

# **Morphology-Dependent Disparities in Deep Learning-Based Lung Nodule Detection**

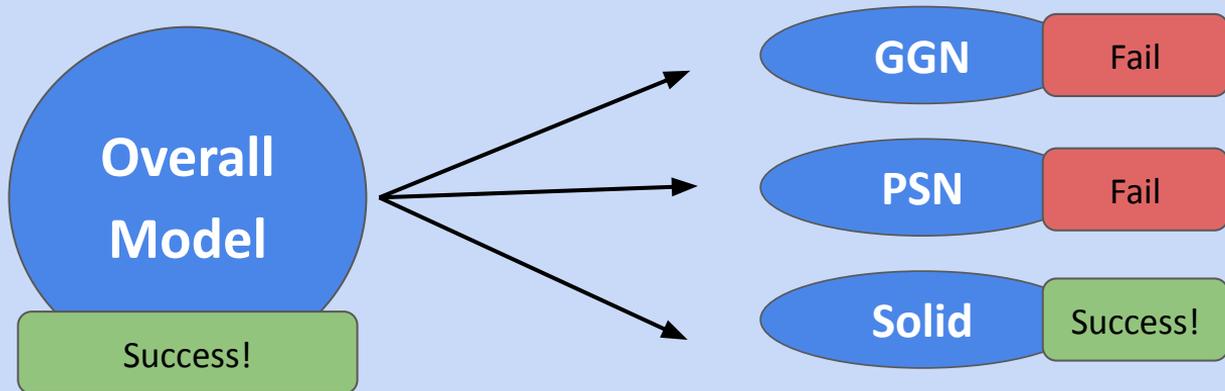
*Improving Early Lung Cancer Detection through  
Morphology-Aware and Interpretable AI*

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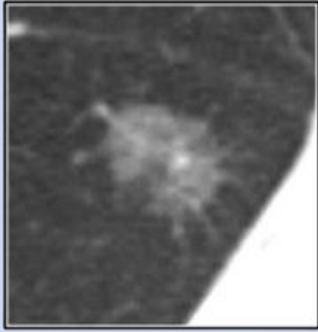
# Background

- Lung cancer is the leading cause of cancer mortality globally.
- Early detection allows for a dramatic increase in survival rate.
- AI is widely used to aid radiologists in screening.

**But, current models optimize overall accuracy while masking critical failures.**

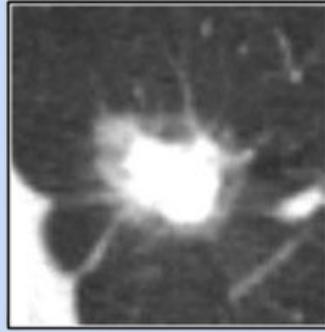


# Clinical & Technical Gap



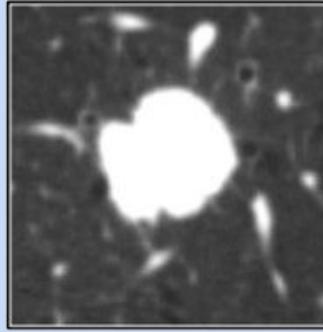
Ground-Glass  
Nodule (GGN)

[early stage, preinvasive,  
harder to detect]



Part-Solid Nodule  
(PSN)

[mix of ground-glass and  
solid components; hard to  
identify]



Solid Nodule

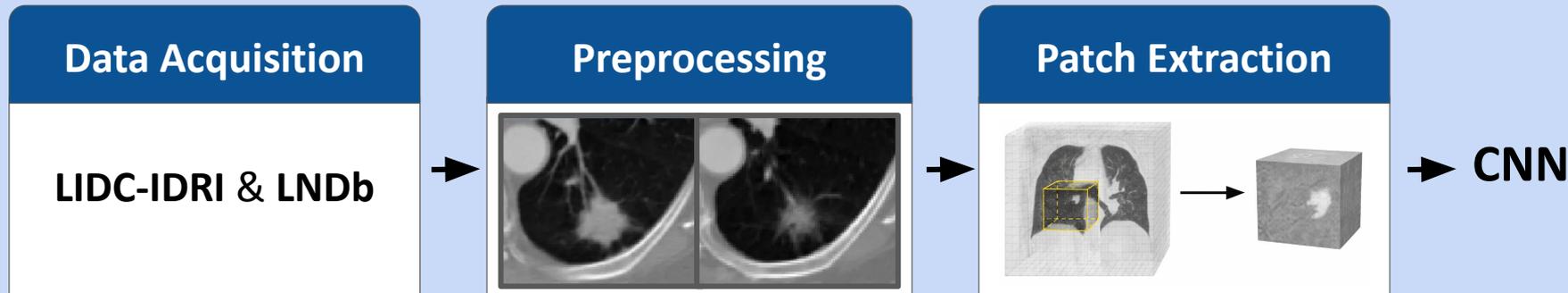
[later stage, malignant,  
easier to detect]

Do AI models perform  
equally across  
morphologies?

**If not, early-stage  
cancers may be  
systematically missed.**

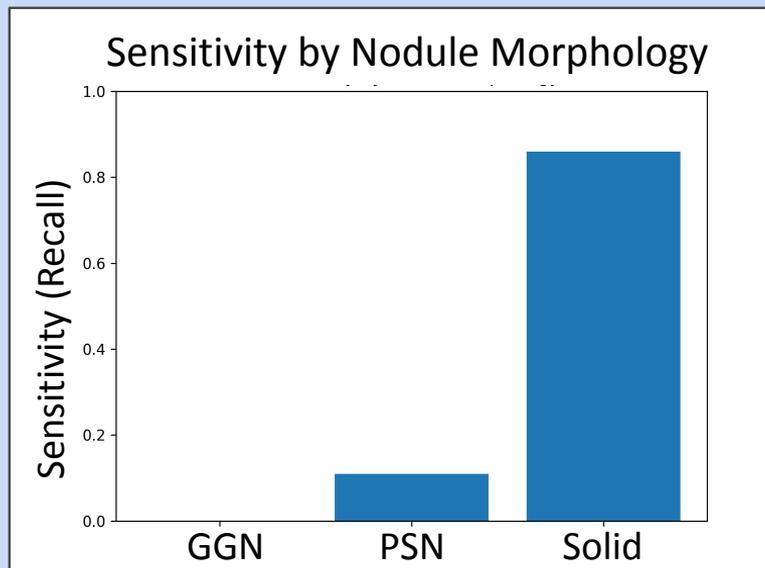
# Methodology

- Datasets: LIDC-IDRI (1,018 CT scans) and LNDb (294 CT scans)
- Preprocessing:
  - Density clipping (-1000 HU to 400 HU)
  - Vortex normalization
- Model: 3D CNN (14x14x14 patches)



## Key Discovery: Hidden Morphology-Dependent Bias

Performance drops significantly for clinically critical GGNs, even when controlling for lesion size and location in the lung.



## Morphology-Aware Training

- Retrained model with balanced sampling & explicit morphology learning.

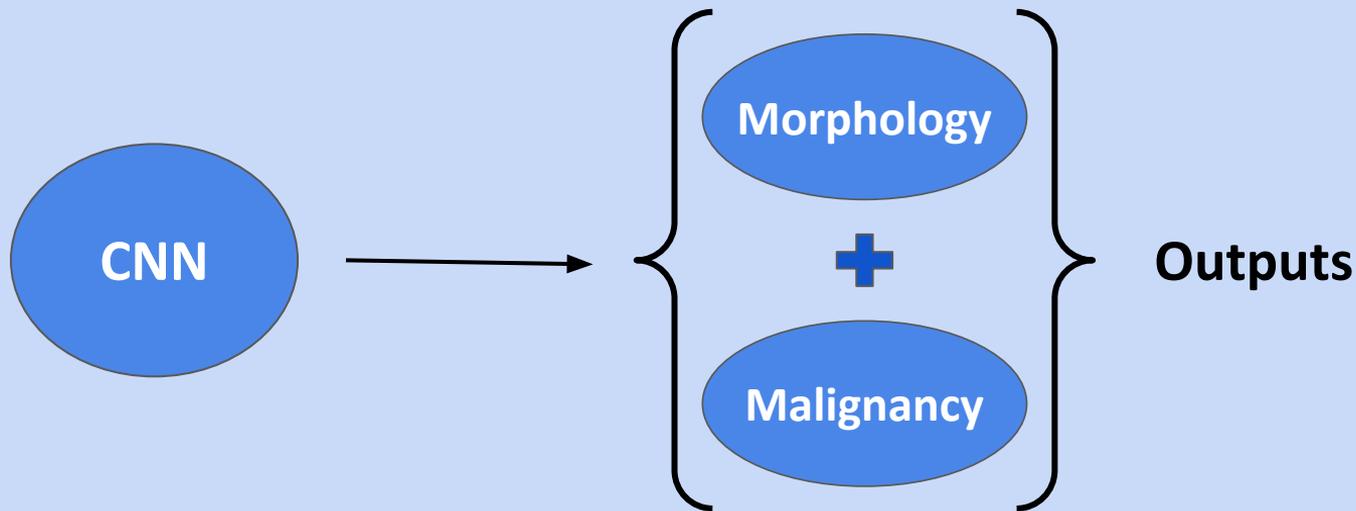
Morphology	Baseline AUC	Improved AUC	$\Delta$ AUC
<b>GGN</b>	0.79	0.93	<b>+0.14</b>
<b>PSN</b>	0.66	0.72	<b>+0.06</b>
<b>Solid</b>	0.77	0.79	<b>+0.02</b>

**Largest improvement occurs in the most clinically important nodules (GGNs).**

# From Detection to Clinical Decision-Making

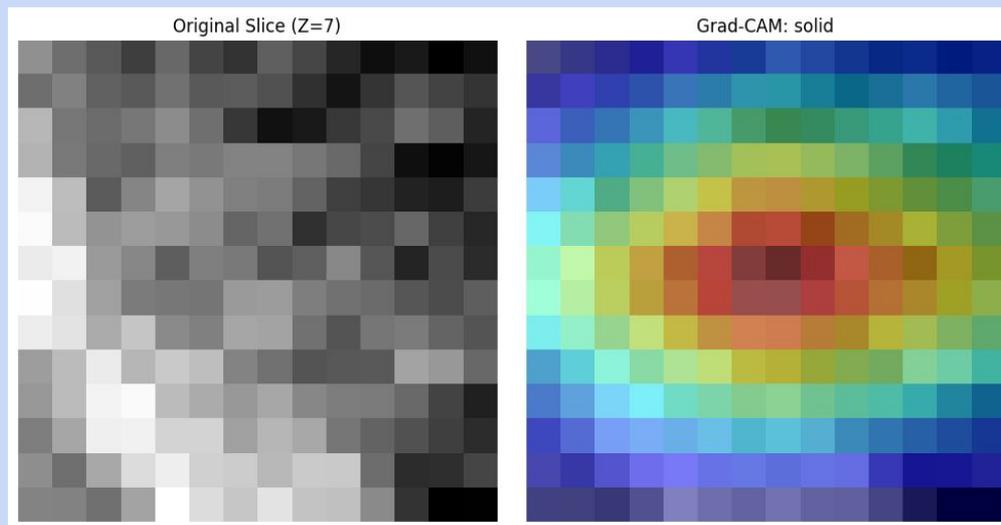
- Added jointed prediction:
  - Morphology + malignancy

**Explicit morphology awareness improves downstream cancer prediction.**



# Understanding model behavior (Interpretability)

- Grad-CAM for the radiologist to understand the model's decision-making and analysis process.



## Impact & Conclusion

- Current AI models exhibit hidden morphology bias.
- Morphology-aware training reduces disparity.
- Improves early-stage cancer detection.

**Evaluating AI by subgroup performance, rather than just for overall accuracy, is essential for safe clinical deployment.**

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