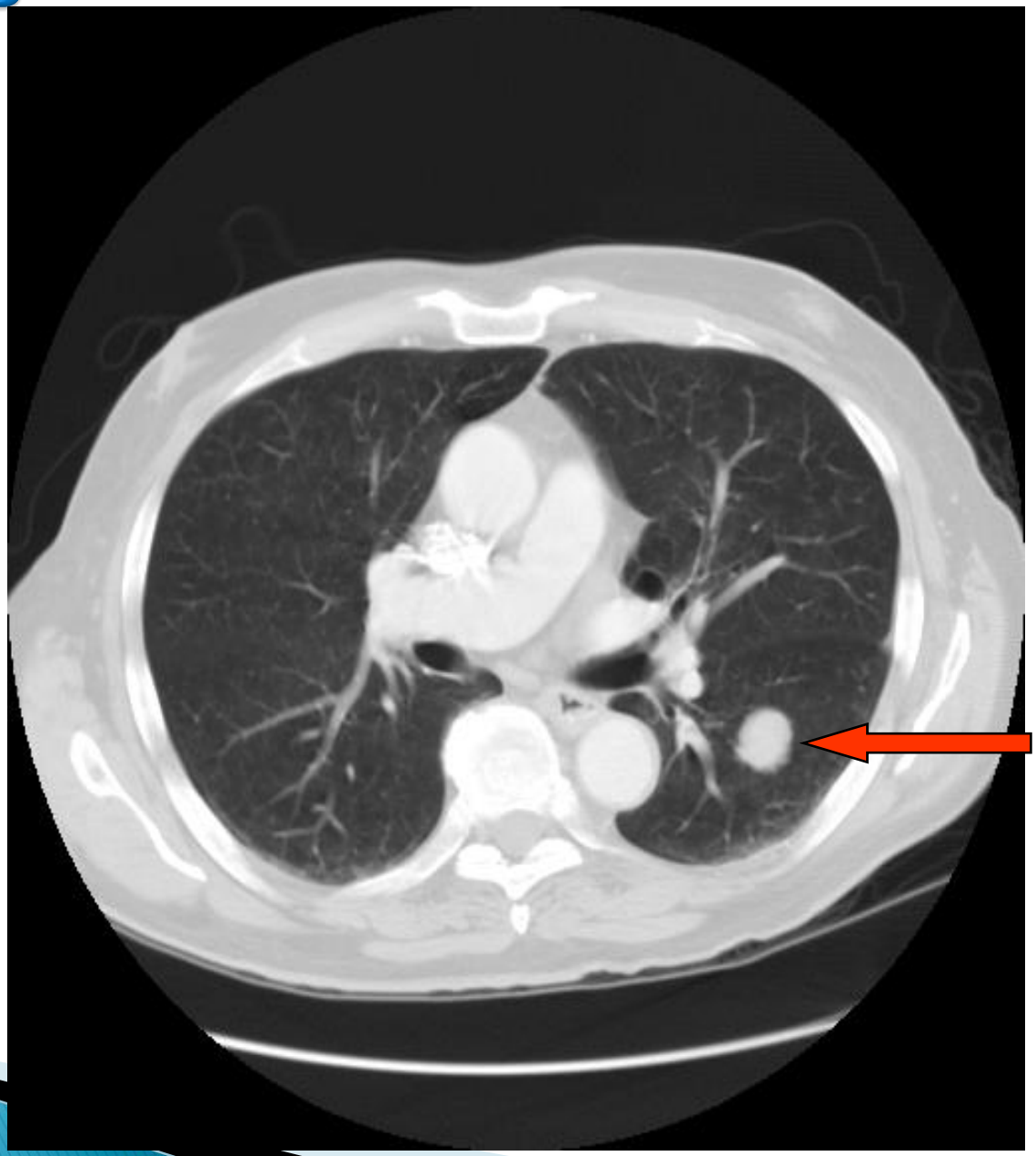
Waldo



Where's Waldo?



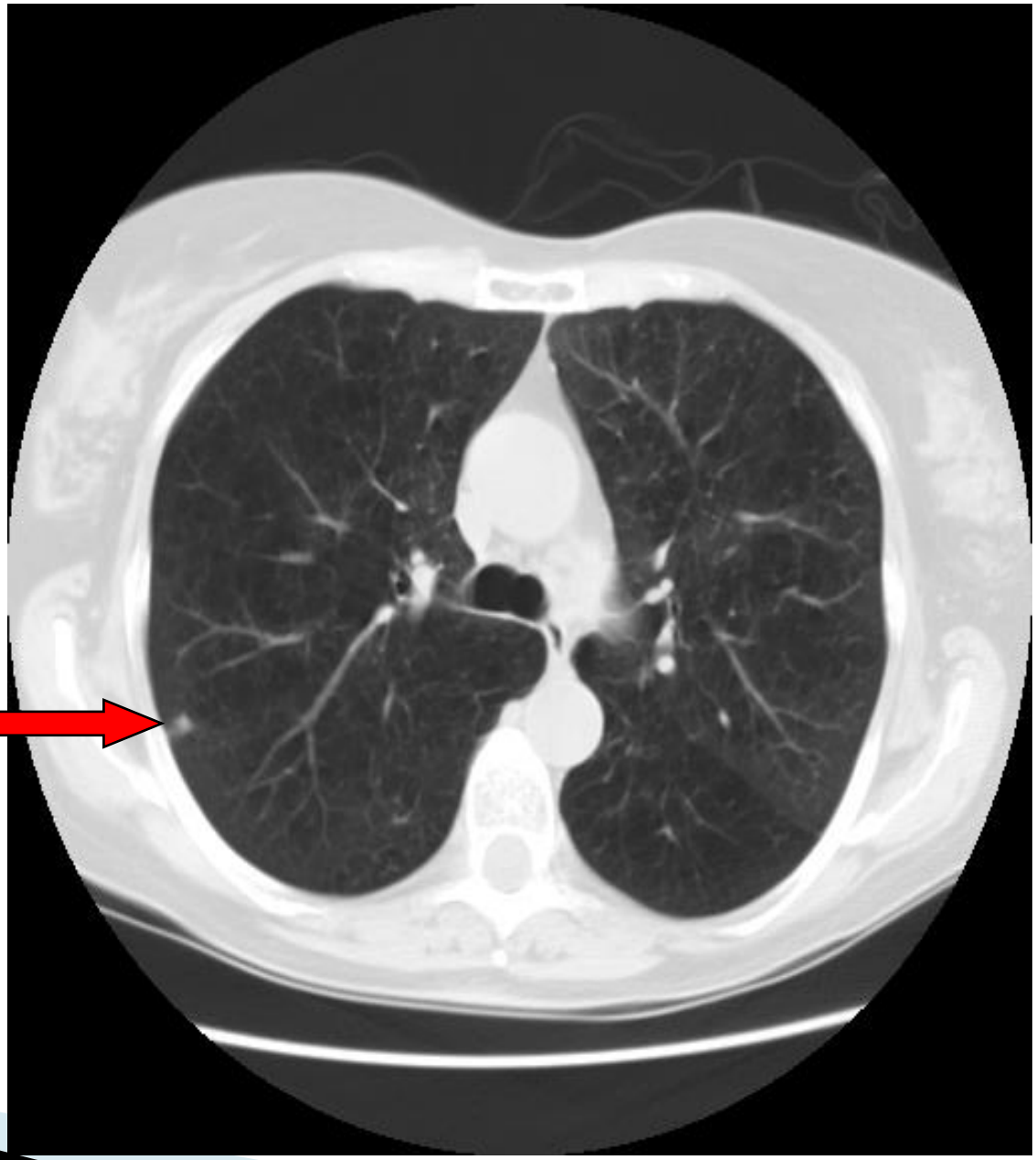
CT- Lung Nodule



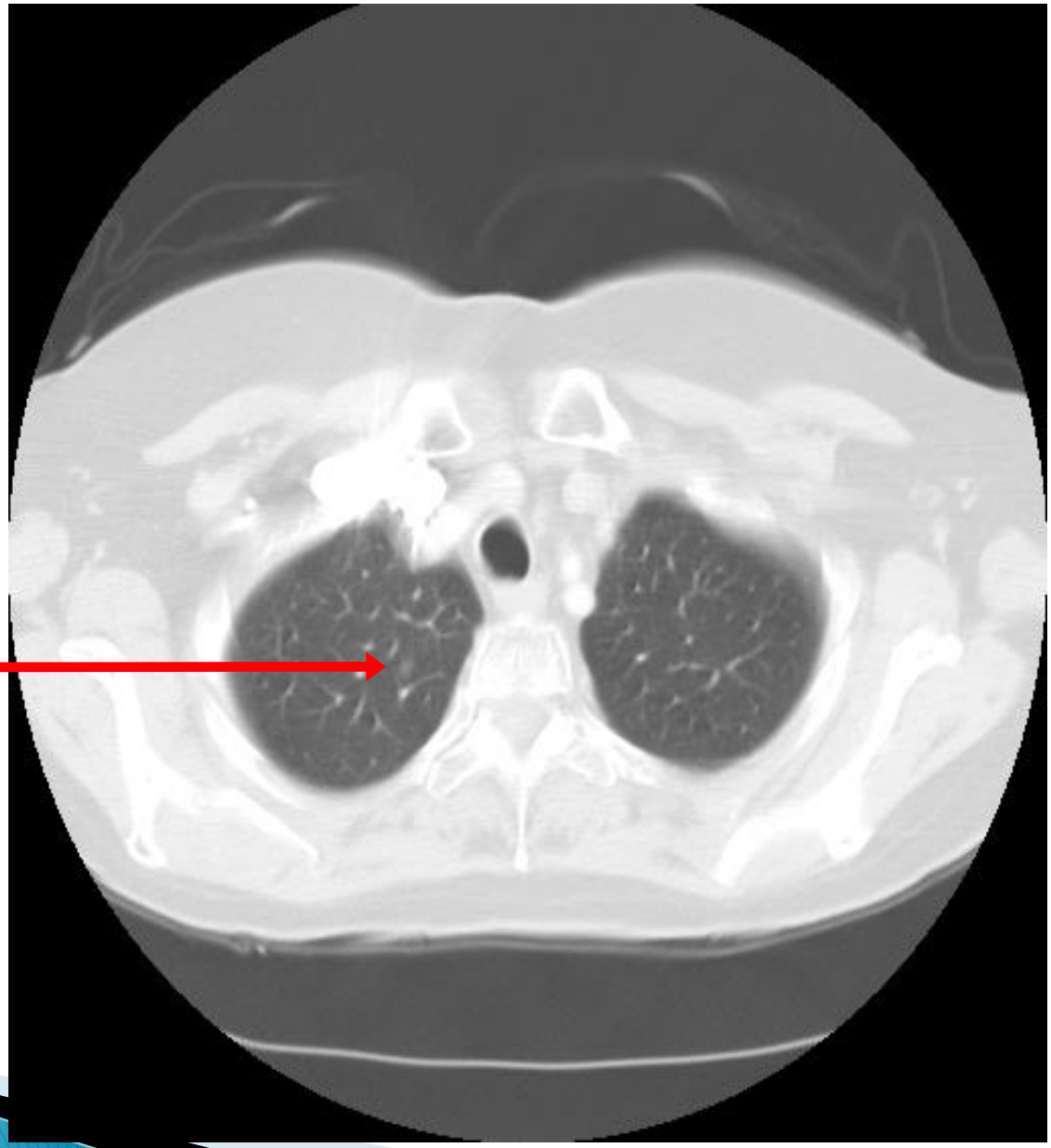
20 mm Nodule

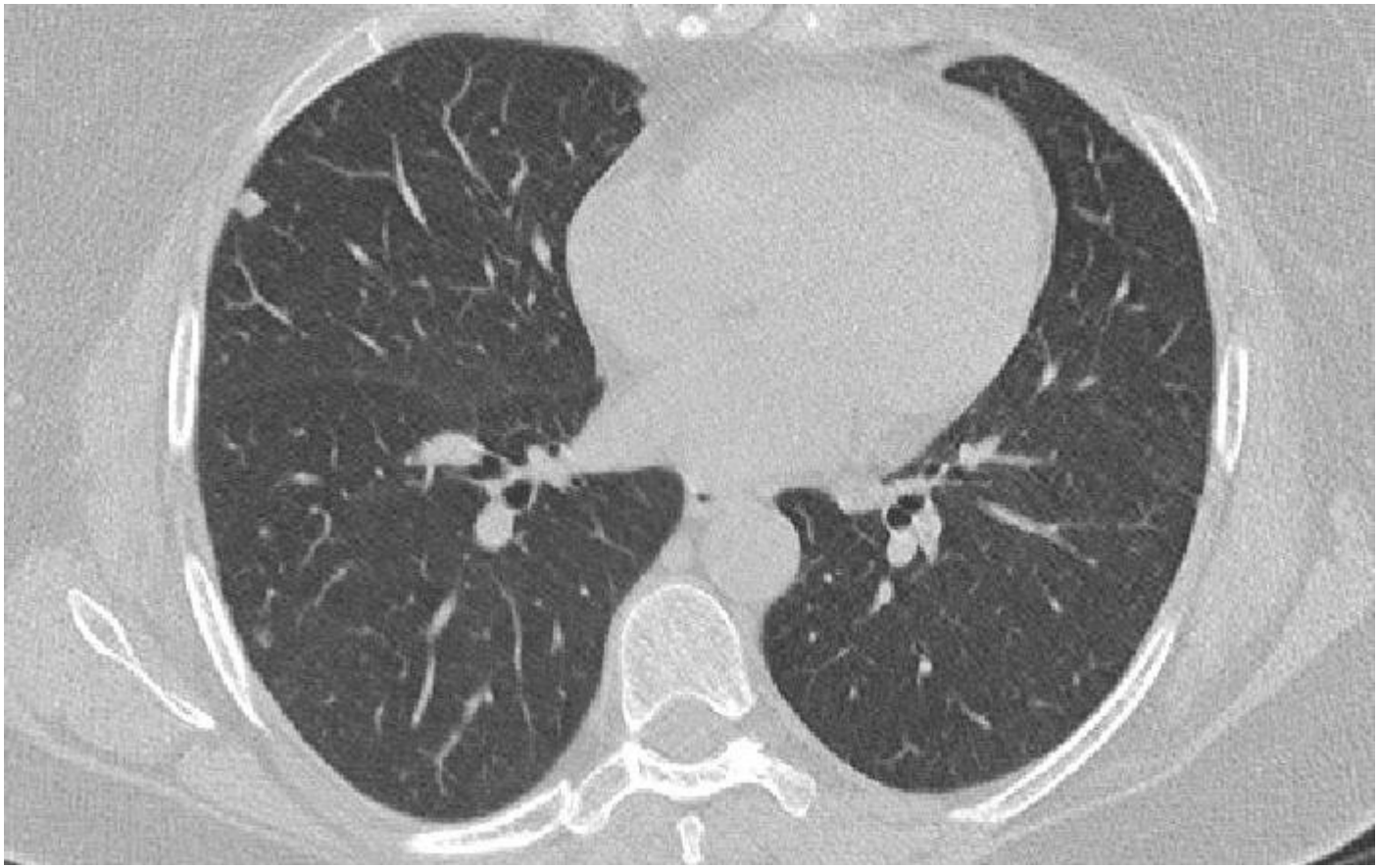
CT- Lung Nodule

4 mm
Nodule

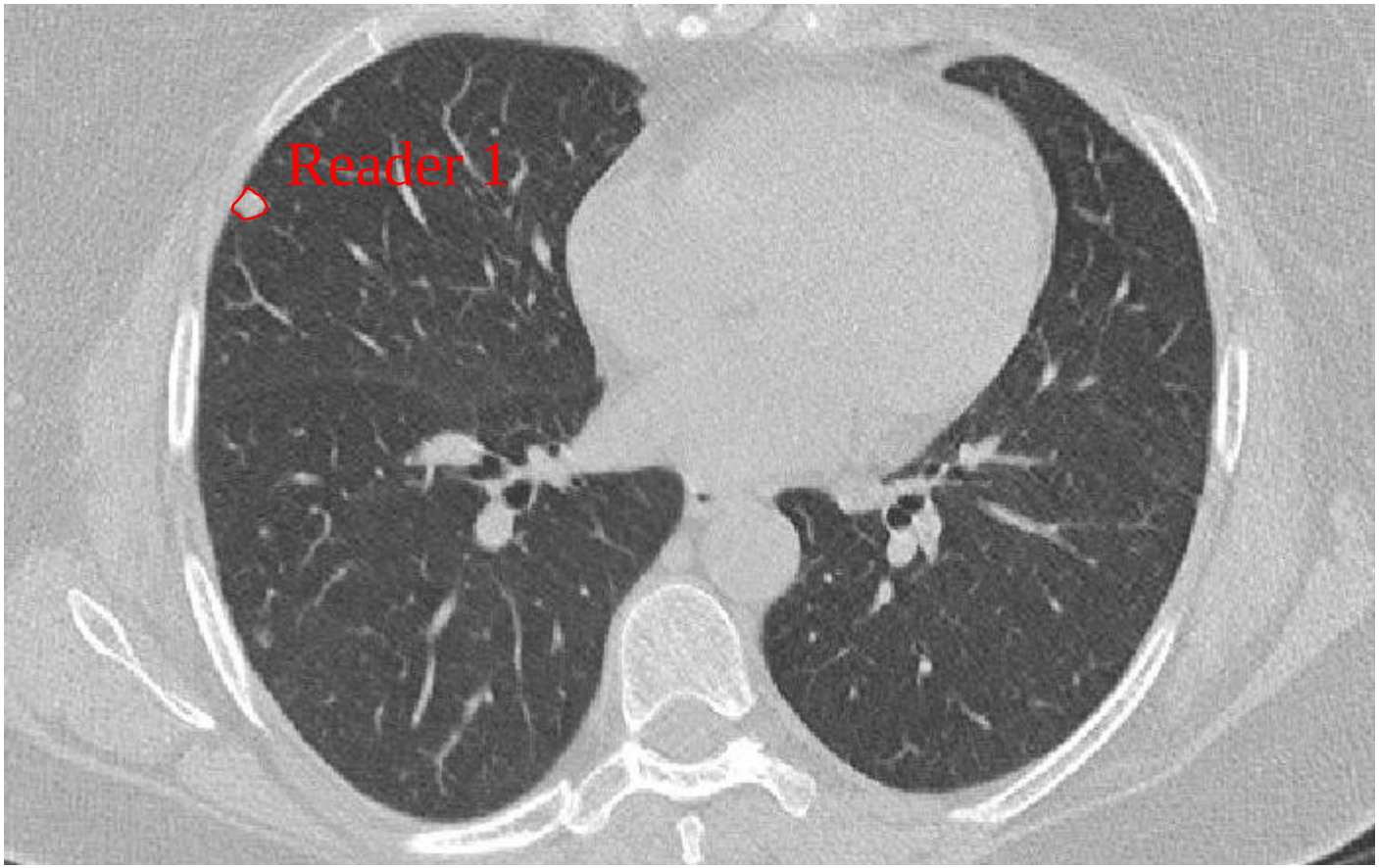


CT- Lung Nodule

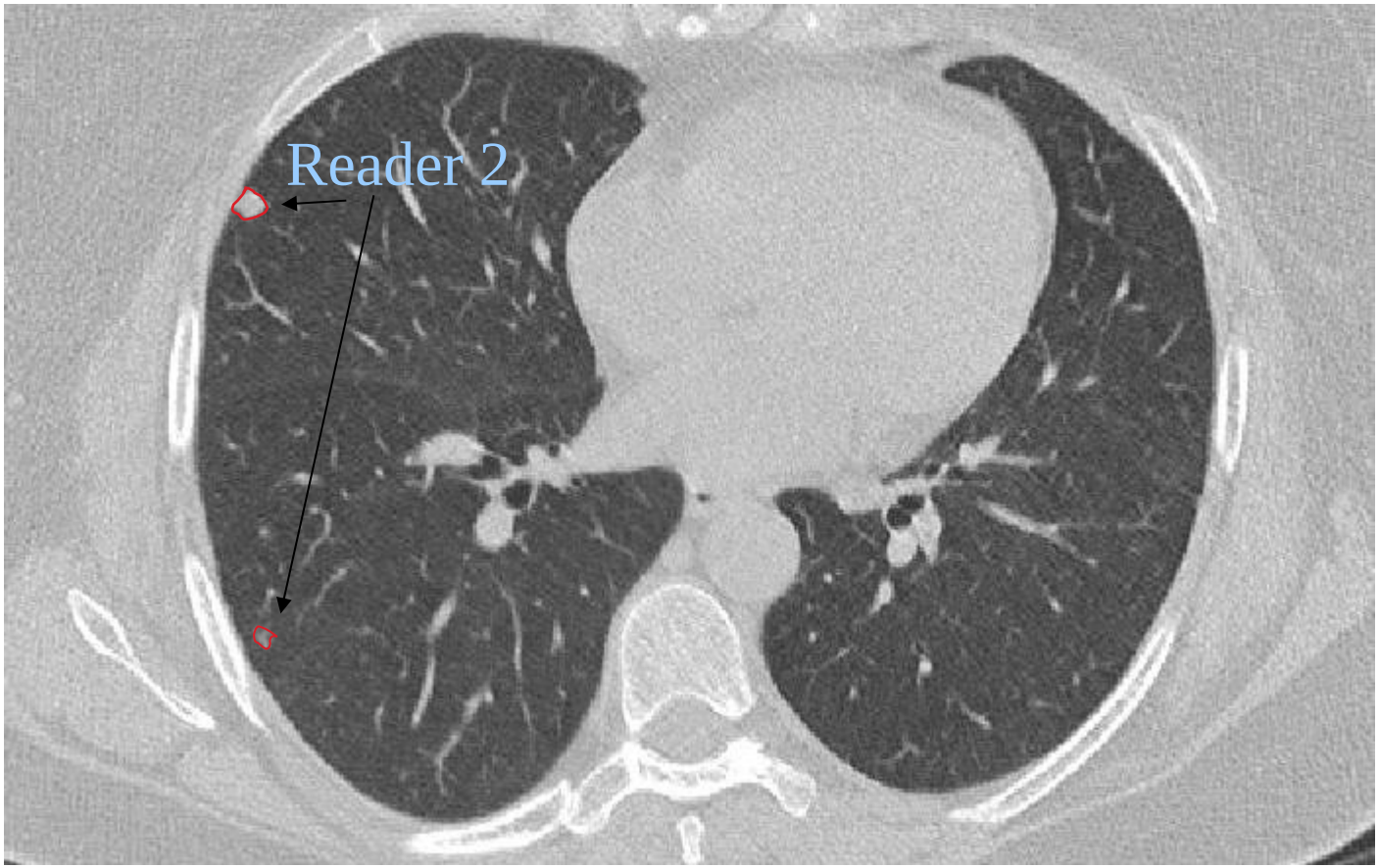




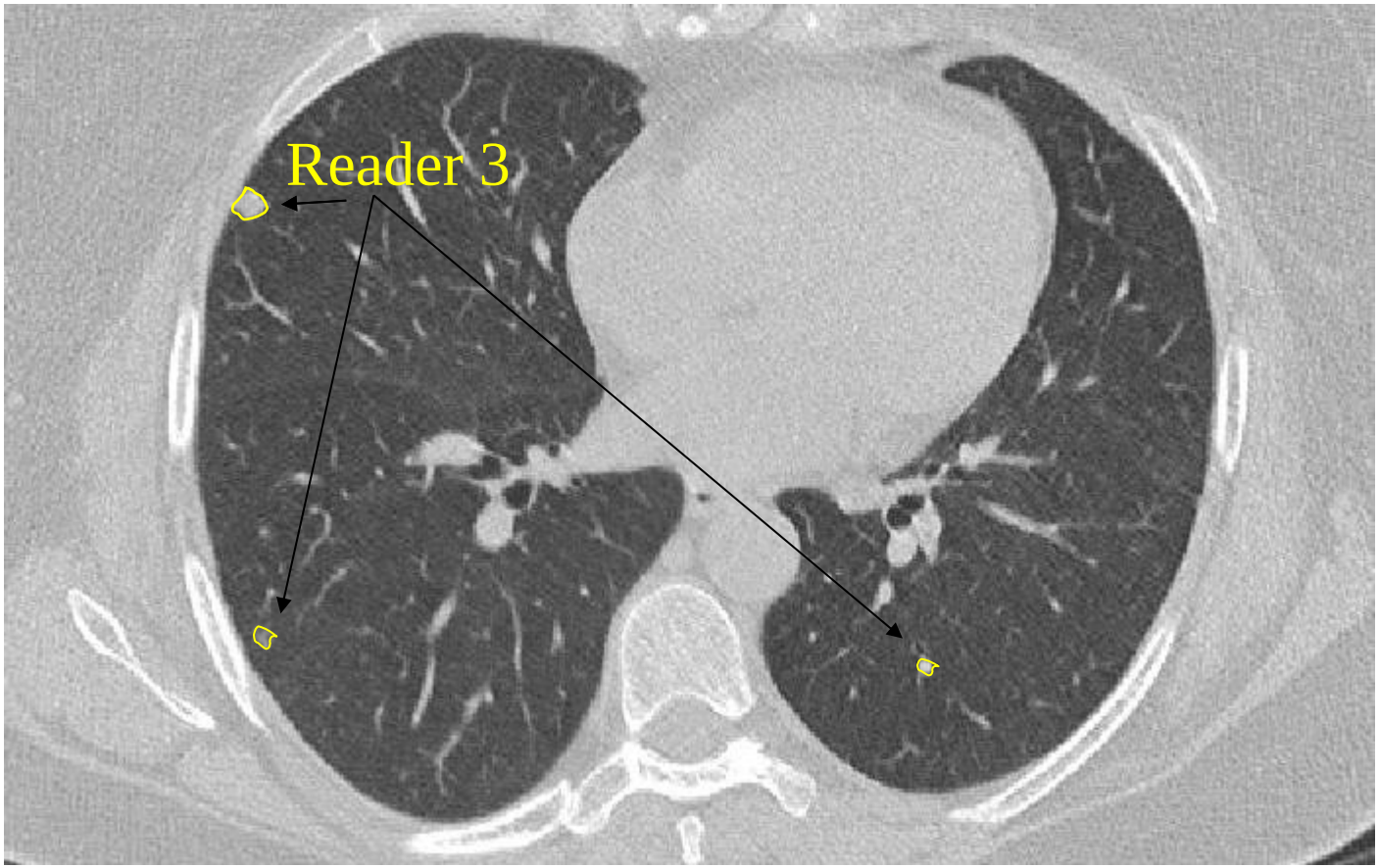
Reader 1



Reader 2



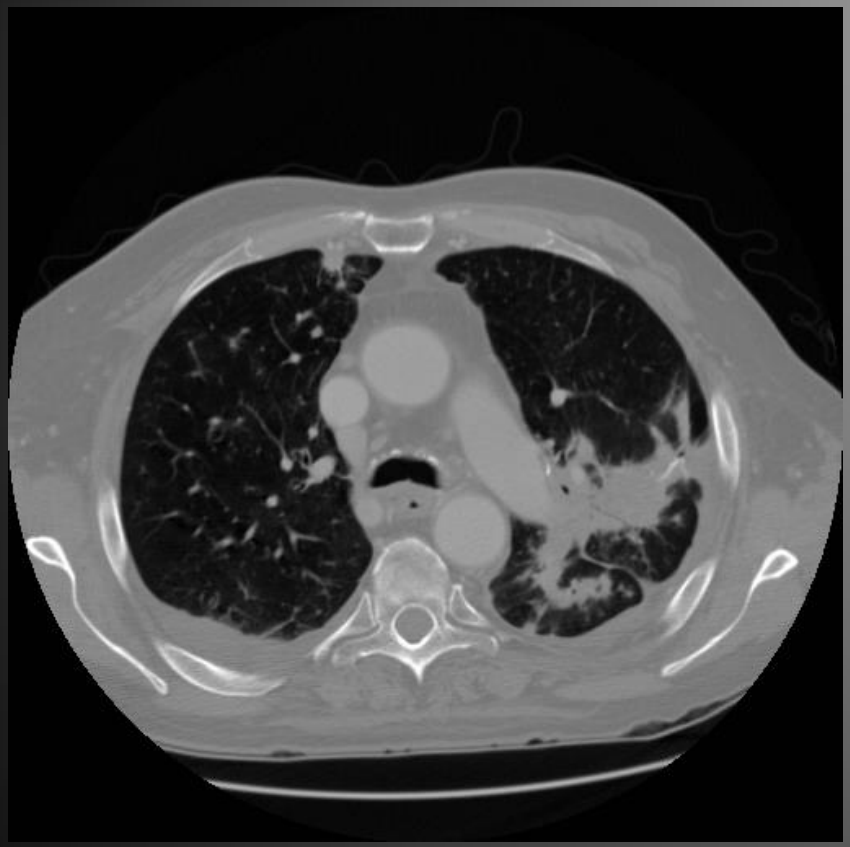
Reader 3



Observational Lapses

- Fatigue
- Distraction
- Emotional stress
- Variation in reader
- Satisfaction of Search

Satisfaction of Search



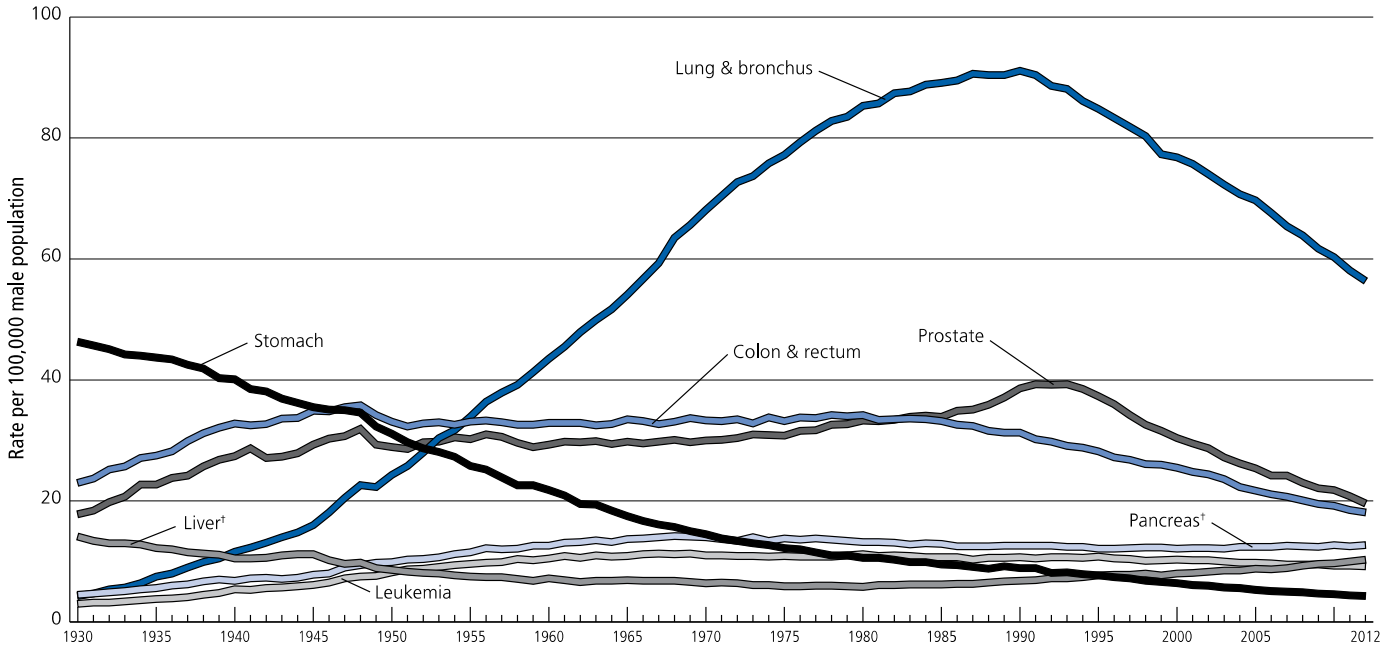
Cancer Miss Rate

- Breast cancer is missed 10-30%

  …
- by Expert Mammographers

Cancer Statistics

Figure 1. Trends in Age-adjusted Cancer Death Rates* by Site, Males, US, 1930-2012



*Per 100,000, age adjusted to the 2000 US standard population. †Mortality rates for pancreatic and liver cancers are increasing.

Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancers of the liver, lung and bronchus, and colon and rectum are affected by these coding changes.

Source: US Mortality Volumes 1930 to 1959 and US Mortality Data 1960 to 2012, National Center for Health Statistics, Centers for Disease Control and Prevention.

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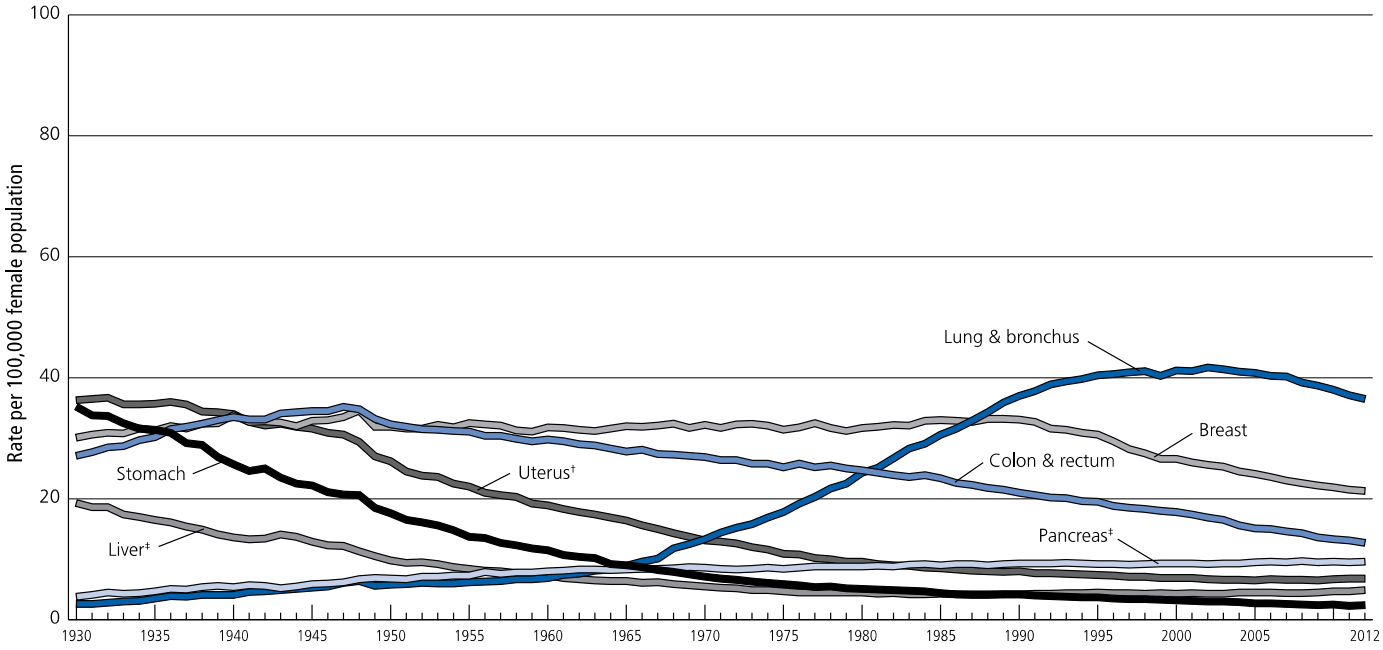
Cancer Statistics

Figure 2. Trends in Age-adjusted Cancer Death Rates* by Site, Females, US, 1930-2012



*Per 100,000, age adjusted to the 2000 US standard population. †Uterus refers to uterine cervix and uterine corpus combined. ‡Mortality rates for pancreatic and liver cancers are increasing.

Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancers of the liver, lung and bronchus, and colon and rectum are affected by these coding changes.

Source: US Mortality Volumes 1930 to 1959, US Mortality Data 1960 to 2012, National Center for Health Statistics, Centers for Disease Control and Prevention.

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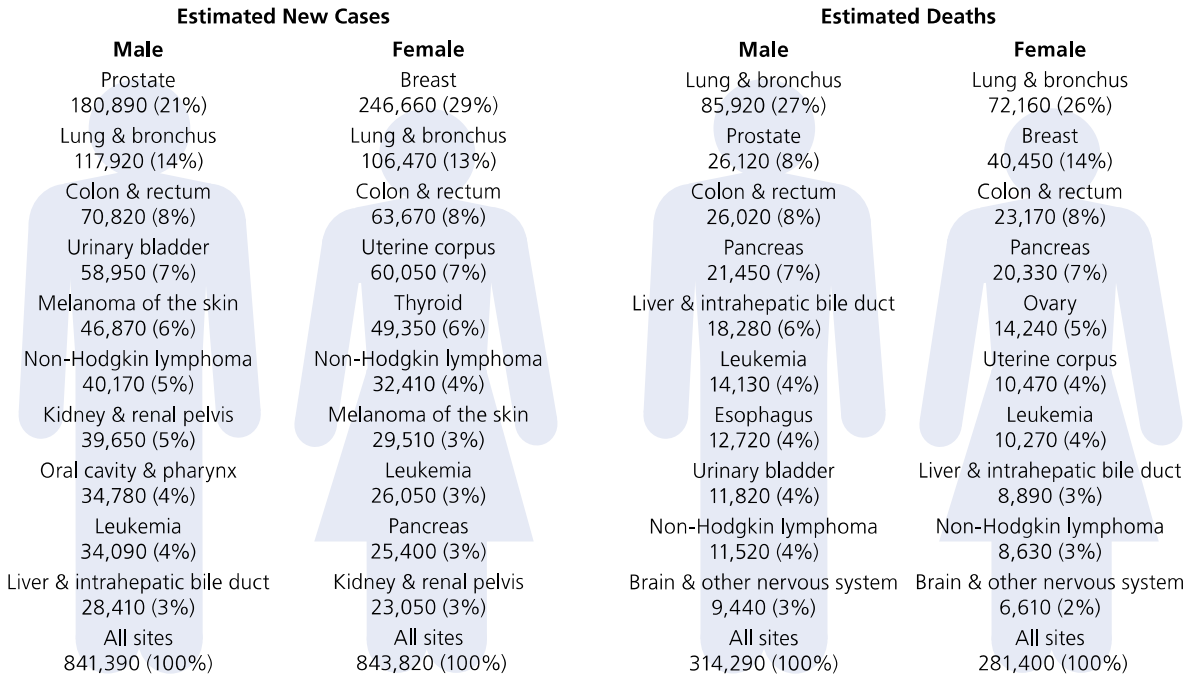
Cancer Statistics

Figure 3. Leading Sites of New Cancer Cases and Deaths – 2016 Estimates



Estimated New Cases		Estimated Deaths	
Male	**Female**	**Male**	**Female**
Prostate 180,890 (21%)	Breast 246,660 (29%)	Lung & bronchus 85,920 (27%)	Lung & bronchus 72,160 (26%)
Lung & bronchus 117,920 (14%)	Lung & bronchus 106,470 (13%)	Prostate 26,120 (8%)	Breast 40,450 (14%)
Colon & rectum 70,820 (8%)	Colon & rectum 63,670 (8%)	Colon & rectum 26,020 (8%)	Colon & rectum 23,170 (8%)
Urinary bladder 58,950 (7%)	Uterine corpus 60,050 (7%)	Pancreas 21,450 (7%)	Pancreas 20,330 (7%)
Melanoma of the skin 46,870 (6%)	Thyroid 49,350 (6%)	Liver & intrahepatic bile duct 18,280 (6%)	Ovary 14,240 (5%)
Non-Hodgkin lymphoma 40,170 (5%)	Non-Hodgkin lymphoma 32,410 (4%)	Leukemia 14,130 (4%)	Uterine corpus 10,470 (4%)
Kidney & renal pelvis 39,650 (5%)	Melanoma of the skin 29,510 (3%)	Esophagus 12,720 (4%)	Leukemia 10,270 (4%)
Oral cavity & pharynx 34,780 (4%)	Leukemia 26,050 (3%)	Urinary bladder 11,820 (4%)	Liver & intrahepatic bile duct 8,890 (3%)
Leukemia 34,090 (4%)	Pancreas 25,400 (3%)	Non-Hodgkin lymphoma 11,520 (4%)	Non-Hodgkin lymphoma 8,630 (3%)
Liver & intrahepatic bile duct 28,410 (3%)	Kidney & renal pelvis 23,050 (3%)	Brain & other nervous system 9,440 (3%)	Brain & other nervous system 6,610 (2%)
All sites 841,390 (100%)	All sites 843,820 (100%)	All sites 314,290 (100%)	All sites 281,400 (100%)

Estimates are rounded to the nearest 10, and cases exclude basal cell and squamous cell skin cancers and in situ carcinoma except urinary bladder.

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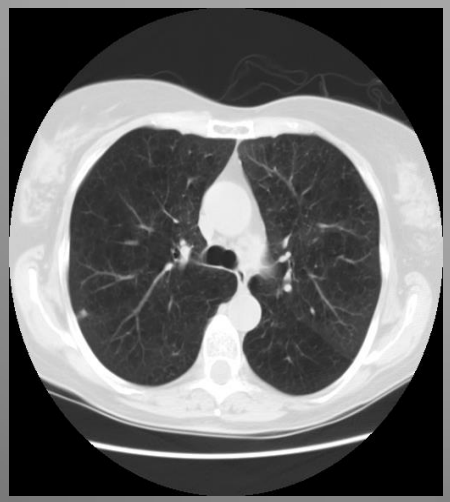
New Technology



Double reading

- Sensitivity of radiologists in detecting breast cancer on mammograms can be improved by 15% through double reading.

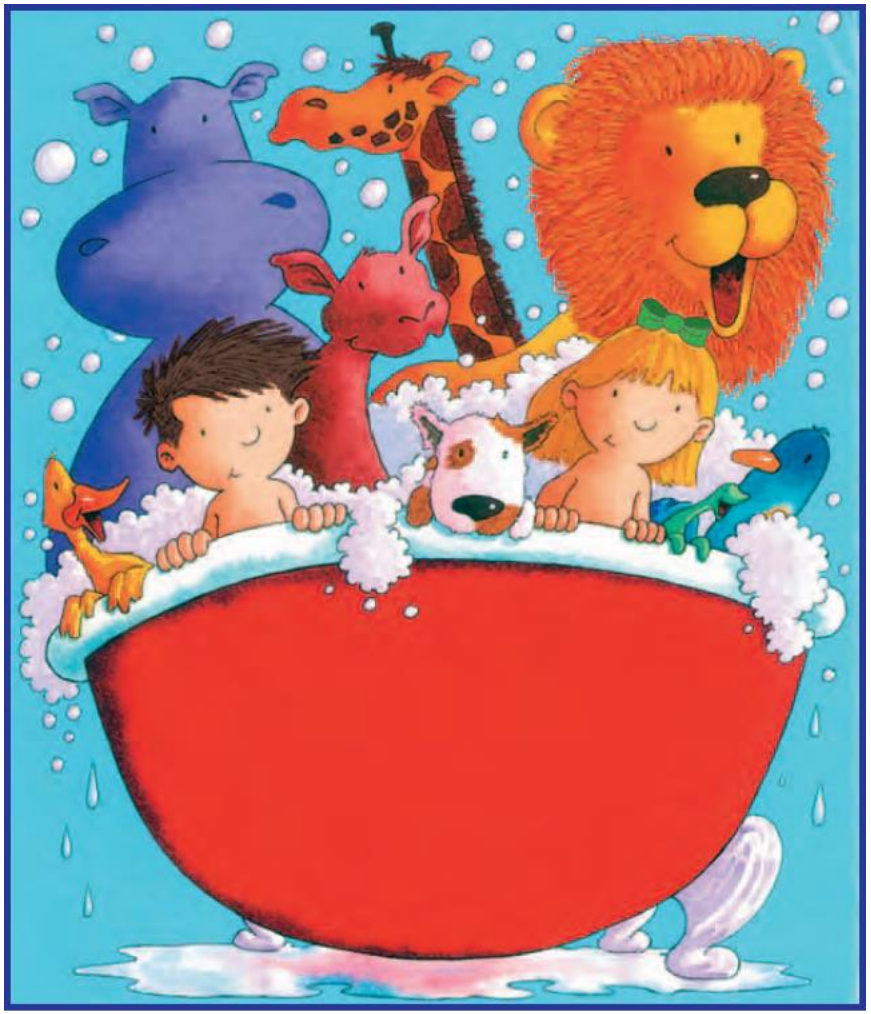
CAD

- Computer-aided diagnosis:
  - a diagnosis made by a physician using the output of a computerized system
- Computerized system
  - Automated image (or data) analysis

CAD Applications

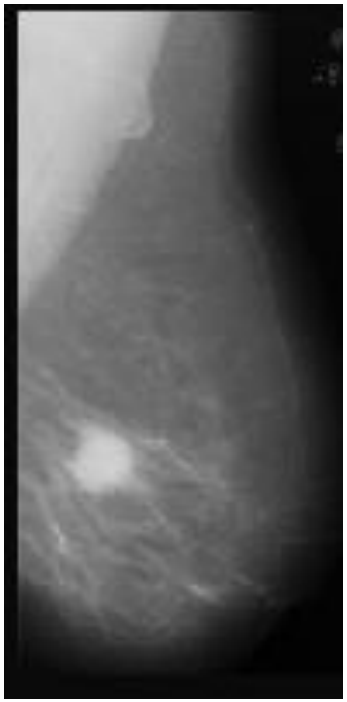
- Breast Cancer
- Lung Cancer
- Brain Cancer
- Colon Cancer

Find Six Differences

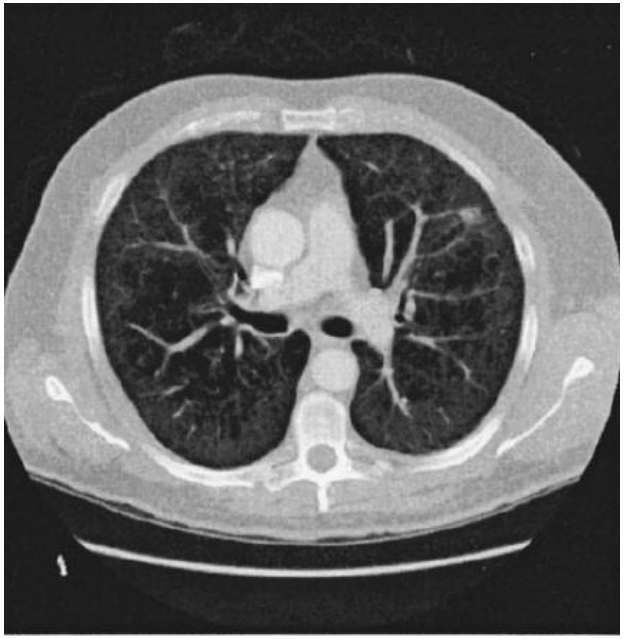


Find Six Differences

Computer-Aided Detection

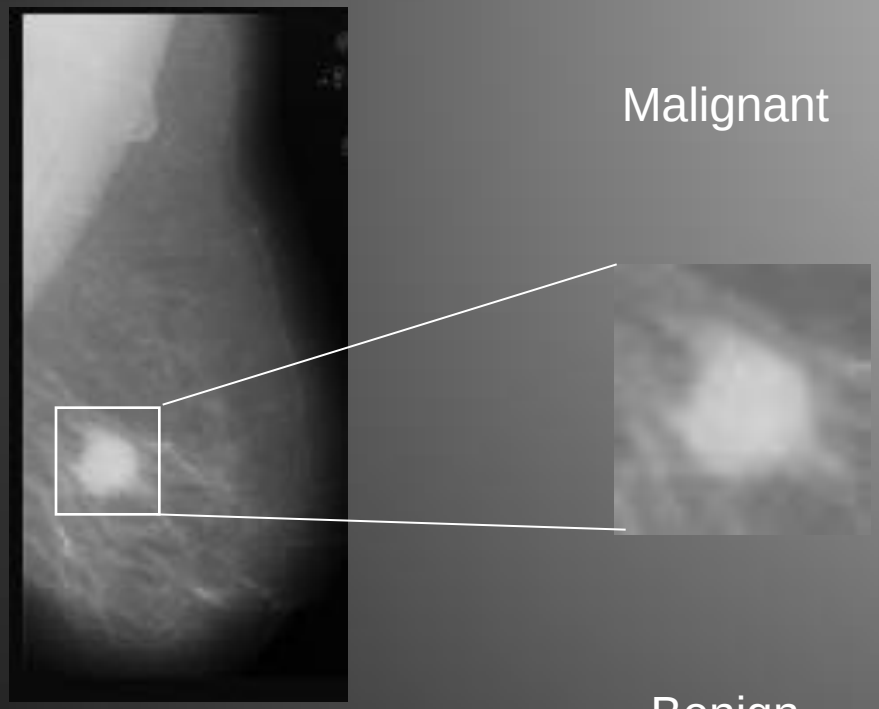


- Microcalcifications
- Masses

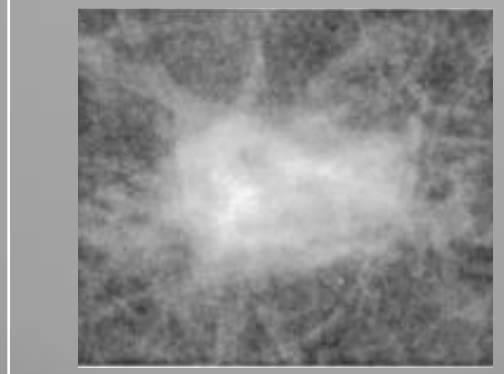


- Solitary Pulmonary Nodules
- Ground Glass Opacities

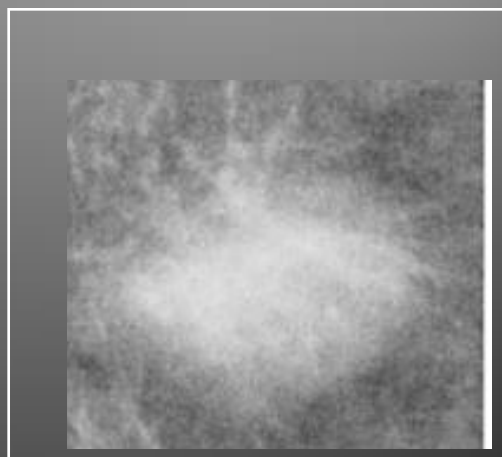
Computer-Aided Diagnosis



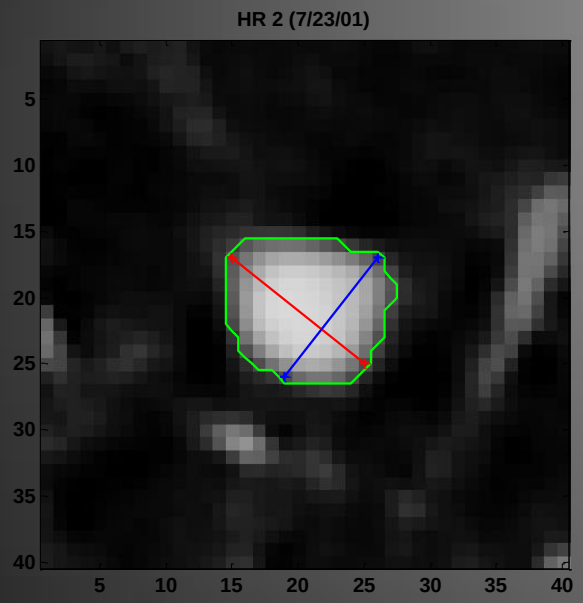
Malignant

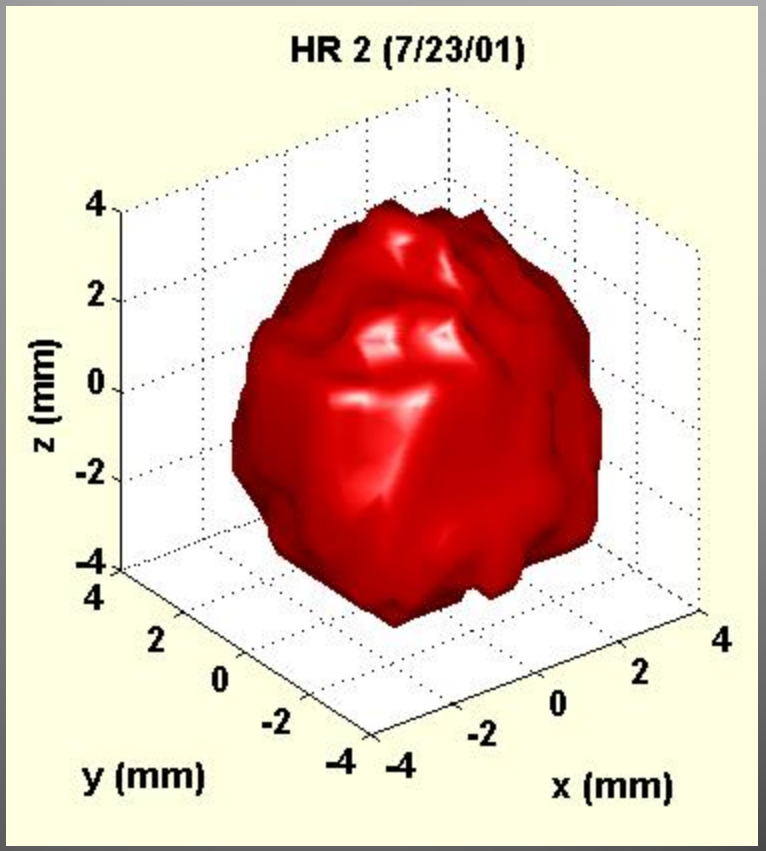


Benign

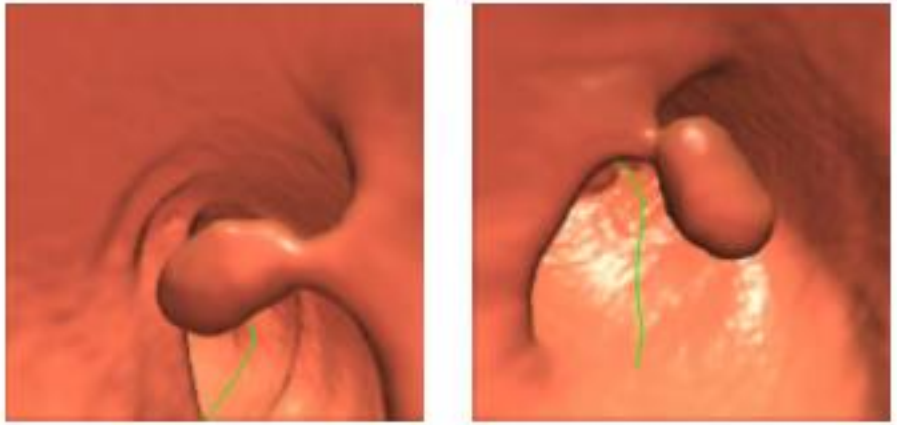


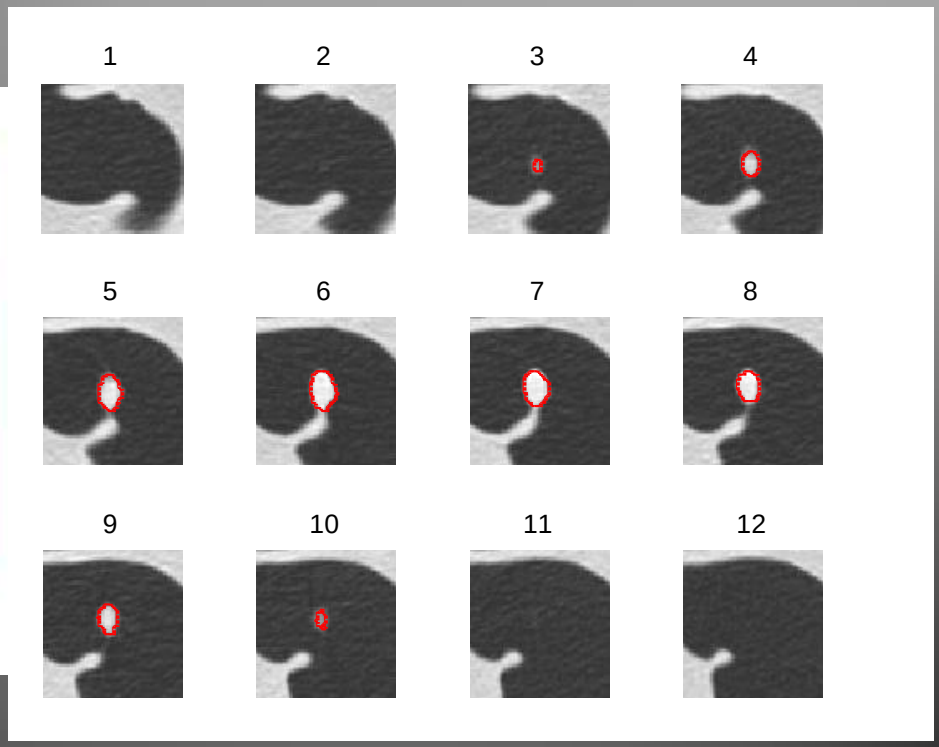
Nodule Segmentation



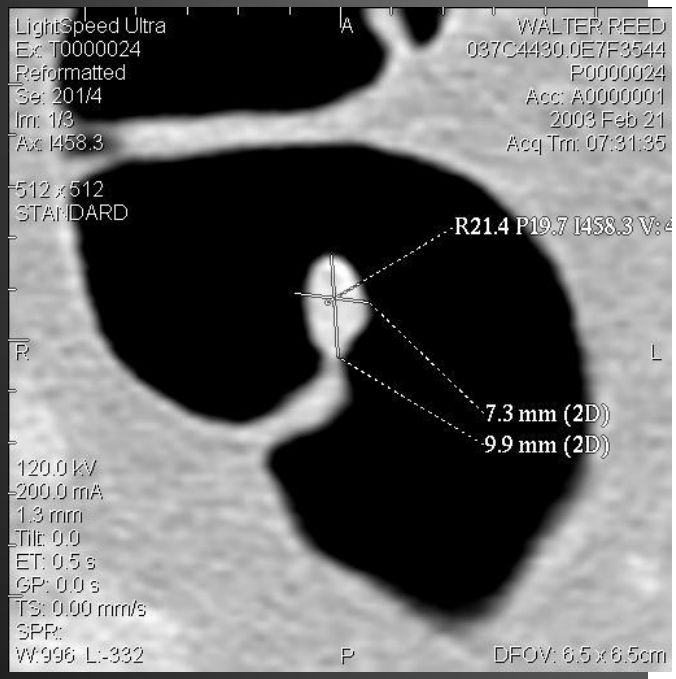


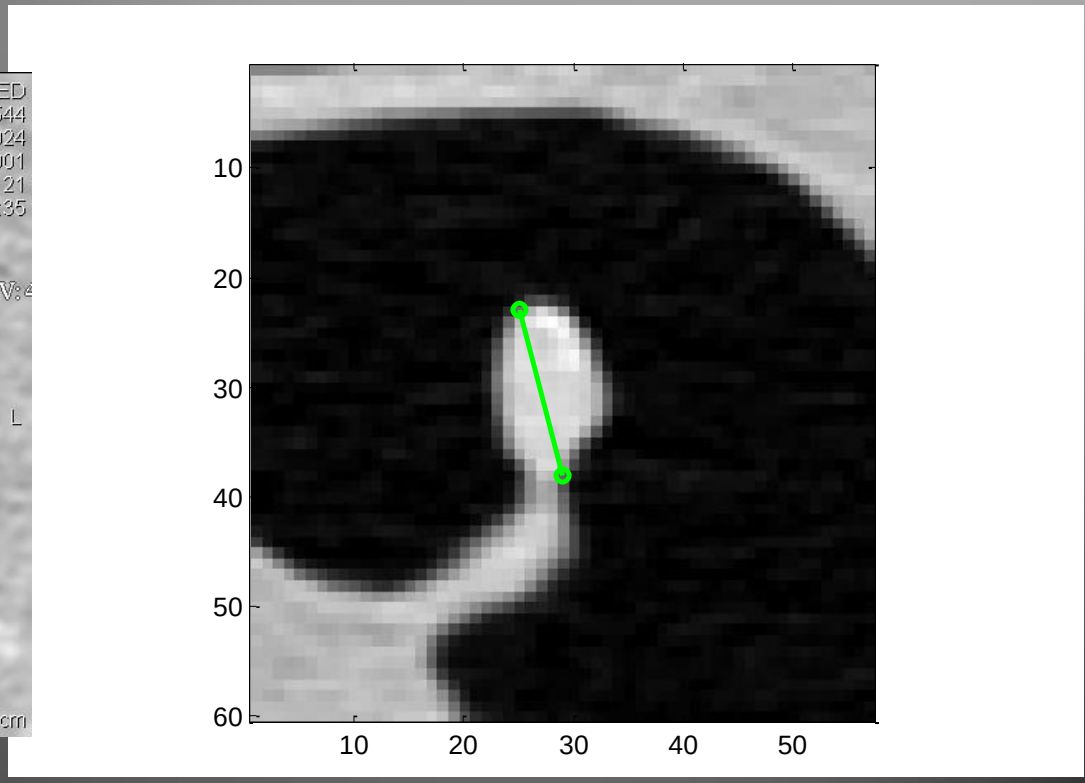
Polyp Segmentation





Measurement





CAD System

- Organ segmentation
- Candidate detection/segmentation
- Feature Extraction
- Classification/clustering

CAD System

- Organ segmentation
- Candidate detection/segmentation
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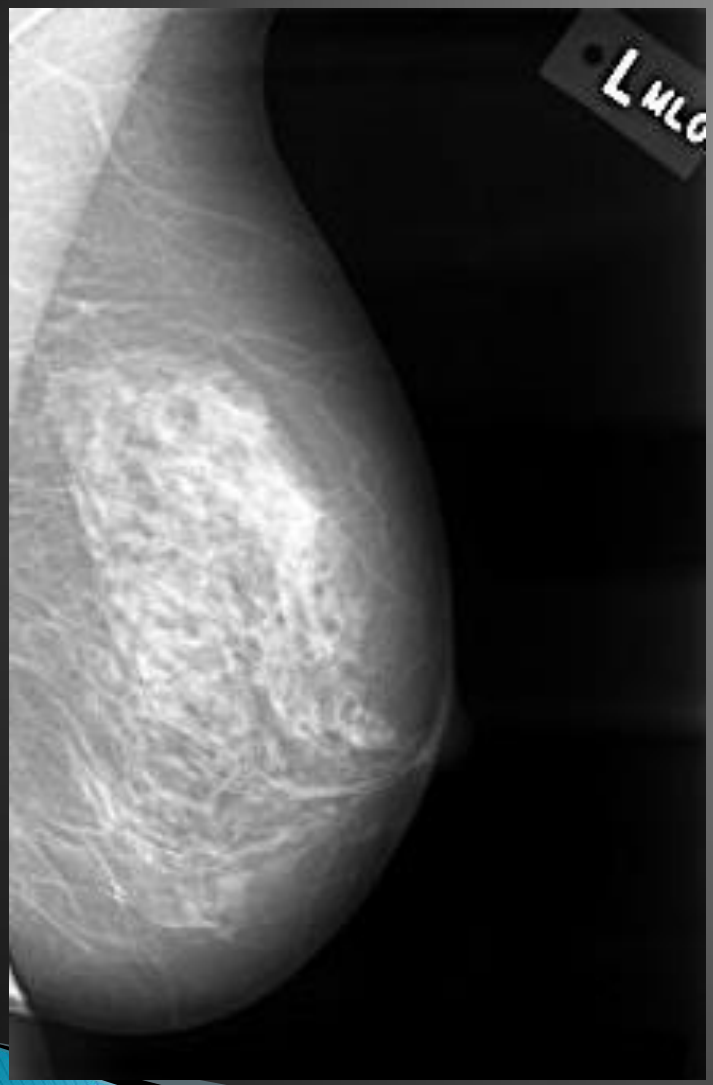
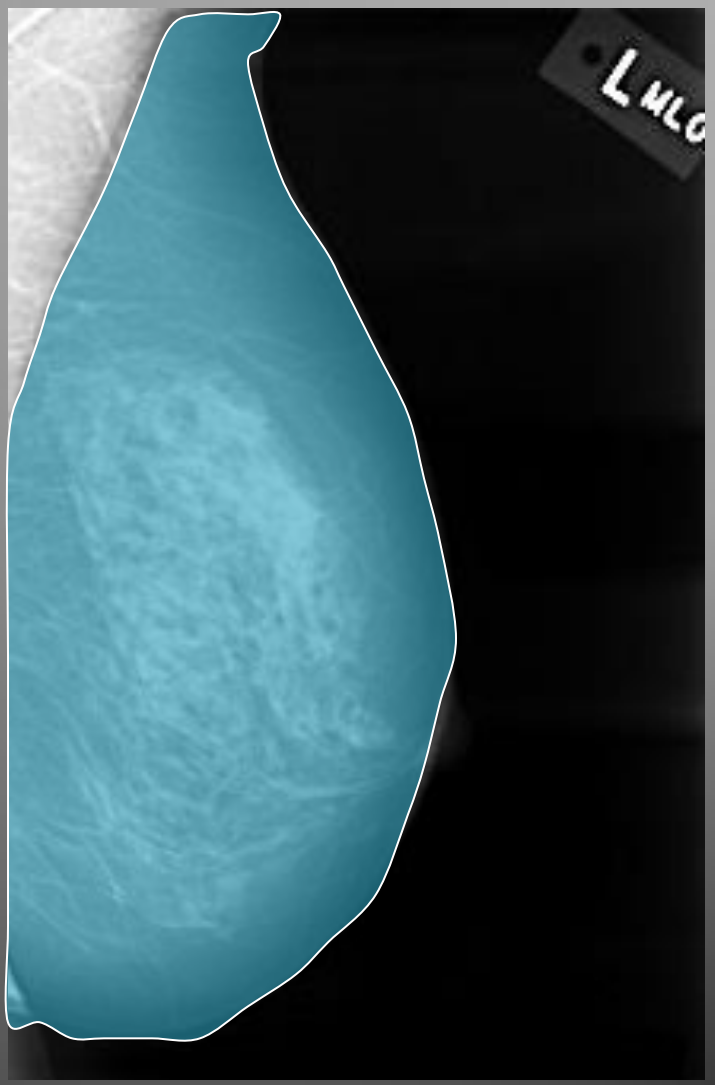
Breast Segmentation

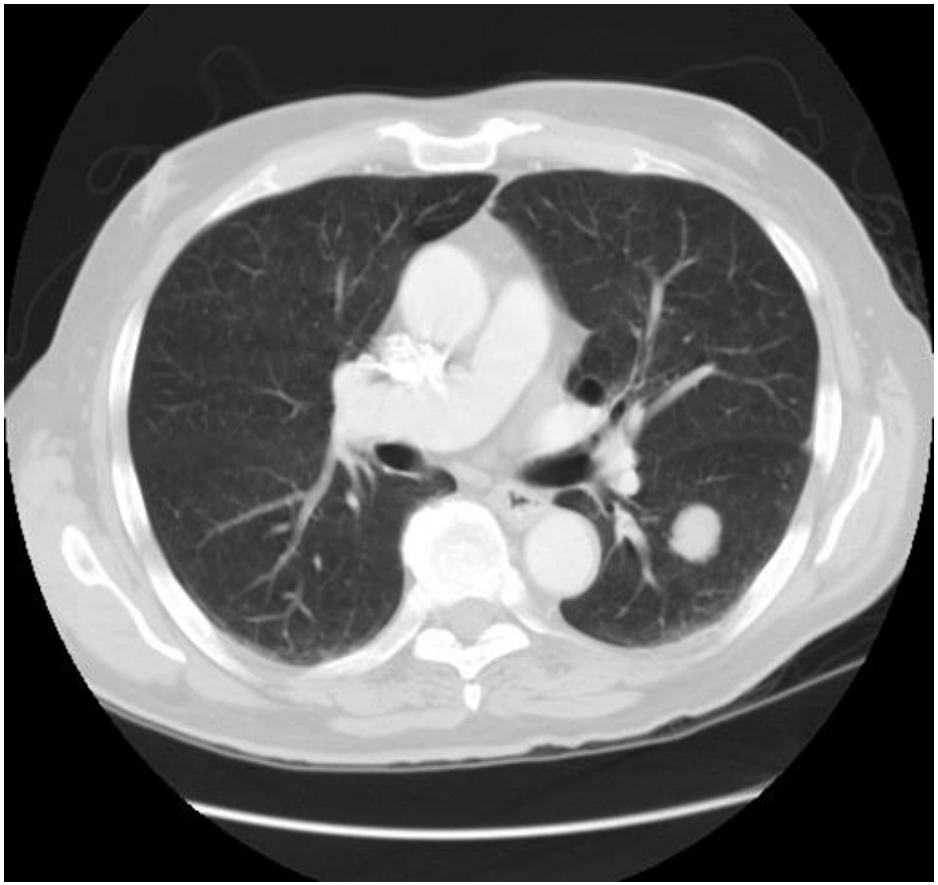




Lung Segmentation

- Segment Lung Regions within the CT slice
- Detect left and right lungs

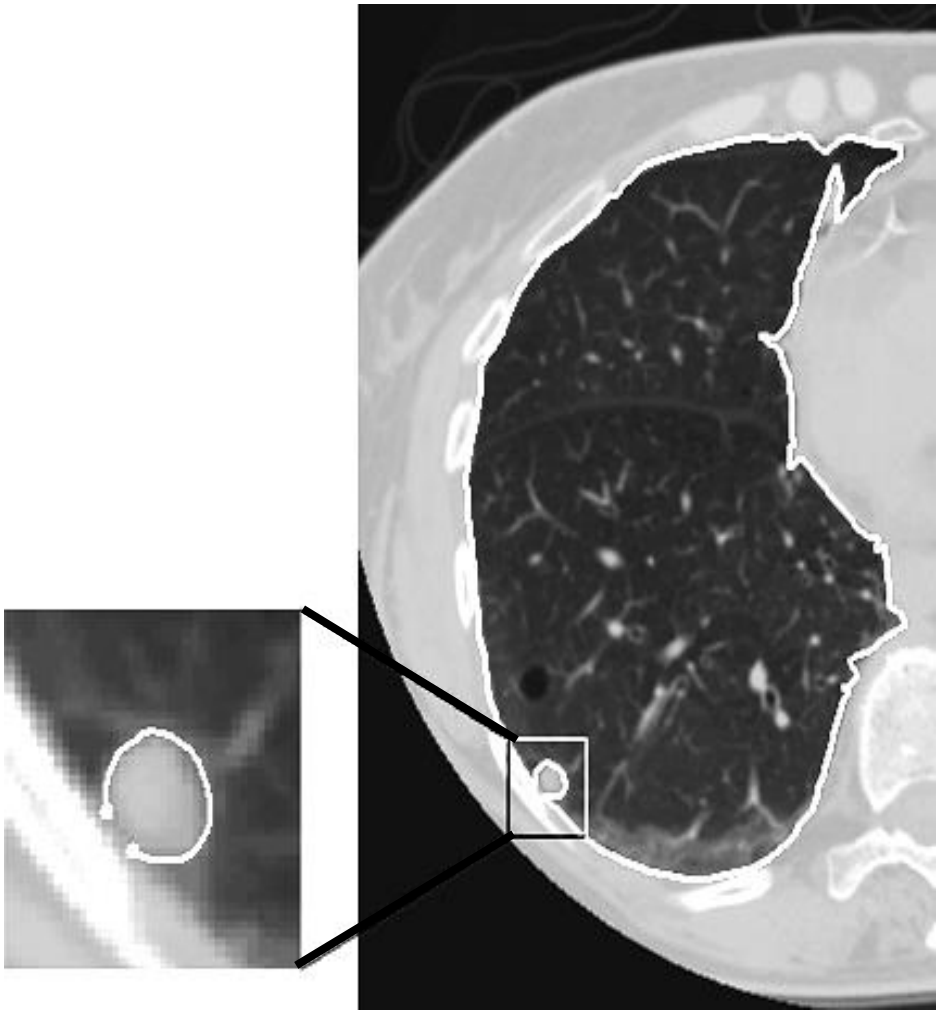
Lung Region Segmentation



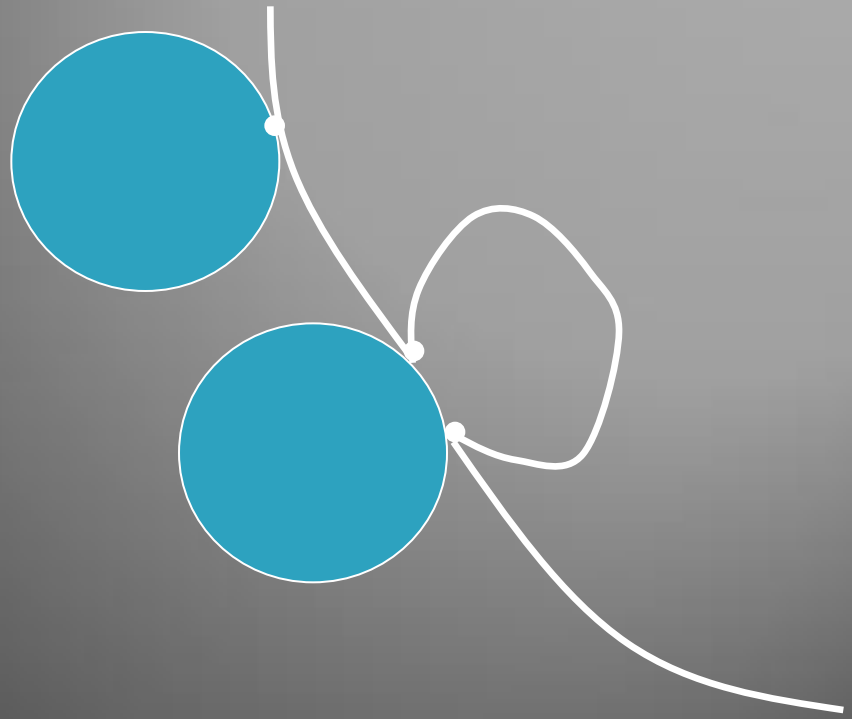
Contour Correction

- **Segmented lung region may exclude some nodules adjacent to pleura**
- **Connect edge points of concave regions**
- **Recover potential nodules adjacent to pleura**

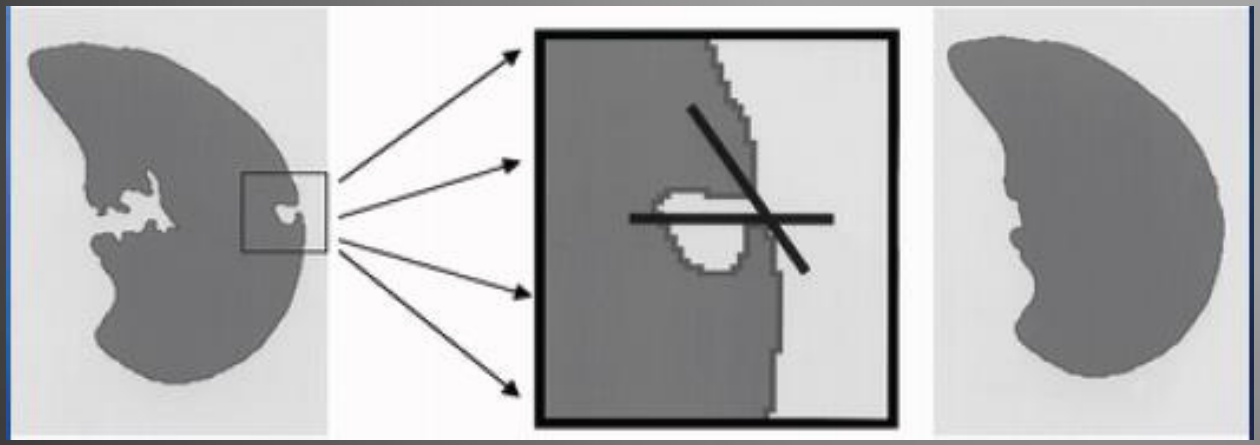
Contour Correction



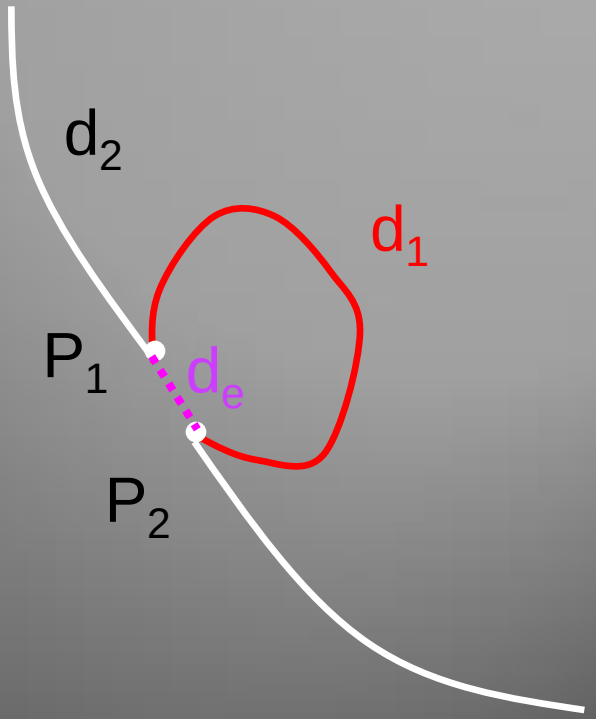
Contour Correction



Contour Correction



Contour Correction



$$R_e = \frac{\min(d_1, d_2)}{d_e}.$$

CAD System

- Organ segmentation
- Candidate detection/segmentation
- Feature Extraction
- Classification/clustering

Mammogram Image

Pre-screening

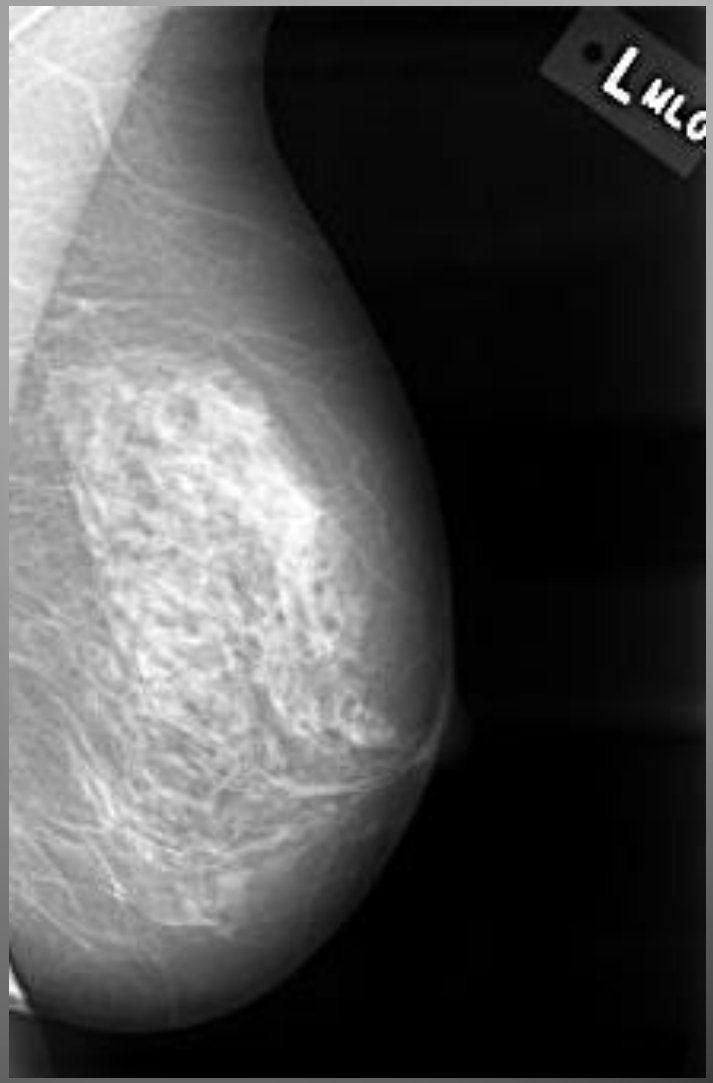
Potential Signals

CNN Classifier

Potential TP Signals

Clustering

Microcalcification Clusters



Initial Detection

Mammogram Image

Pre-screening

Potential Signals

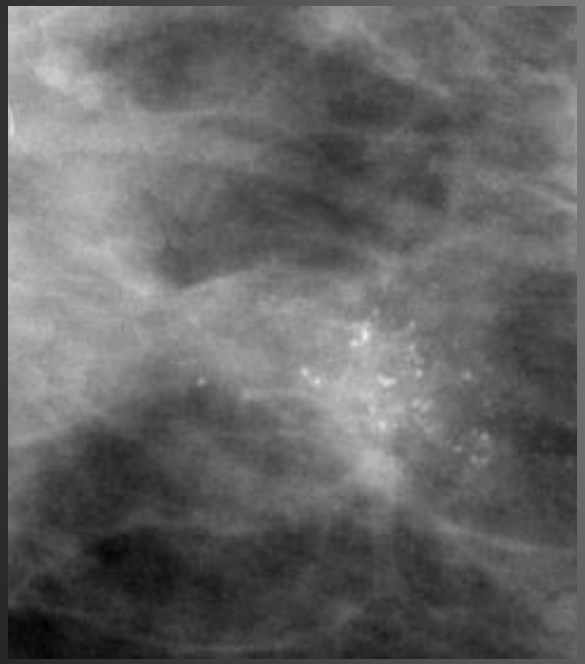
CNN Classifier

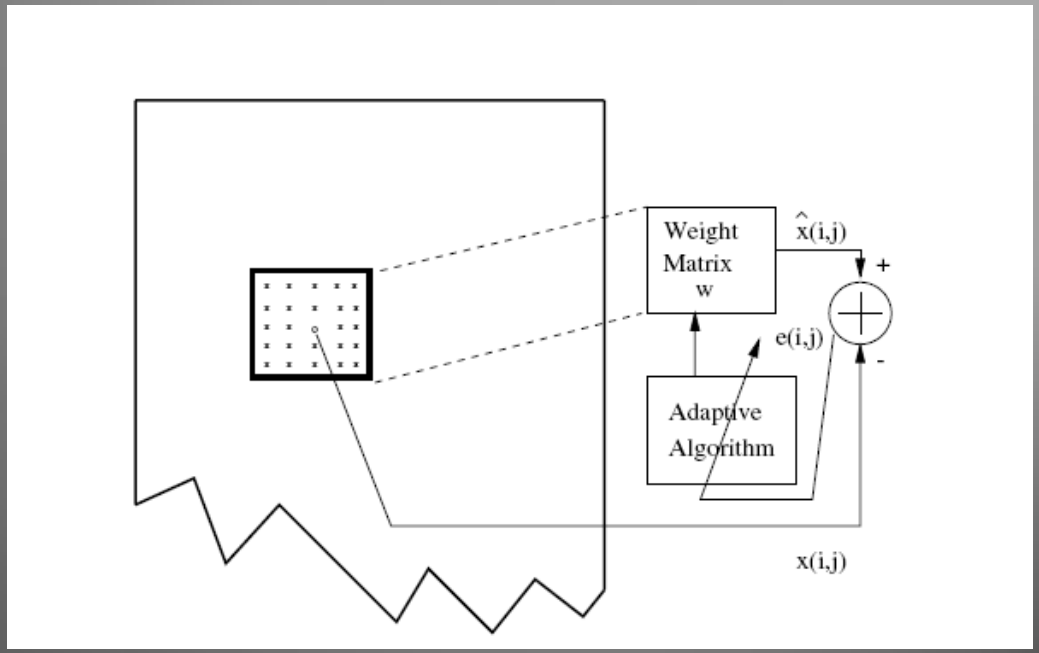
Potential TP Signals

Clustering

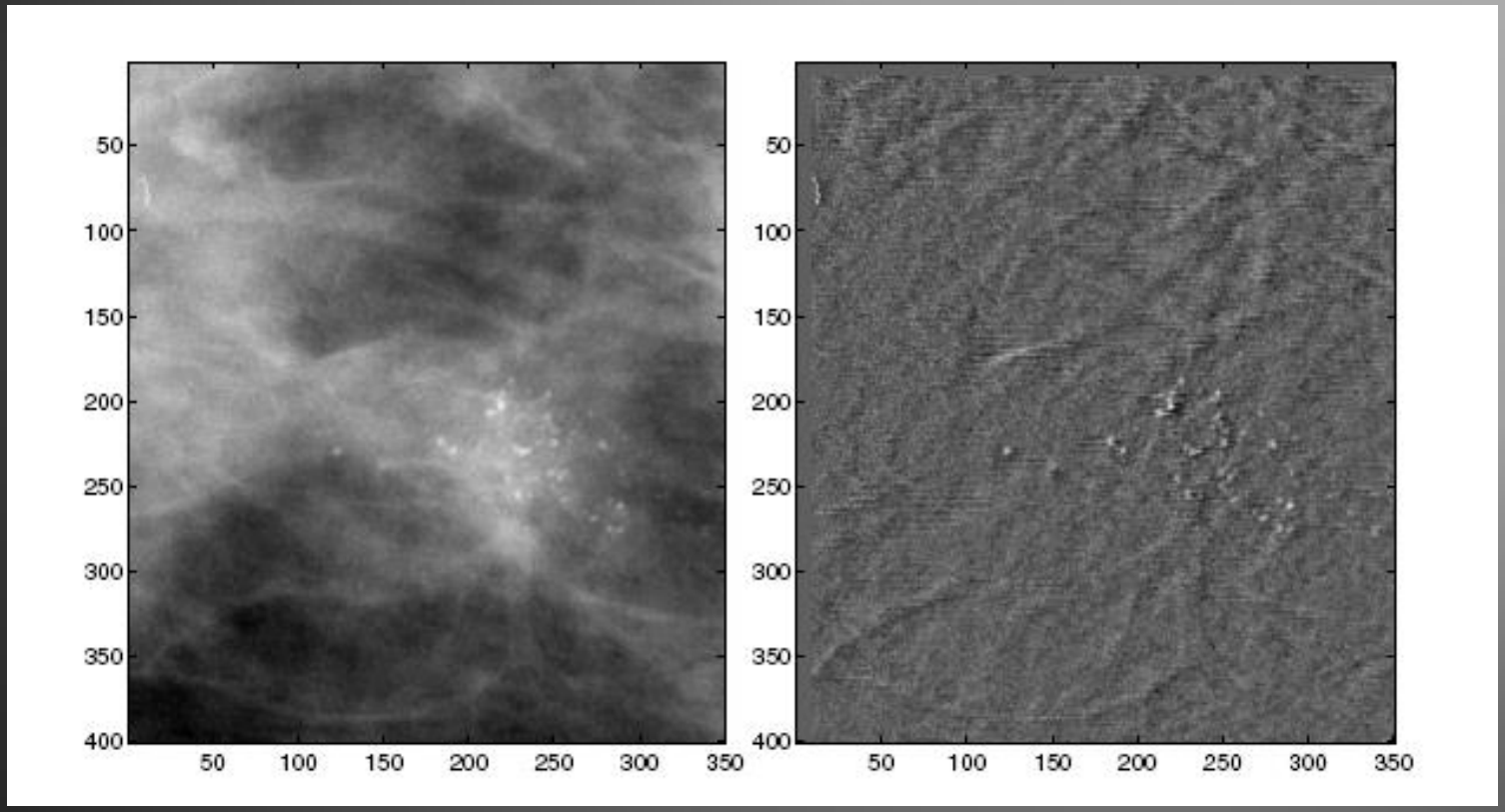
Microcalcification Clusters

Candidate Detection

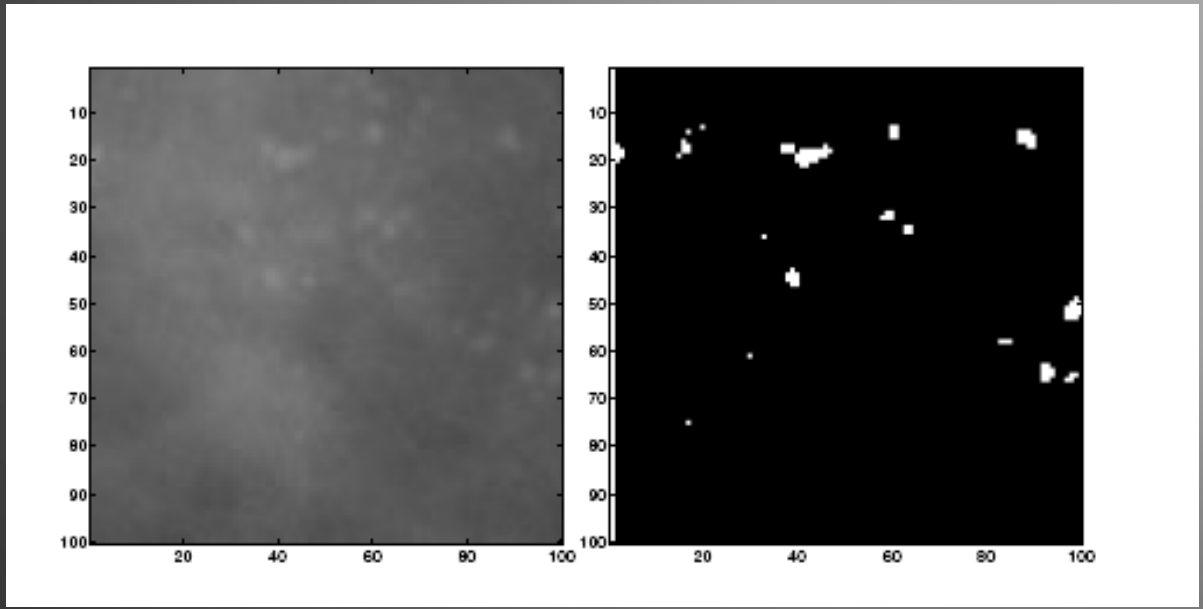




Candidate Detection



Candidate Detection

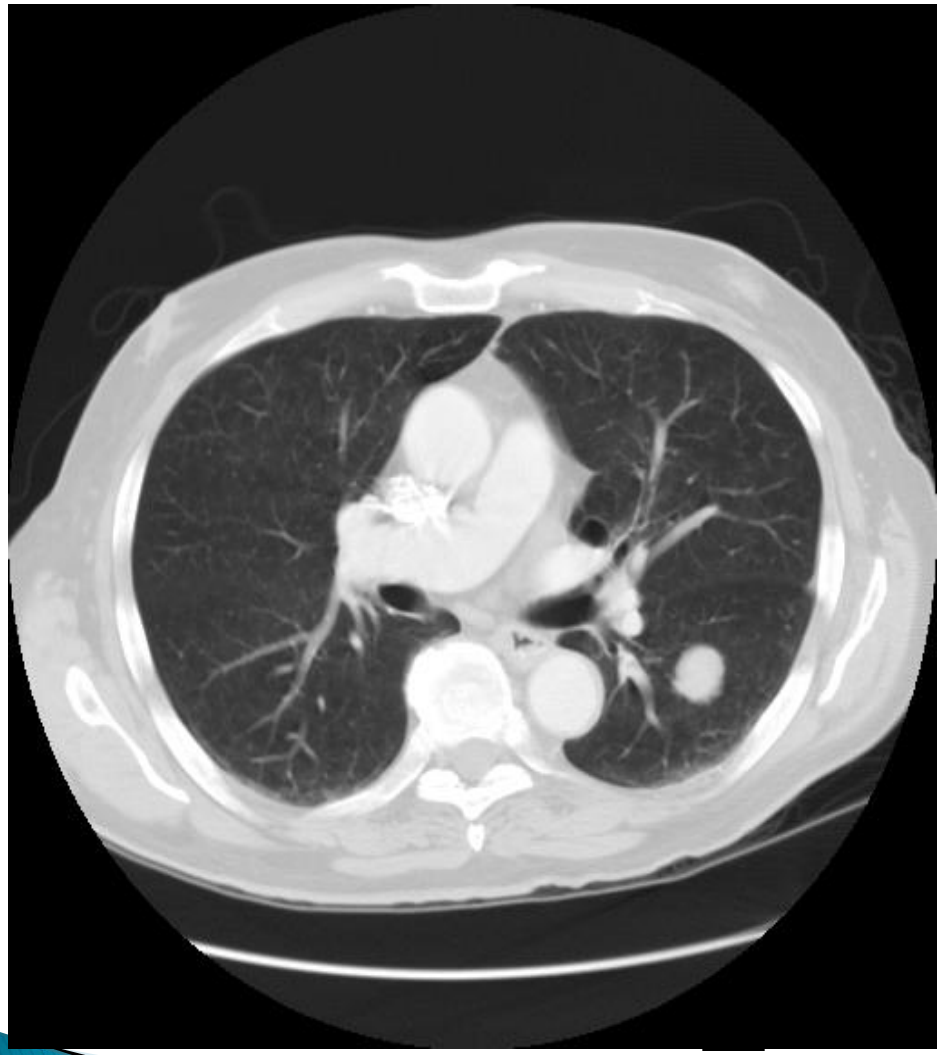


Nodule Candidate Segmentation

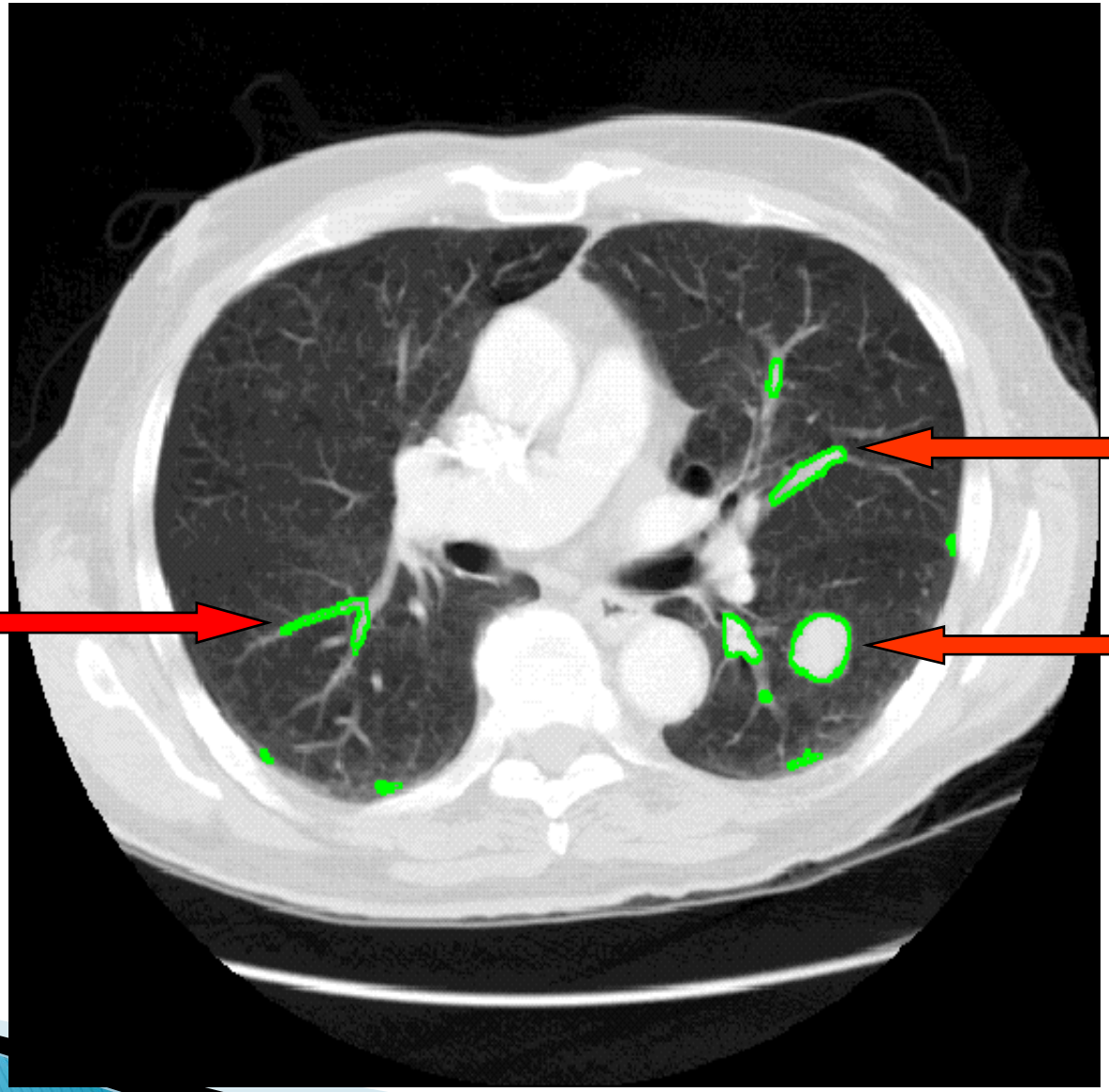
- **Identify high density regions within segmented lung regions**

- **Segmentation by k-means clustering with two classes:**
  - **nodule candidates**
  - **lung region**

Nodule Candidate Segmentation



Identification of Blood Vessels



CAD System

- Organ segmentation
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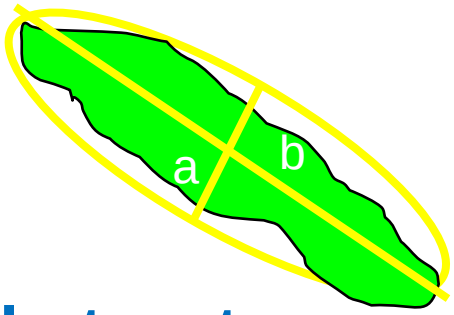
- Classification/clustering

Identification of Blood Vessels

- **Thin long structures**
  - **Major-to-minor axis ratio of a fitted ellipse**
- **V-shaped structures**
  - **Rectangularity**

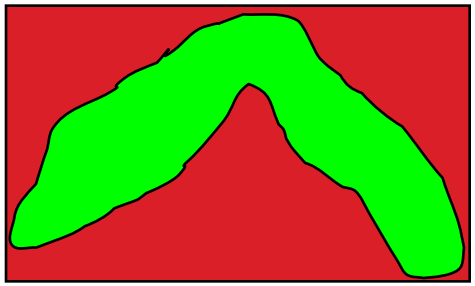
Identification of Blood Vessels

- **Thin long structures**



$$R_{tl} = \frac{a}{b}$$

- **V-shaped structures**



$$R_v = \frac{\text{Area of rectangle}}{\text{Area of object}}$$

CAD System

- Organ segmentation
- Candidate detection/segmentation
- Feature Extraction
- Classification/clustering

Potential Signals

FP ROI

TP ROI

Mammogram Image

Pre-screening

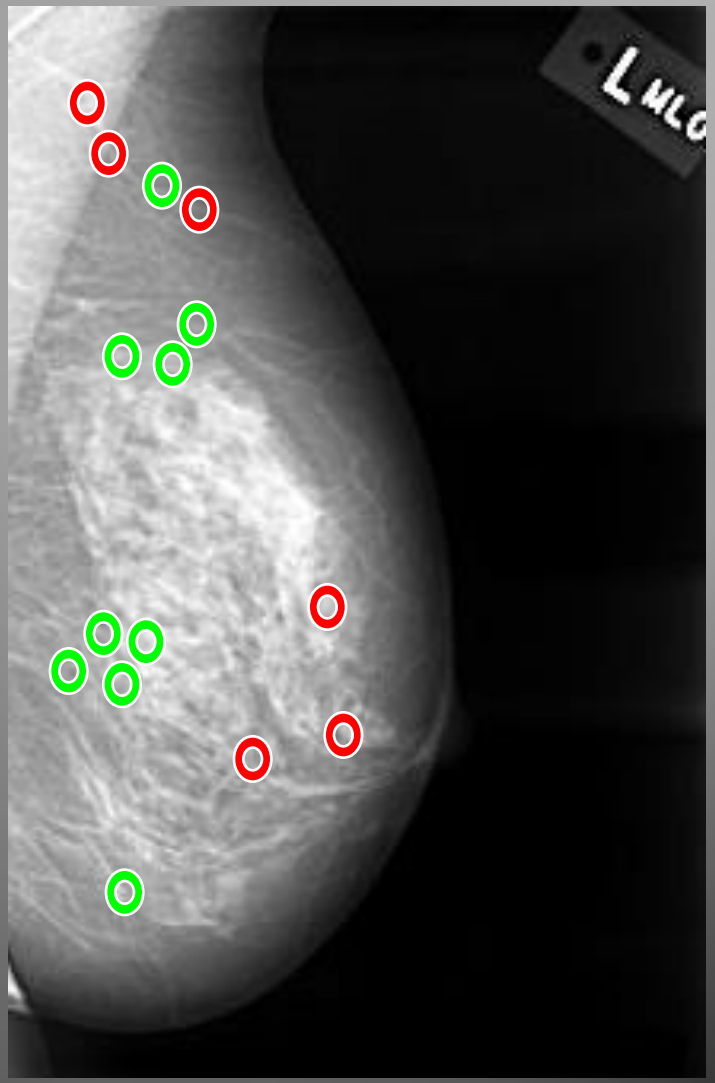
Potential Signals

CNN Classifier

Potential TP Signals

Clustering

Microcalcification Clusters



Classifier

CNN Classifier

0: FP

1: TP

INPUT ROI

Mammogram Image

Pre-screening

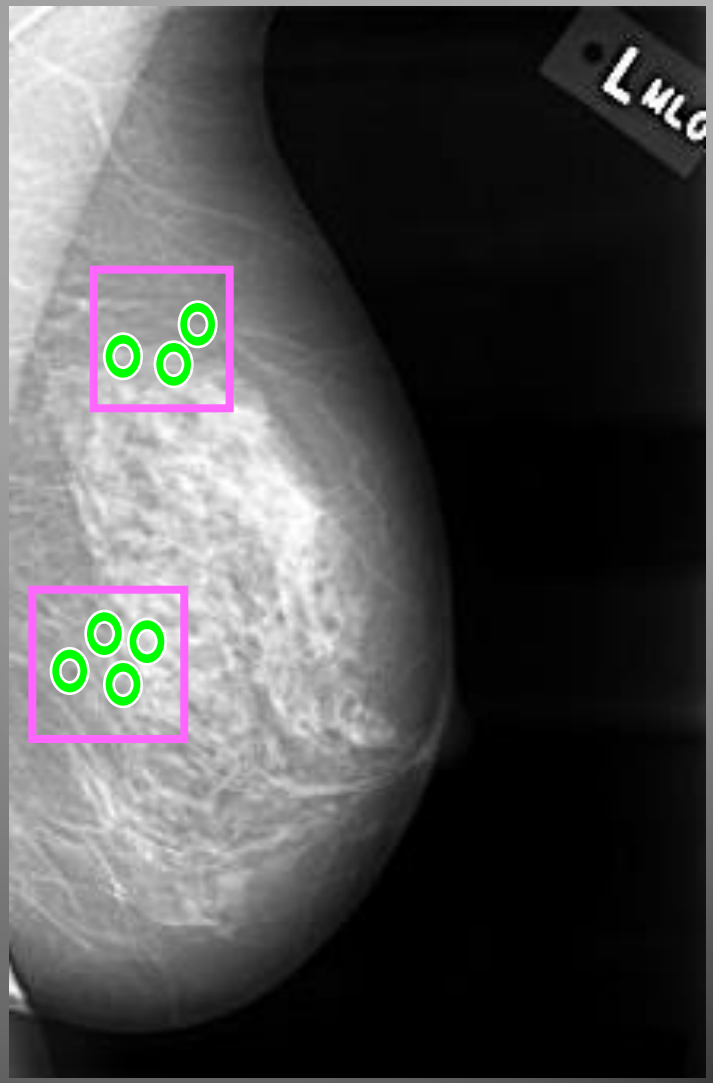
Potential Signals

CNN Classifier

Potential TP Signals

Clustering

Microcalcification Clusters



What we learned

- Image
  - How to represent
  - How to generate it
    - Imaging modalities
  - How to integrate
  - How to manage
- Image Analysis
  - Radiology
  - Big picture