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# Relational Learning between Multiple Pulmonary Nodules via Deep Set Attention Transformers

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# Introduction

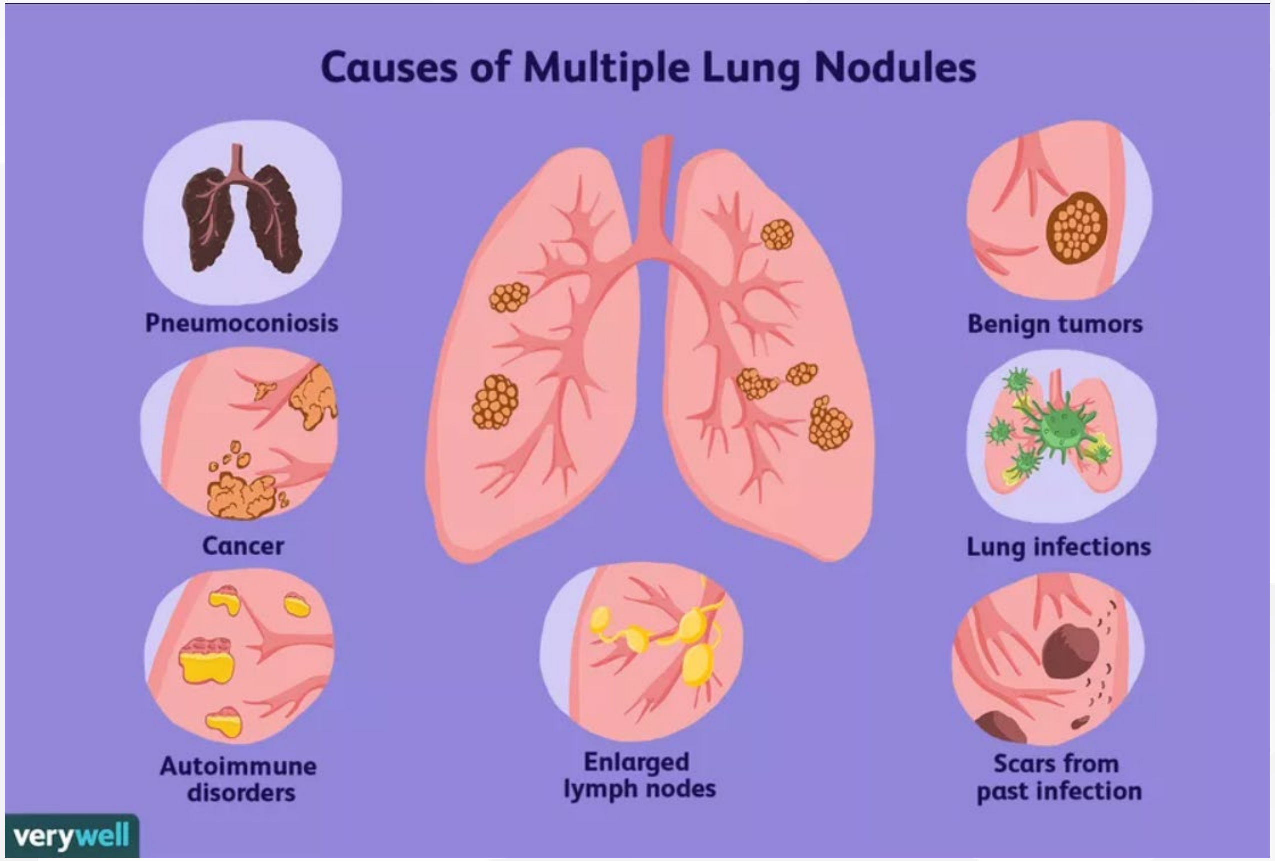



Illustration by Jessica Olah, Verywell
https://www.verywellhealth.com/multiple-lung-nodules-causes-and-diagnosis-2249390

Challenges:

1/ Diagnosis of multiple pulmonary nodules is **complex**

2/ Previous methods use **solitary**-nodule approaches for **multiple** pulmonary nodules, *i.e.*, ignore the relations

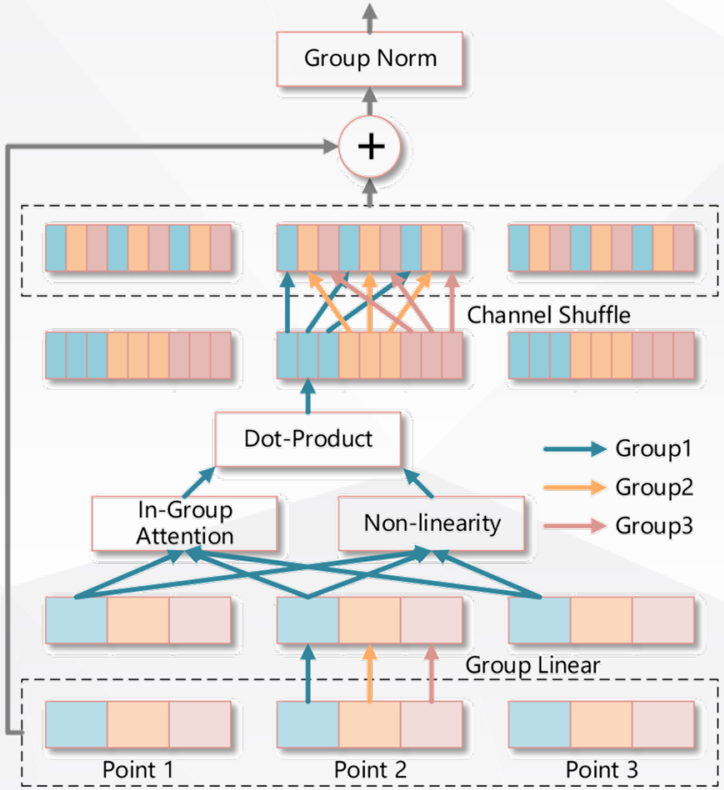
Solutions:

**Relational learning** between multiple nodules via **Set Attention Transformers**

# Methodology: Set Attention Transformers

We propose **Set Attention Transformers (SATs)**, inspired from our previous study, **Point Attention Transformers** for point clouds:

- **Permutation-equivariant** for sets
- **Relational learning** between set elements
- **Parameter-efficient**
- **Group Shuffle Attention**



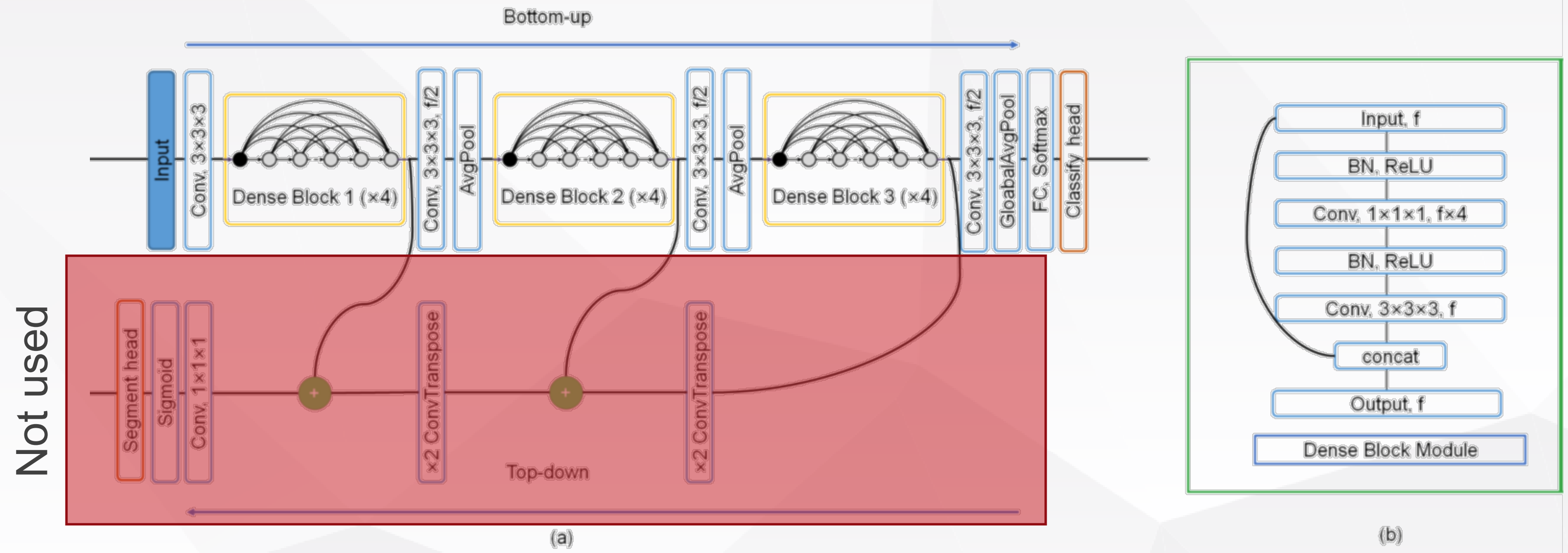

Check our CVPR'19 study on point clouds

Modeling Point Clouds with Self-Attention and Gumbel Subset Sampling.
Jiancheng Yang, Qiang Zhang, Bingbing Ni, Linguo Li, Jinxian Liu, Mengdie Zhou, Qi Tian

# Methodology: 3D DenseNet Backbone



We use a parameter-efficient 3D DenseNet for representation backbone, adapted from our previous study:



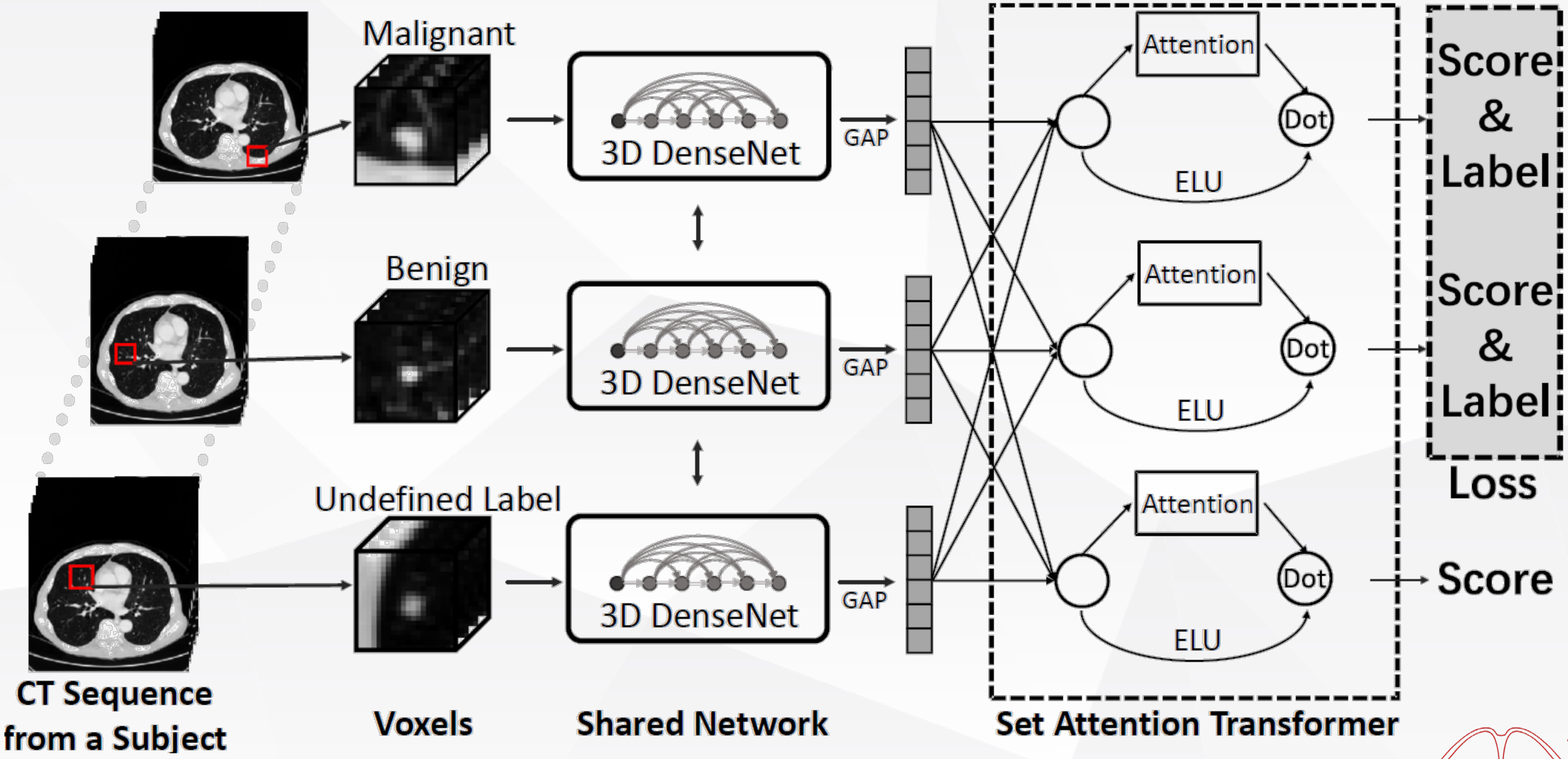

Check our Cancer Research study on tumor invasiveness

3D Deep Learning from CT Scans Predicts Tumor Invasiveness of Subcentimeter Pulmonary Adenocarcinomas.

Wei Zhao*, Jiancheng Yang*, Yingli Sun, *et al.* (*equal contribution).

# Methodology: NoduleSATs

Combining 3D DenseNet backbone with the proposed **Set Attention Transformers (SATs)**, we proposed end-to-end **NoduleSATs**:



# Experiments: Lung Nodule Detection



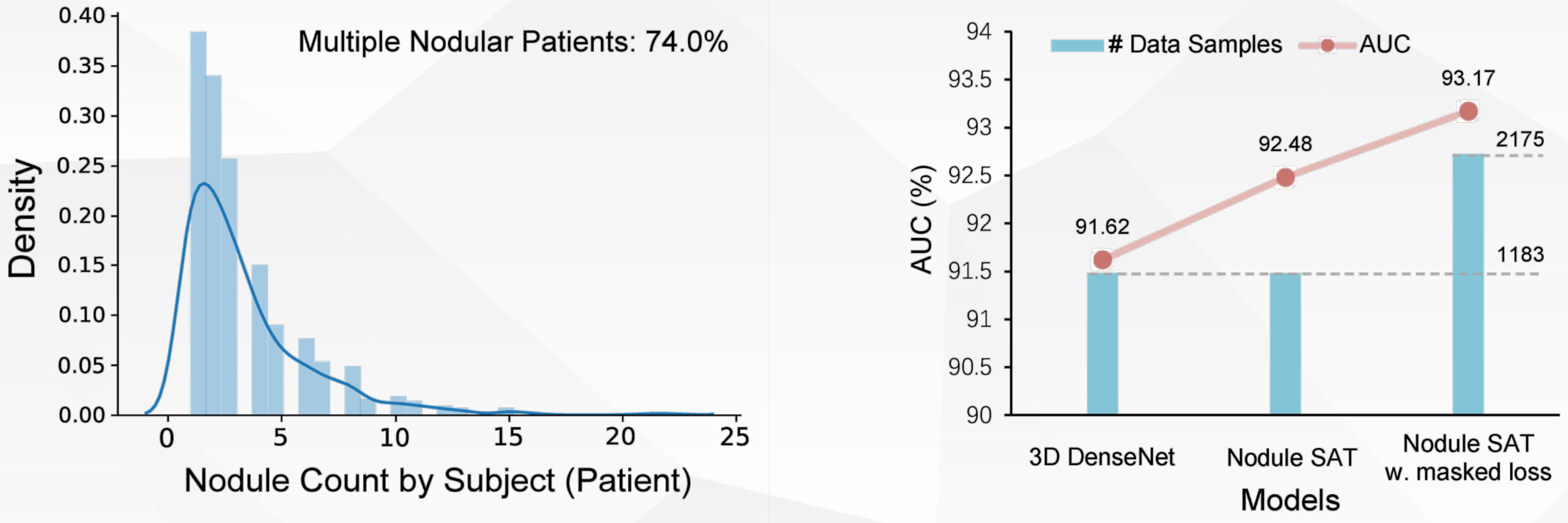
| Dataset | Method | Average FROC (CPM) |
|---|---|---|
| LUNA16 [10] | 2D-CNN [11] | 0.790 |
| | 3D-CNN [12] | 0.908[2] |
| | 3D DenseNet | 0.884 |
| | NoduleSAT | **0.916** |
| Tianchi VAL | 3D DenseNet | 0.677 |
| | NoduleSAT | **0.716** |

1/ LUNA16 False Positive Reduction: 888 subjects with 1186 nodules, totally 754,975 candidates, 10-fold cross validation.

2/ Tianchi Lung Nodule Detection: 800 subjects with 1,224 nodules, 5,531 candidates on the training set, 1,515 candidates on the validation set.

# Experiments: Malignancy Classification






(a) Nodule Count Distribution

(b) Model Performance

LIDC-IDRI: one of the largest public available lung cancer screening databases

Patients in LIDC-IDRI dataset have 1 - 23 nodules

527 malignant + 656 benign + 992 undefined-label

# Conclusion

- We propose a **Set Attention Transformer (SAT),** to explicitly learn relational information between multiple pulmonary nodules from a same subject.
- Integrated with a 3D DenseNet, the proposed end-to-end trainable **NoduleSAT** encourages the model to learn top-down **inter-nodule relations** from bottom-up nodule-level representations.
- We empirically prove the benefit of relation learning between multiple pulmonary nodules.

# Thanks for Listening

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