



Semantic Genesis

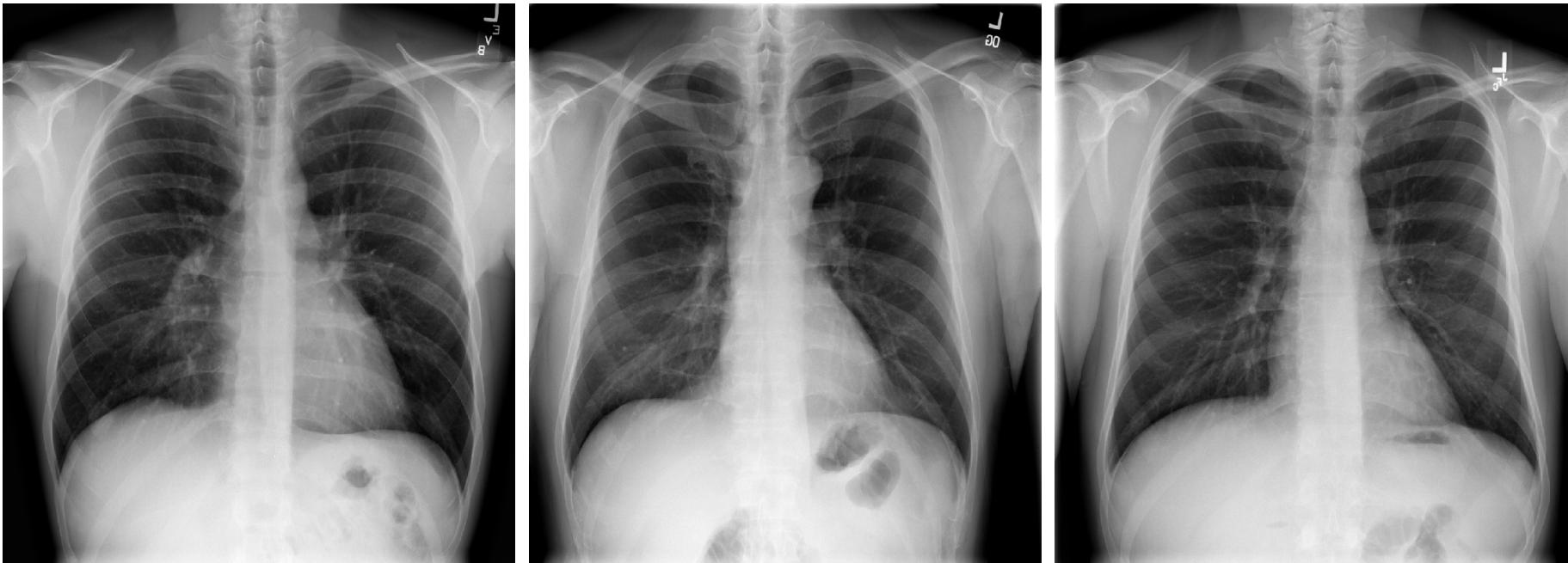
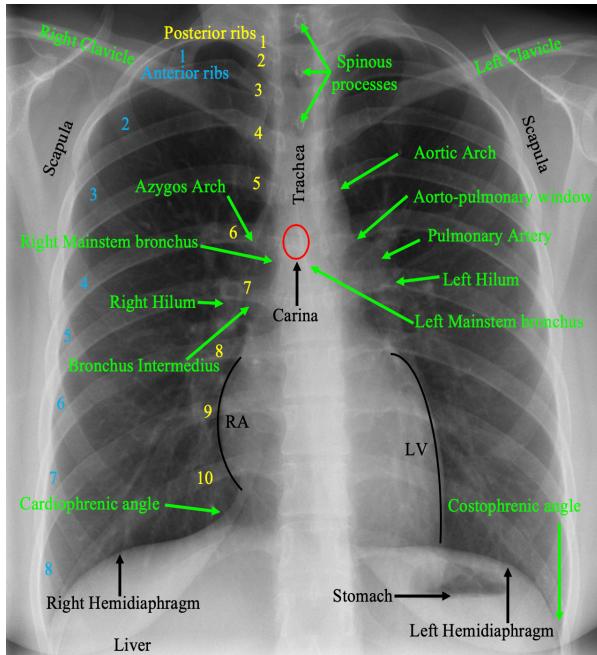
Learning Semantics-enriched Representation via Self-discovery, Self-classification, and Self-restoration

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Michael B. Gotway², and Jianming Liang¹

¹ Arizona State University

² Mayo Clinic

Consistent and Recurrent Anatomy in Medical Images



Anatomical patterns can serve as free yet strong supervisory signals for deep models
to learn *common anatomical representations* automatically via self-supervision



Semantic Genesis

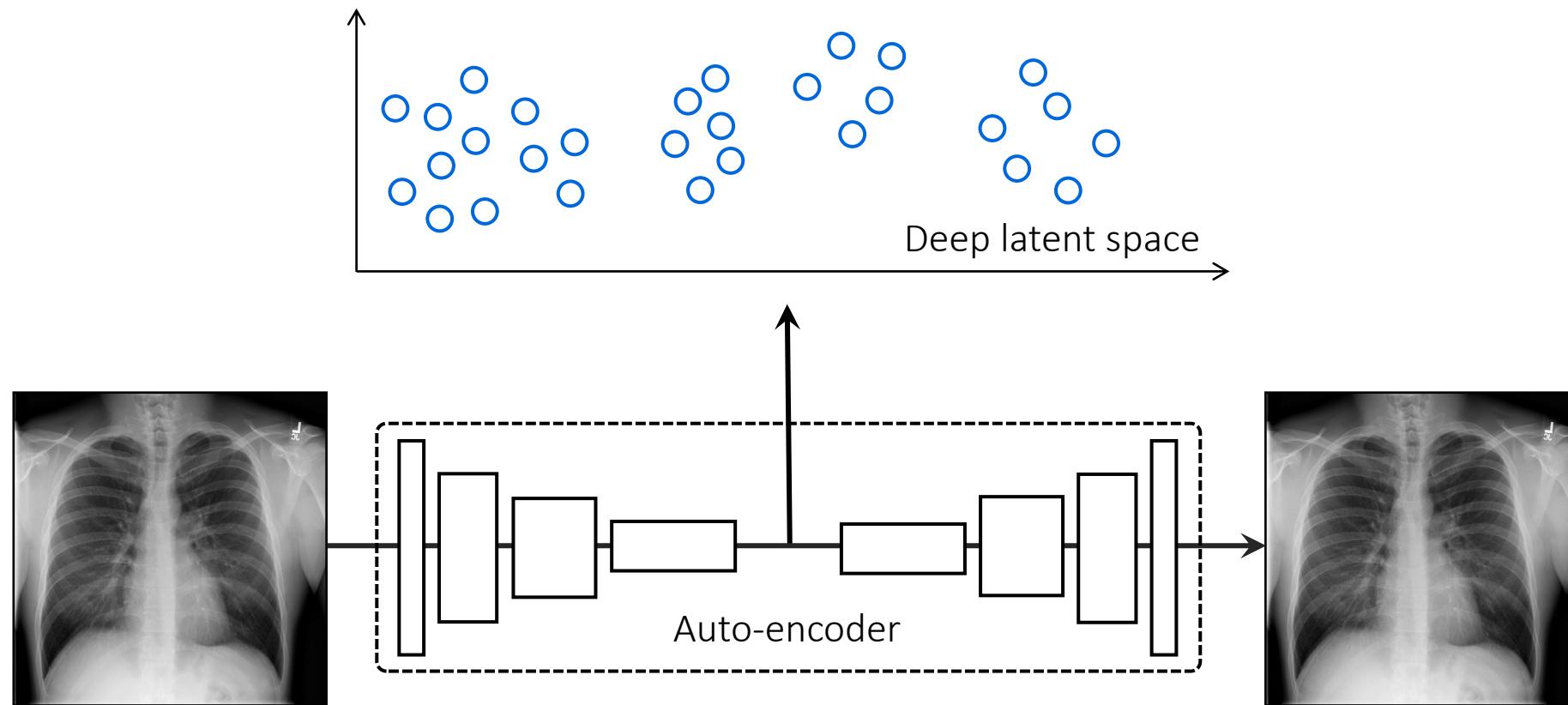
Semantics-enriched pre-trained 3D models

Self-discovery

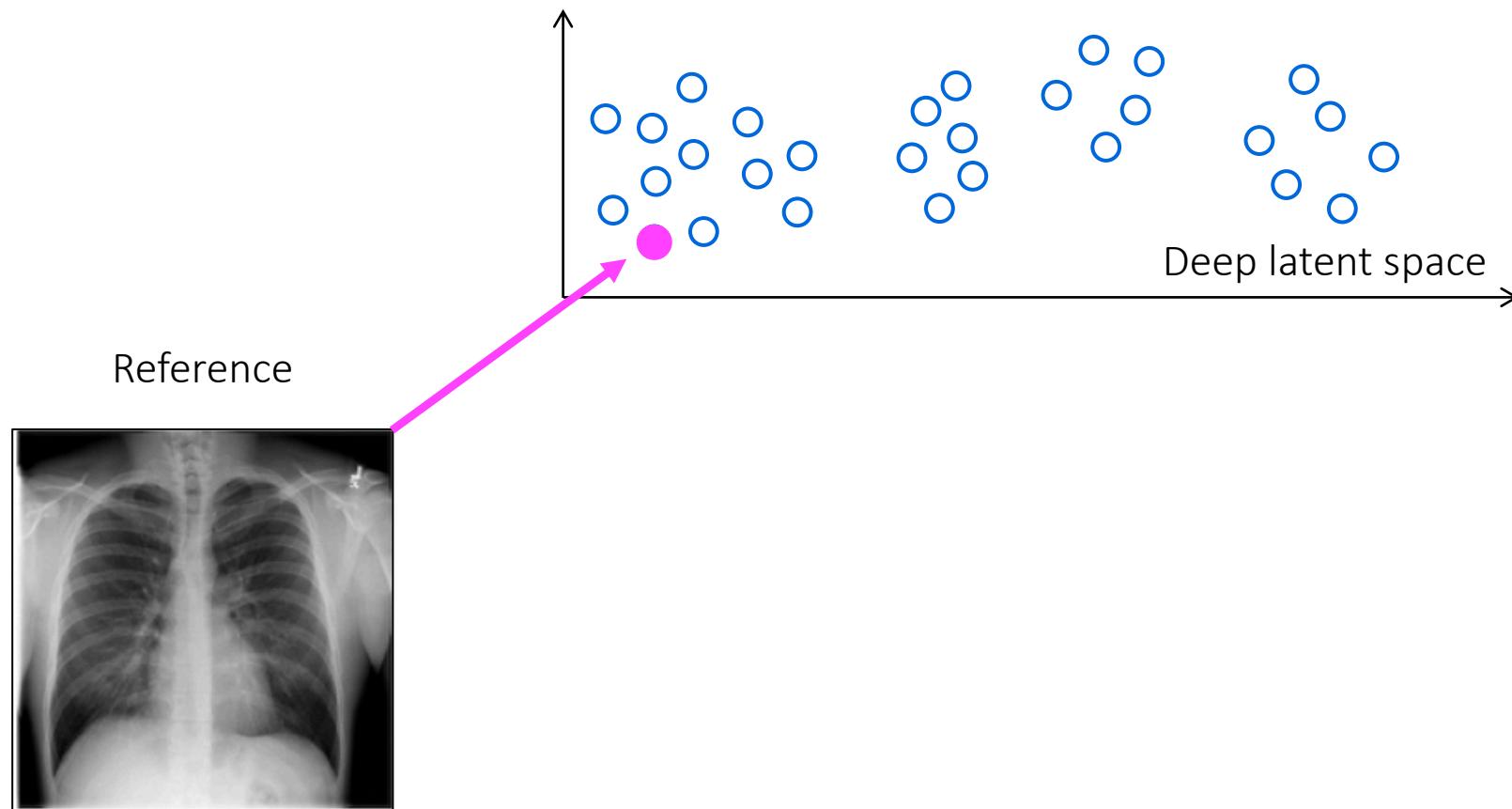
Self-classification

Self-restoration

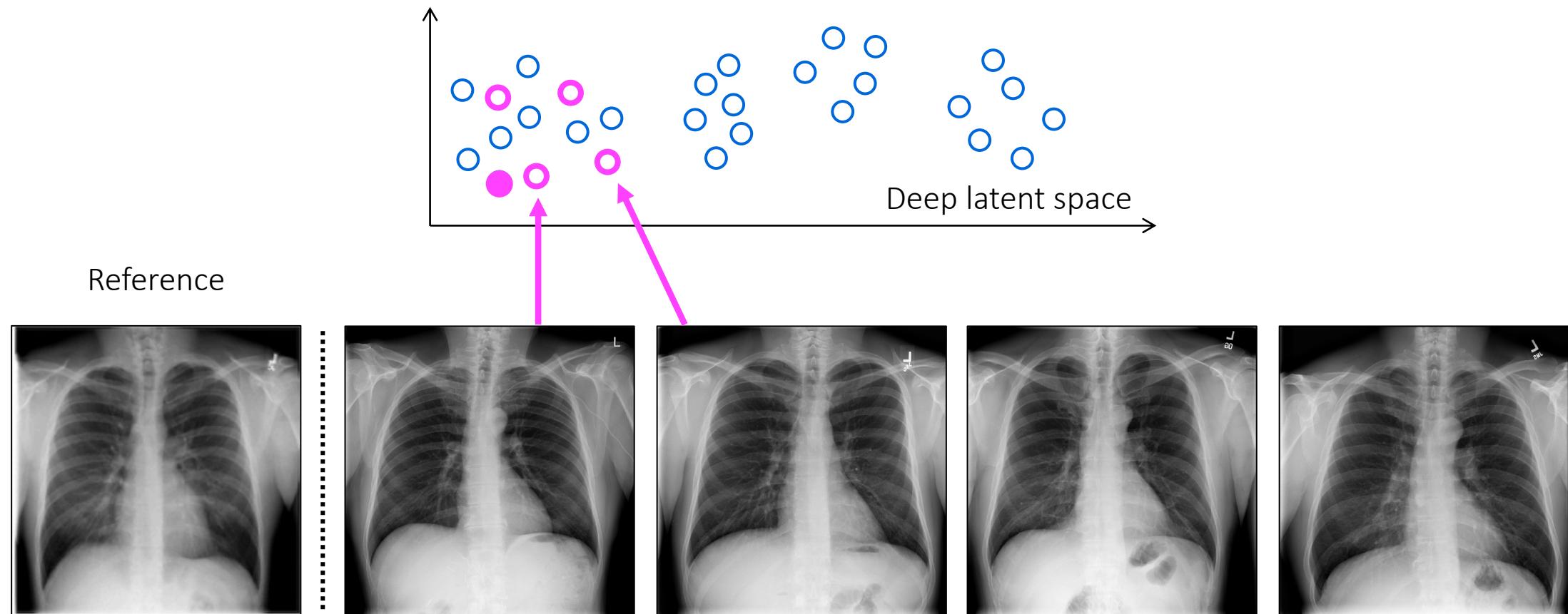
Self-discovery of anatomical patterns



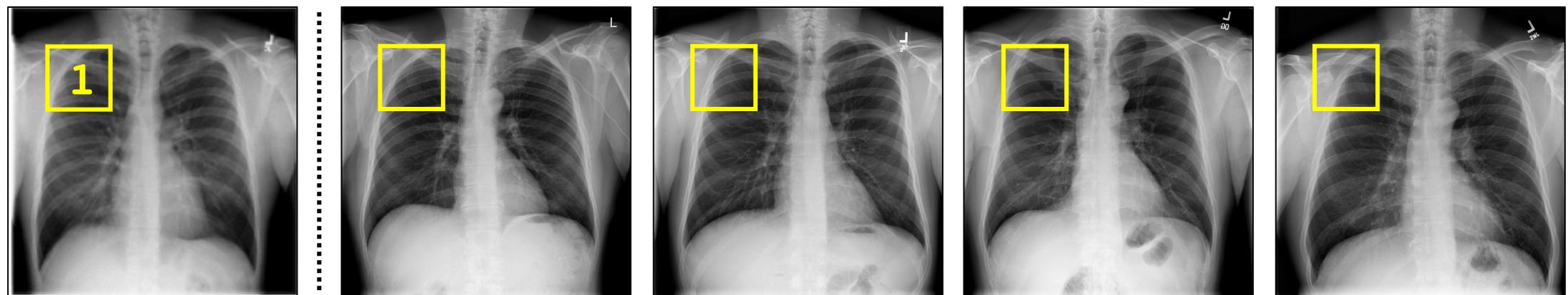
Self-discovery of anatomical patterns



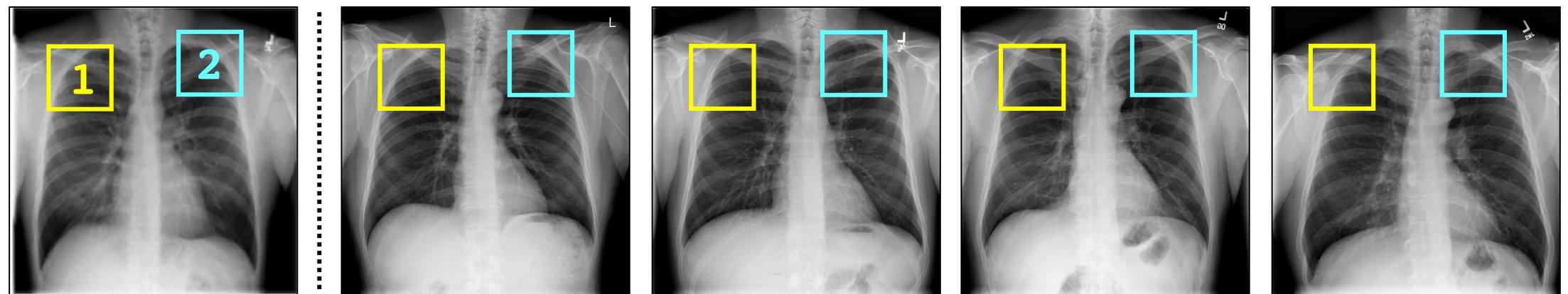
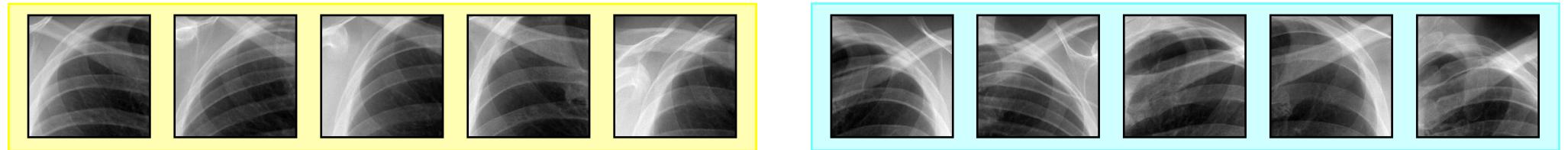
Self-discovery of anatomical patterns



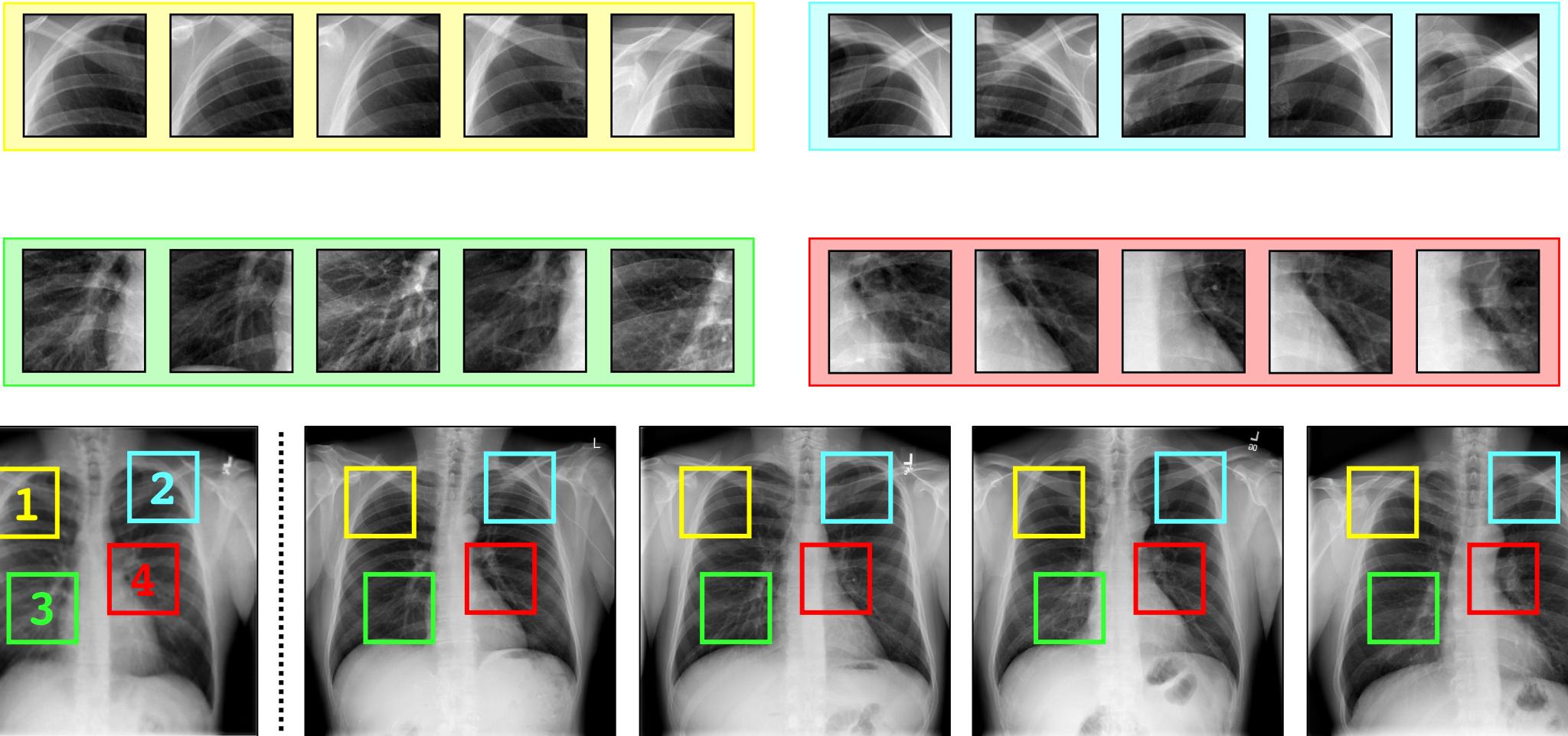
Self-discovery of anatomical patterns



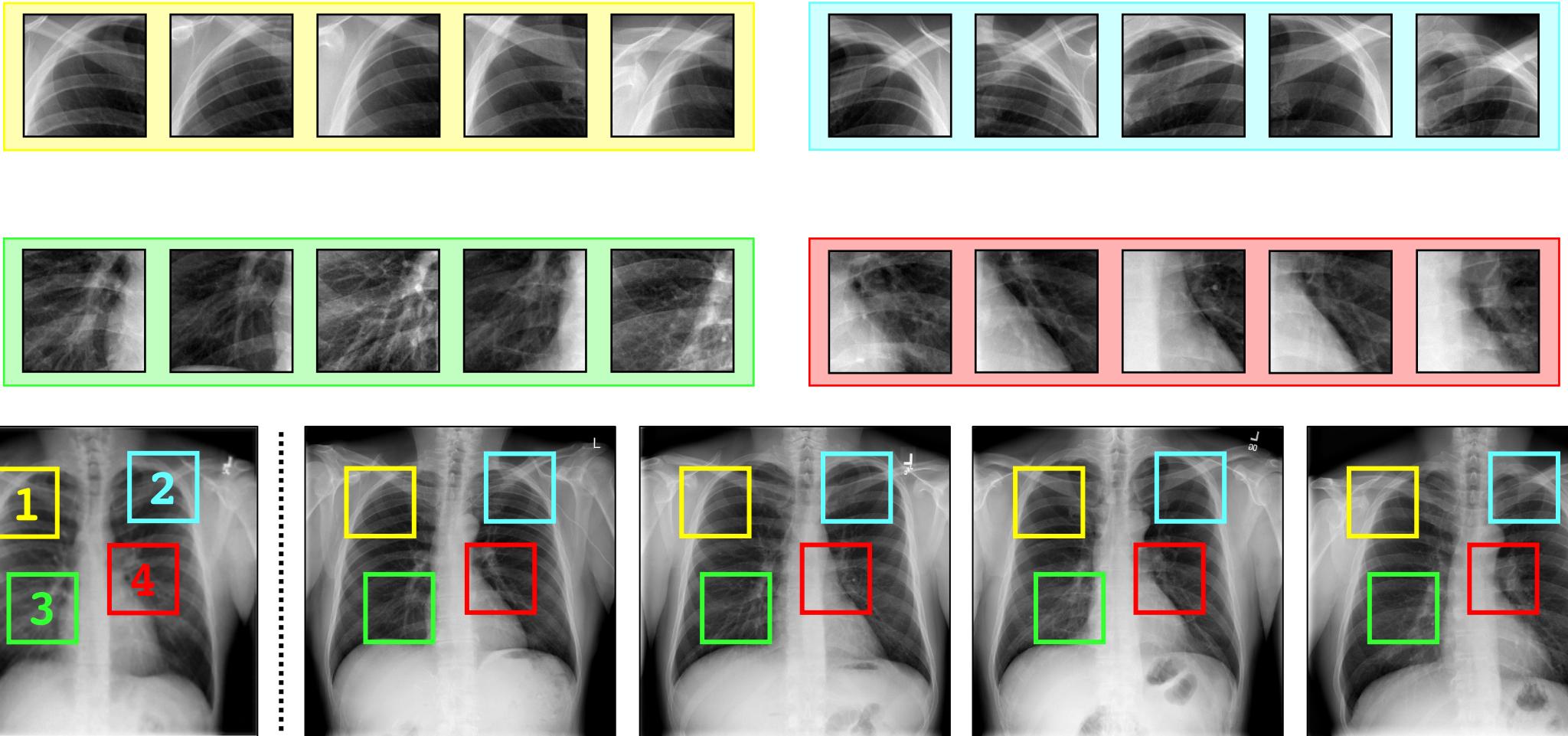
Self-discovery of anatomical patterns



Self-discovery of anatomical patterns



Self-discovery of anatomical patterns



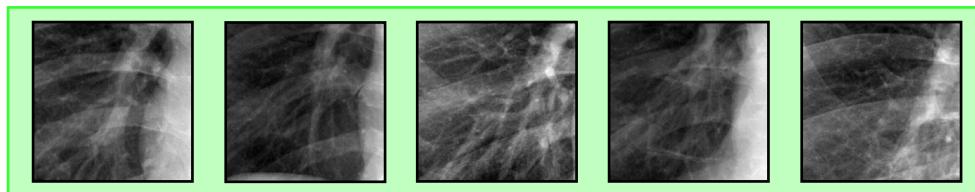
Self-discovery of anatomical patterns



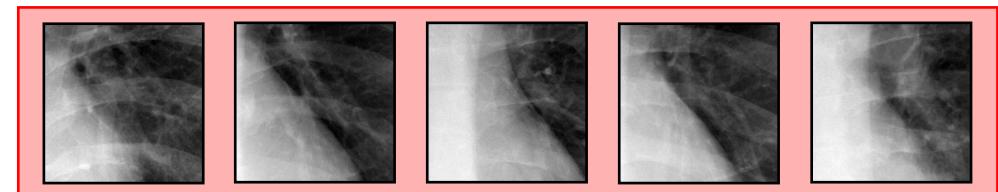
Anterior ribs 2–4



Anterior ribs 1–3



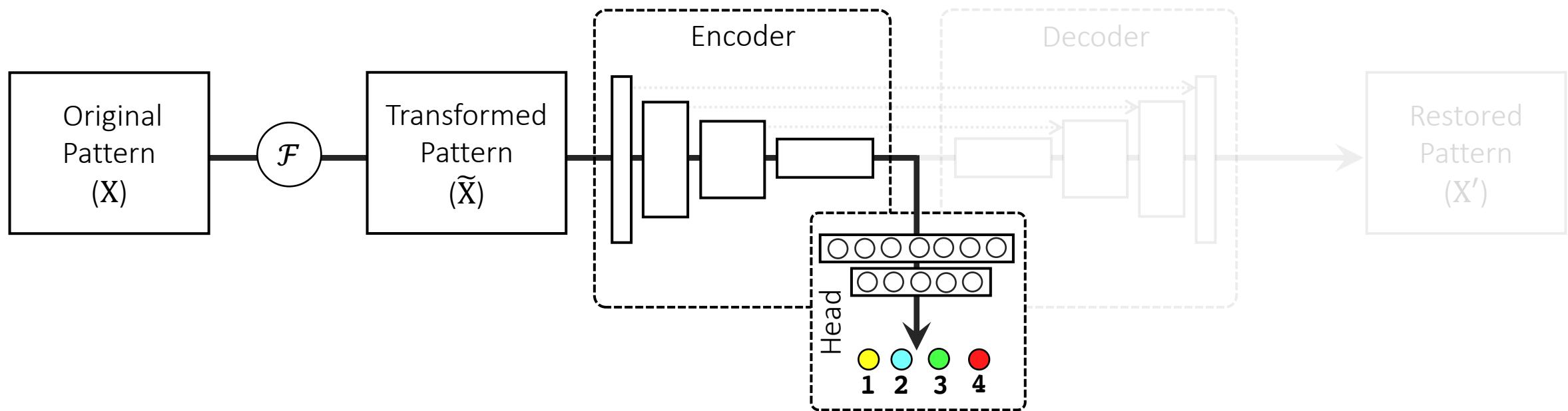
Right pulmonary artery



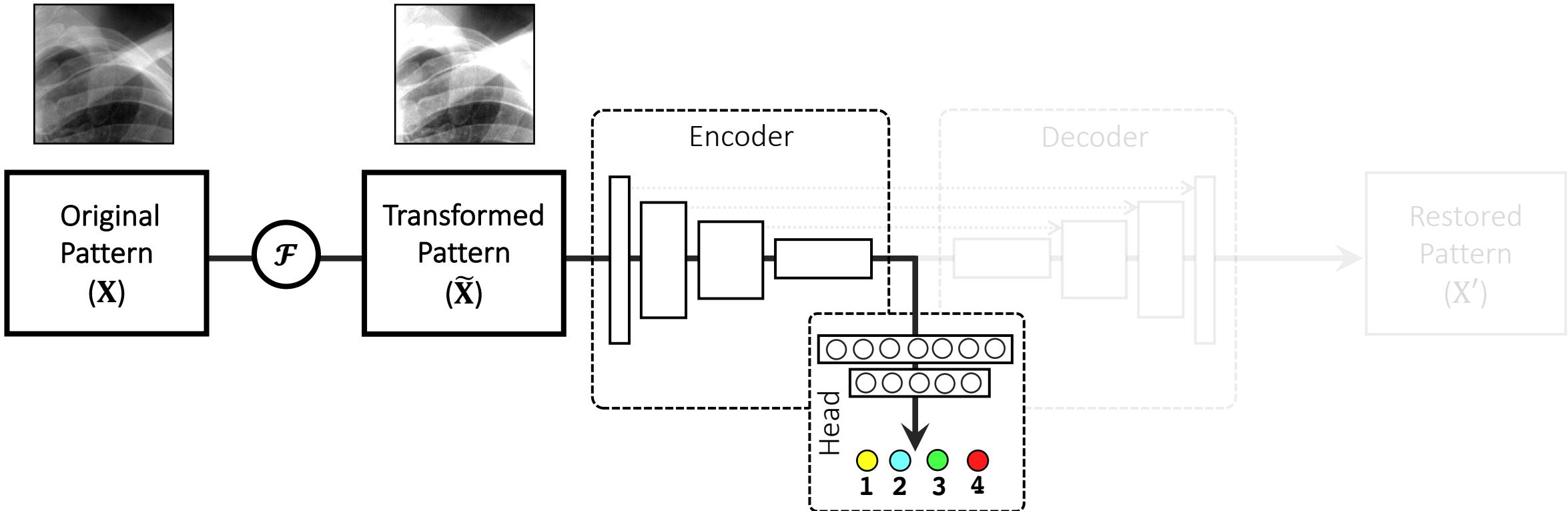
Left ventricular

Anatomical patterns carry rich semantic knowledge about the human body

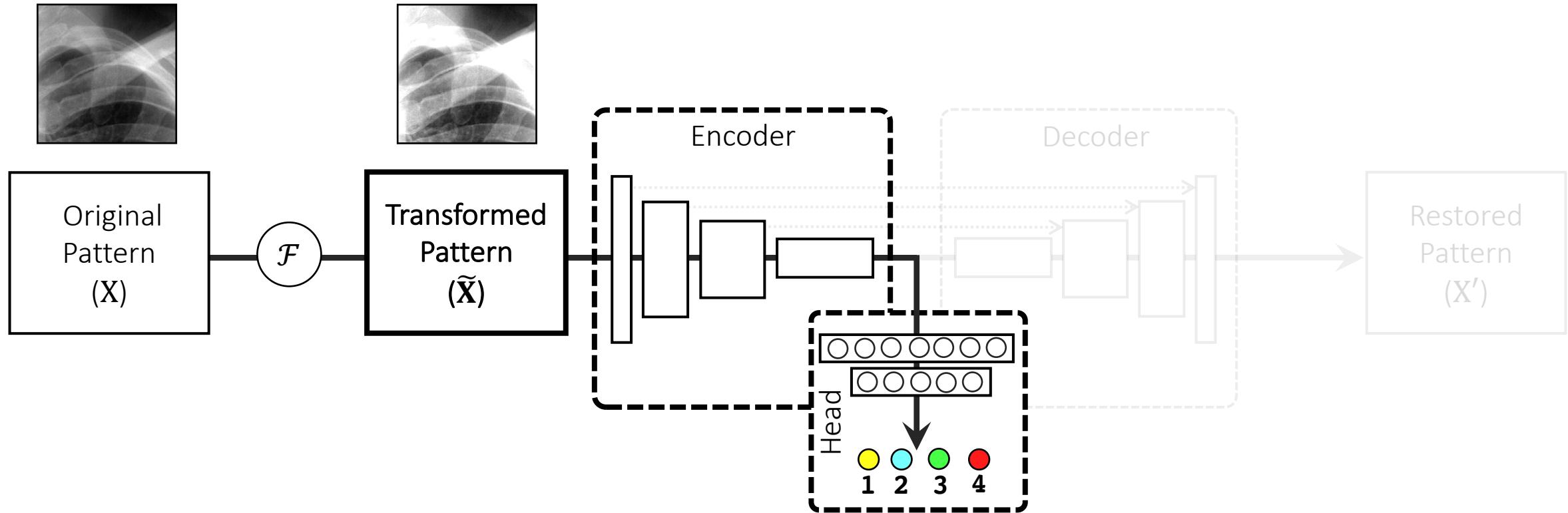
Self-classification of anatomical patterns



Self-classification of anatomical patterns

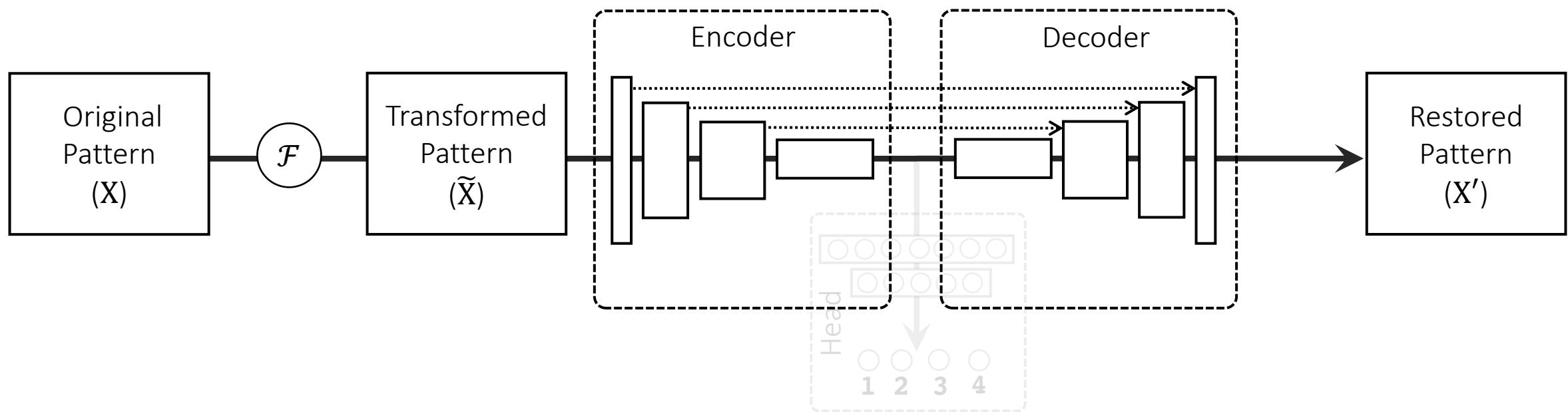


Self-classification of anatomical patterns

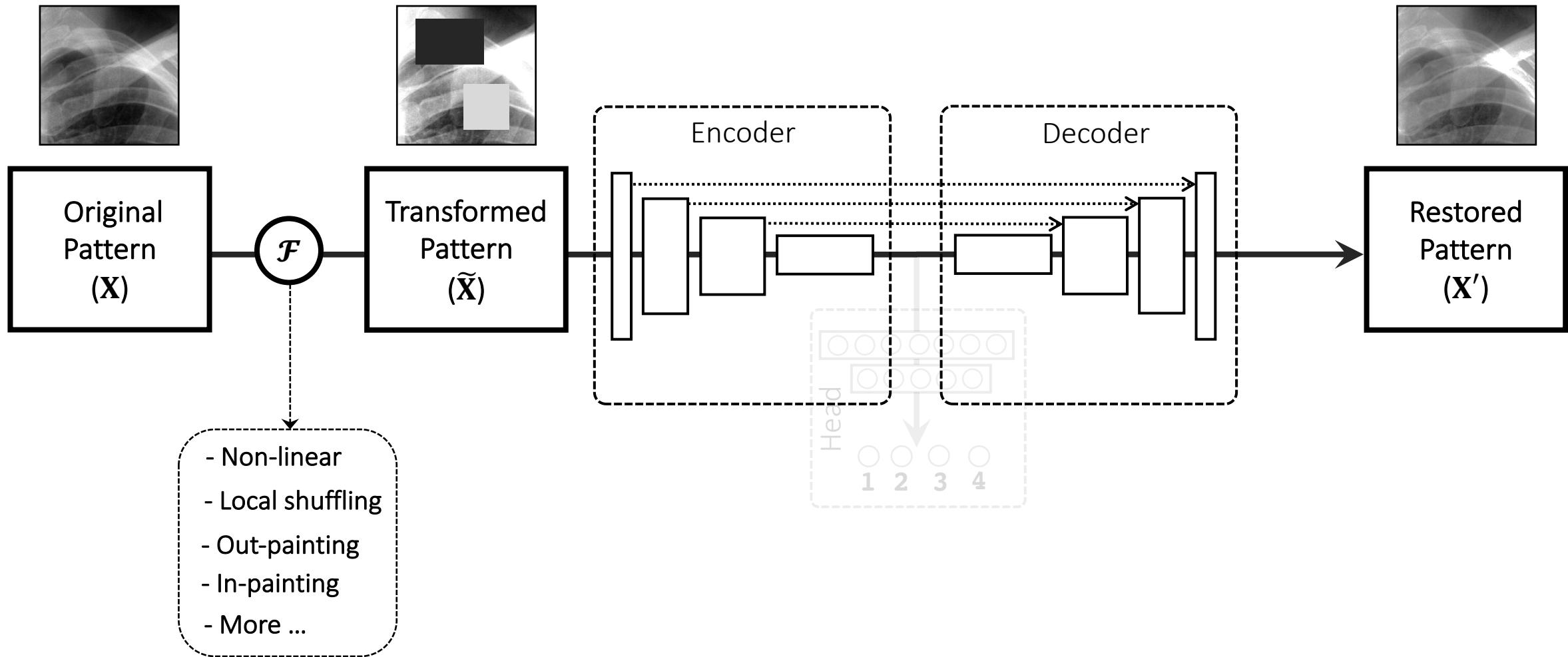


Learning semantics-enriched representations

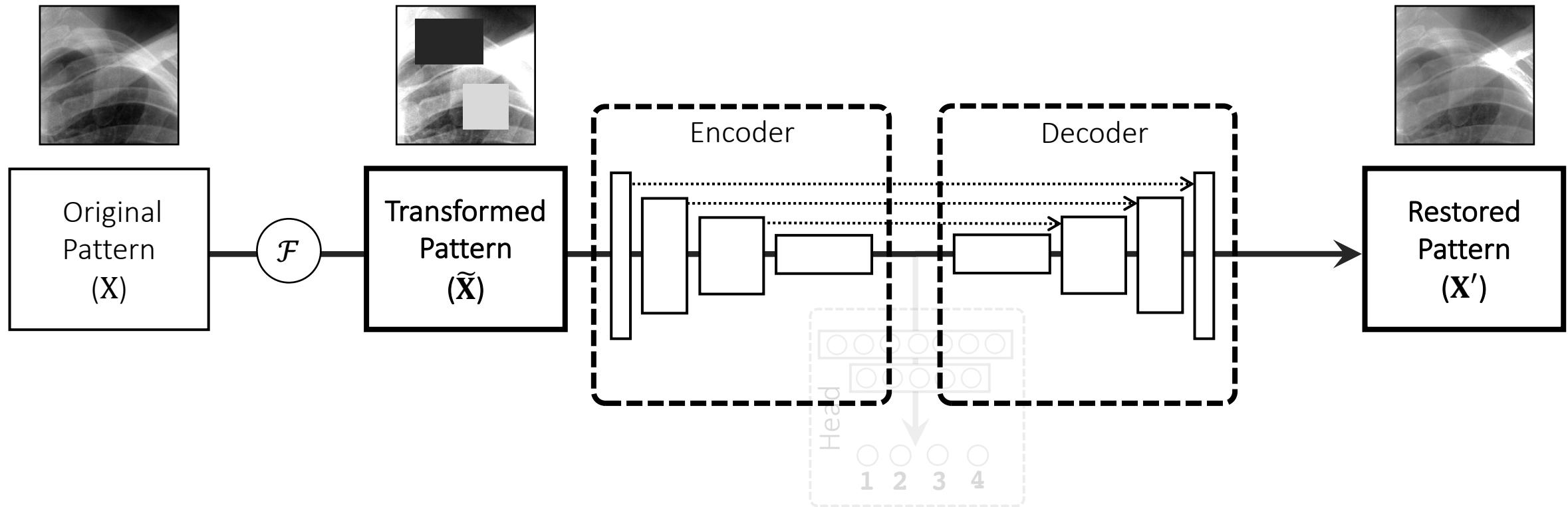
Self-restoration of anatomical patterns



Self-restoration of anatomical patterns

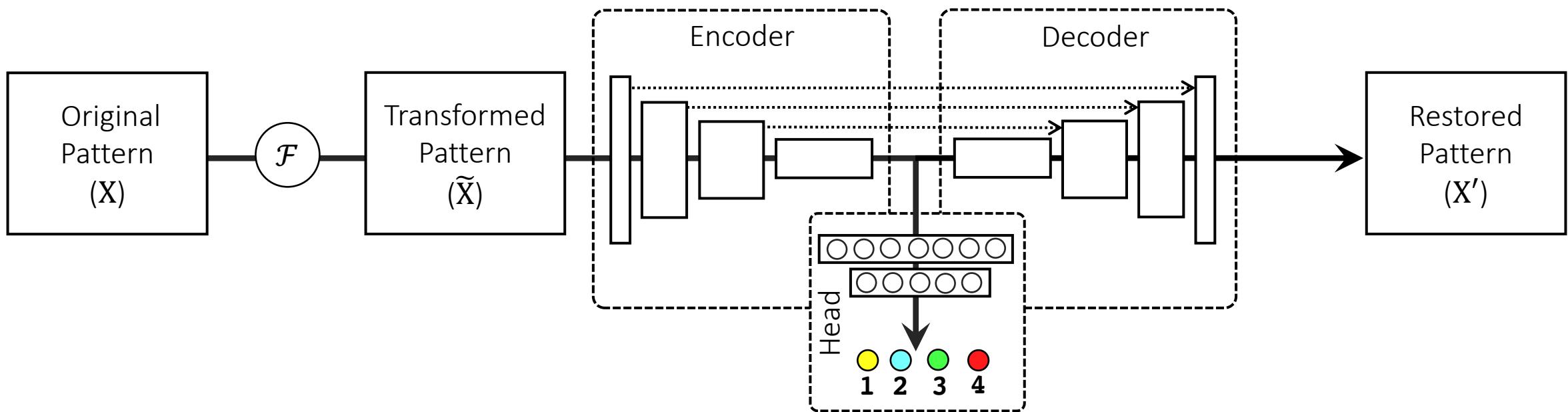


Self-restoration of anatomical patterns

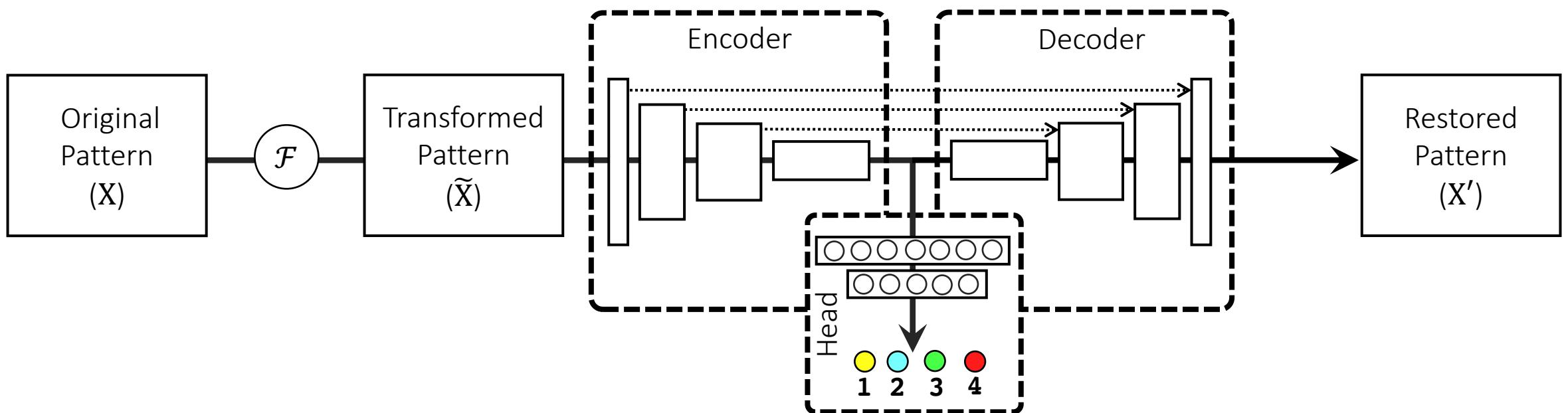


Learning from multiple perspectives

Semantic Genesis

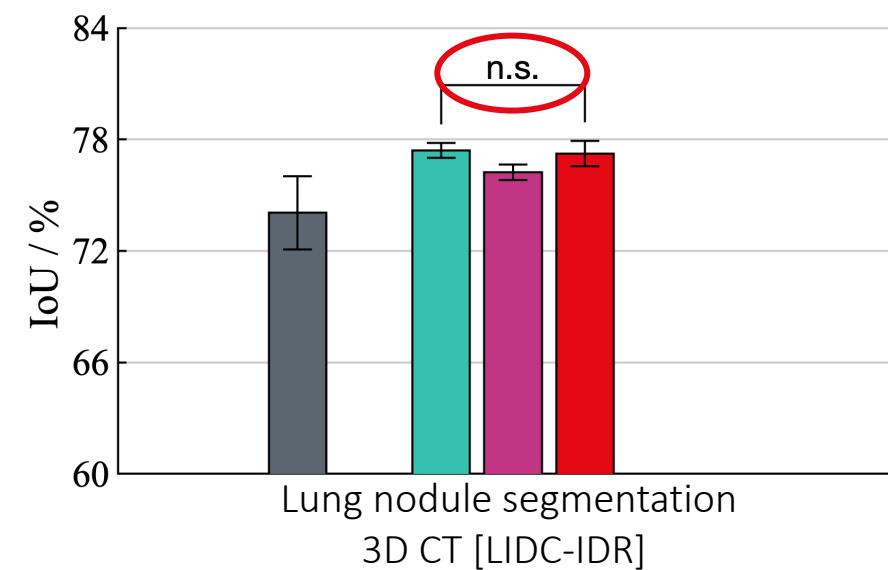
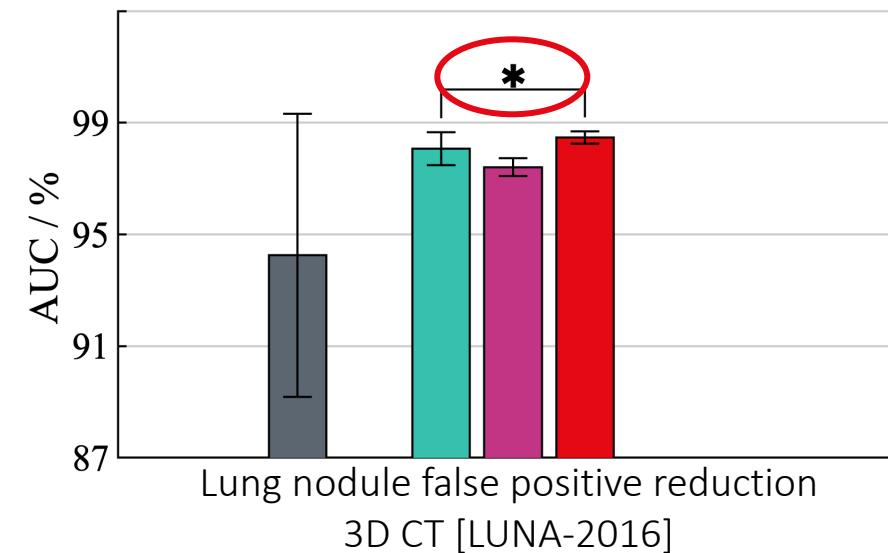
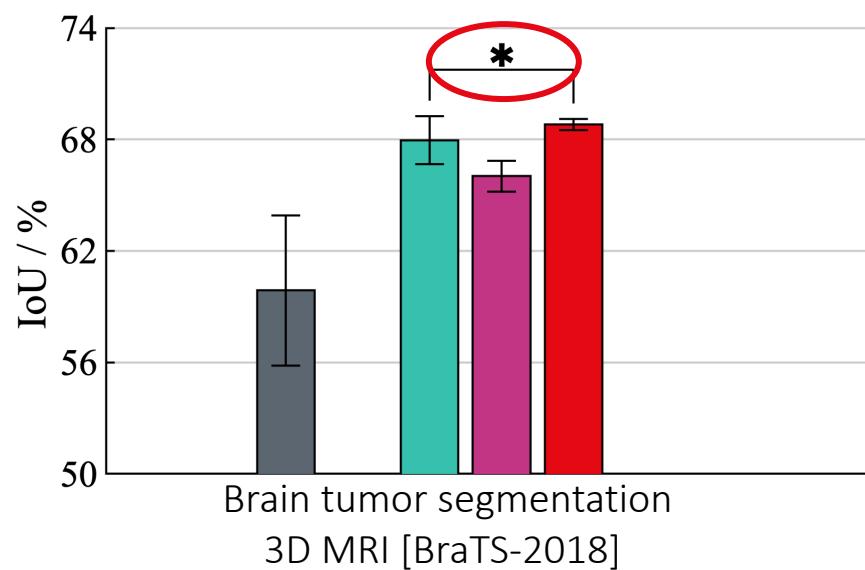
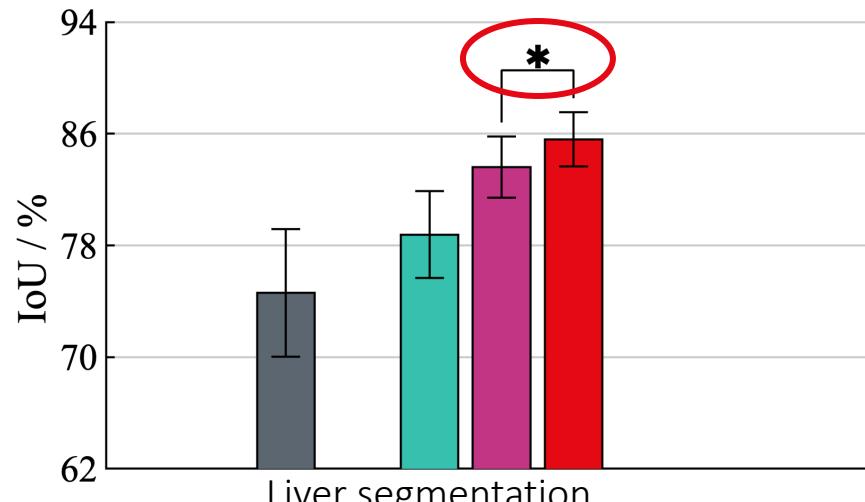


Semantic Genesis



Learning complementary representations

Self-classification and self-restoration learn complementary representations



n.s.	No Significance	
*	$p < 0.05$	n=10
**	$p < 0.01$	n=10
***	$p < 0.001$	n=10
>****	$p < 0.0001$	n=10



VS.

Models Genesis

Models Genesis



Random sub-volumes



No semantics

Semantic Genesis

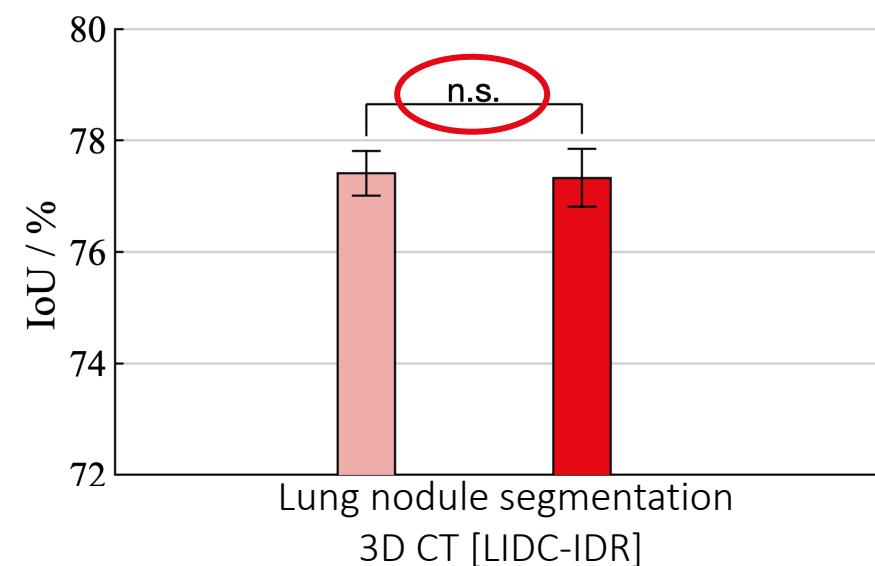
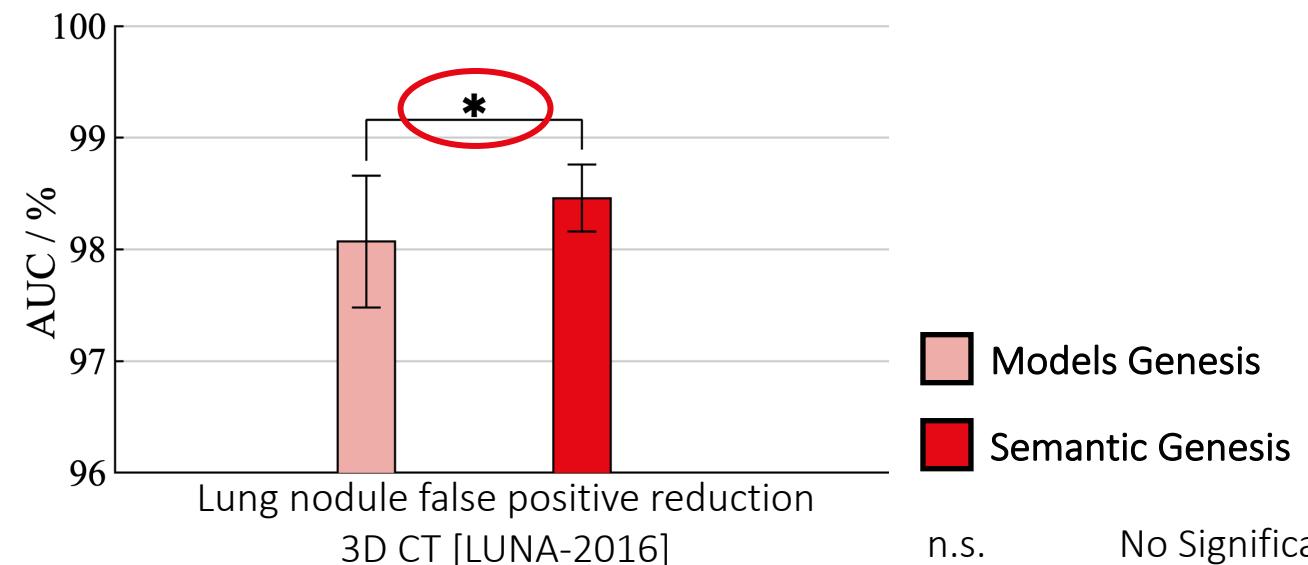
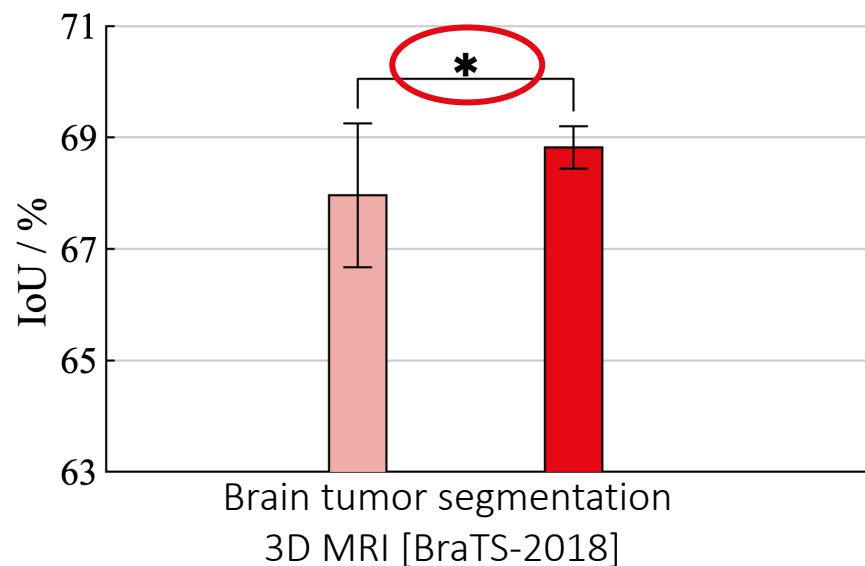
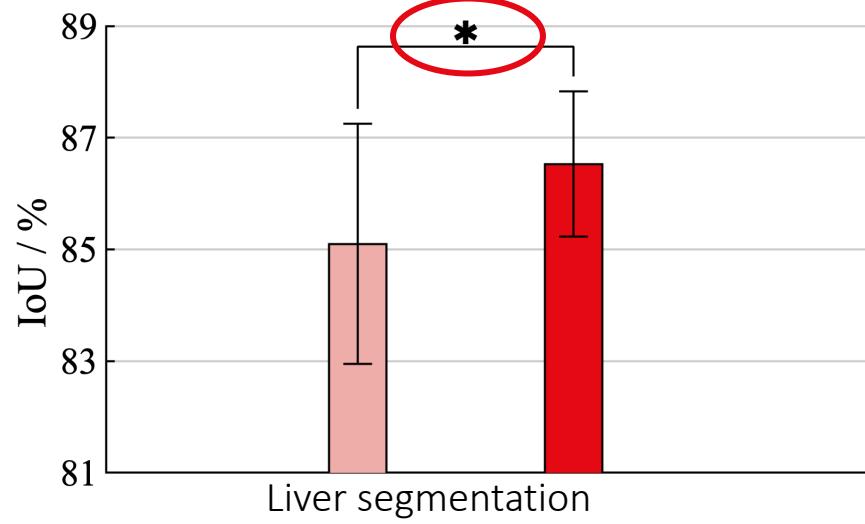


Consistent and recurrent anatomical patterns



Learns semantics

Result I: Semantic Genesis surpasses Models Genesis



Models Genesis
Semantic Genesis

n.s.	No Significance	
*	$p < 0.05$	n=10
**	$p < 0.01$	n=10
***	$p < 0.001$	n=10
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Models Genesis



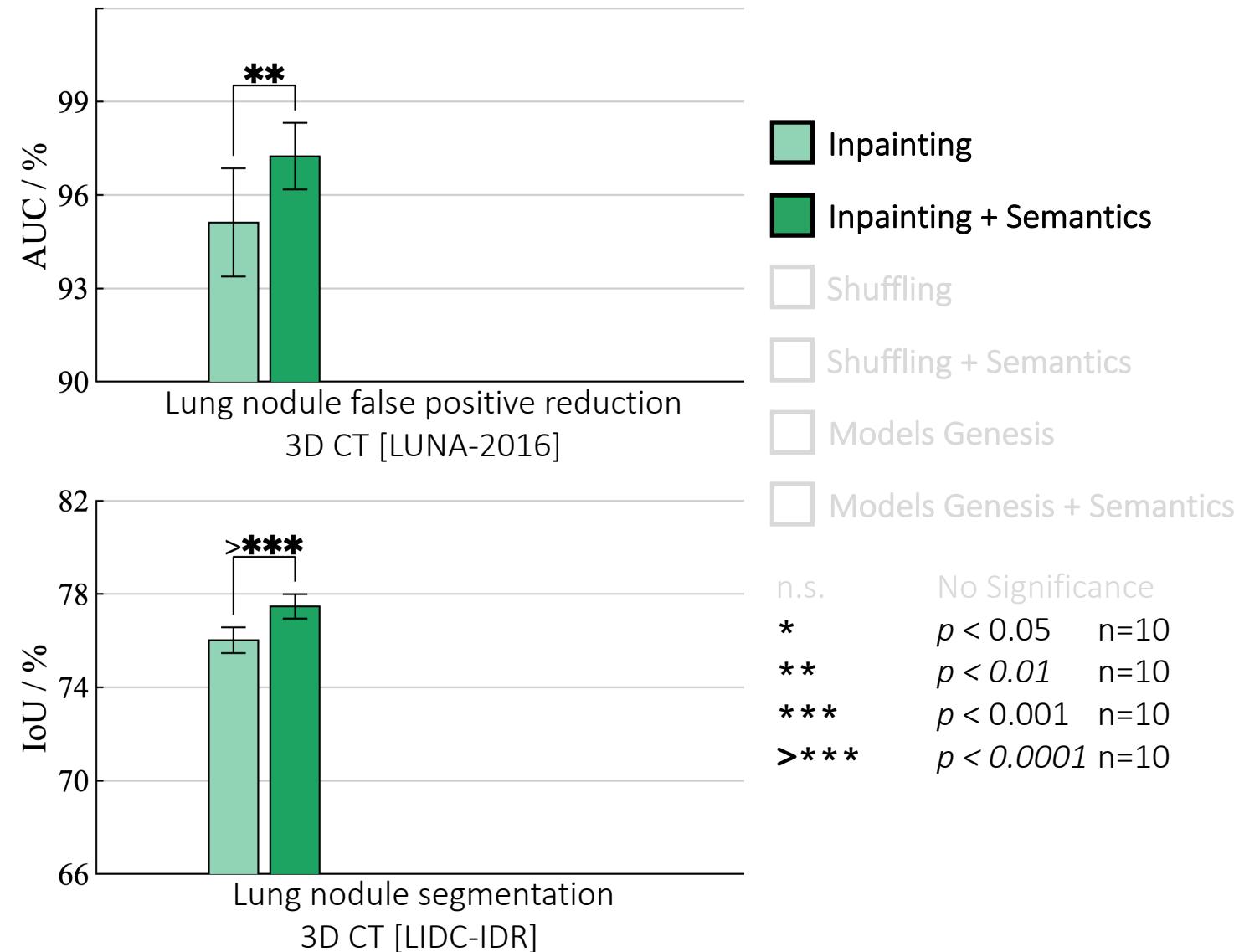
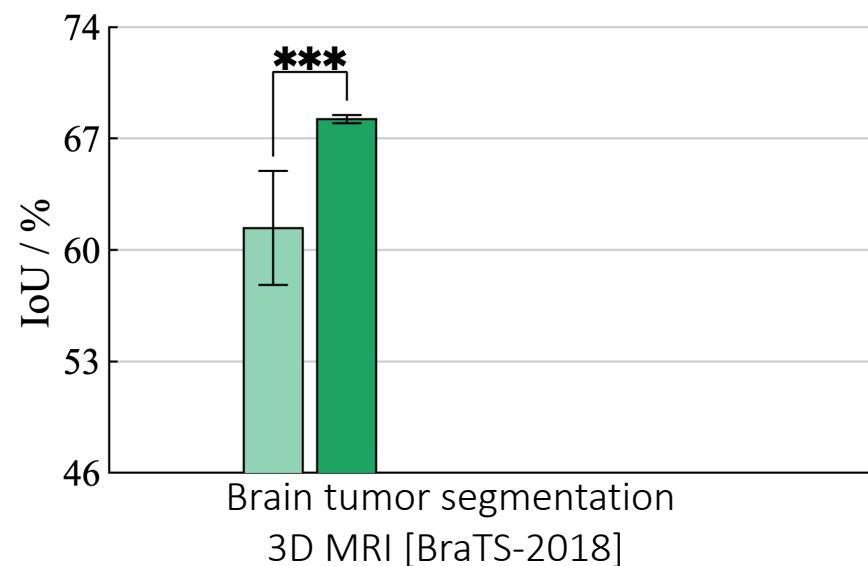
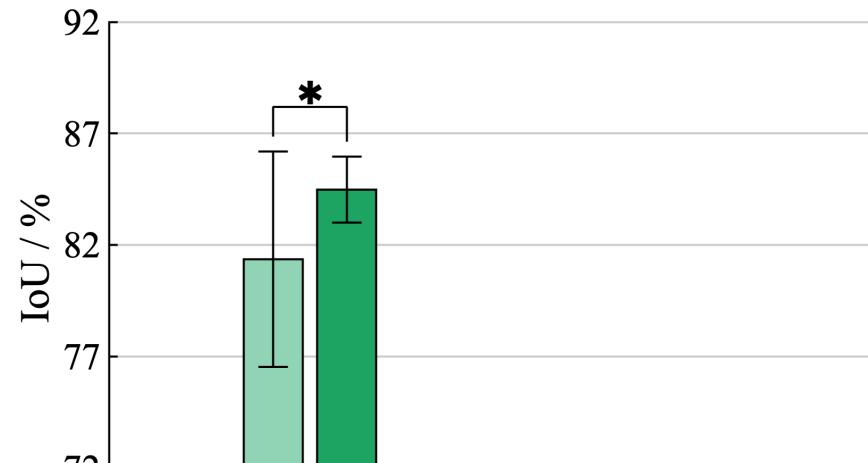
A self-supervised learning method

Semantic Genesis

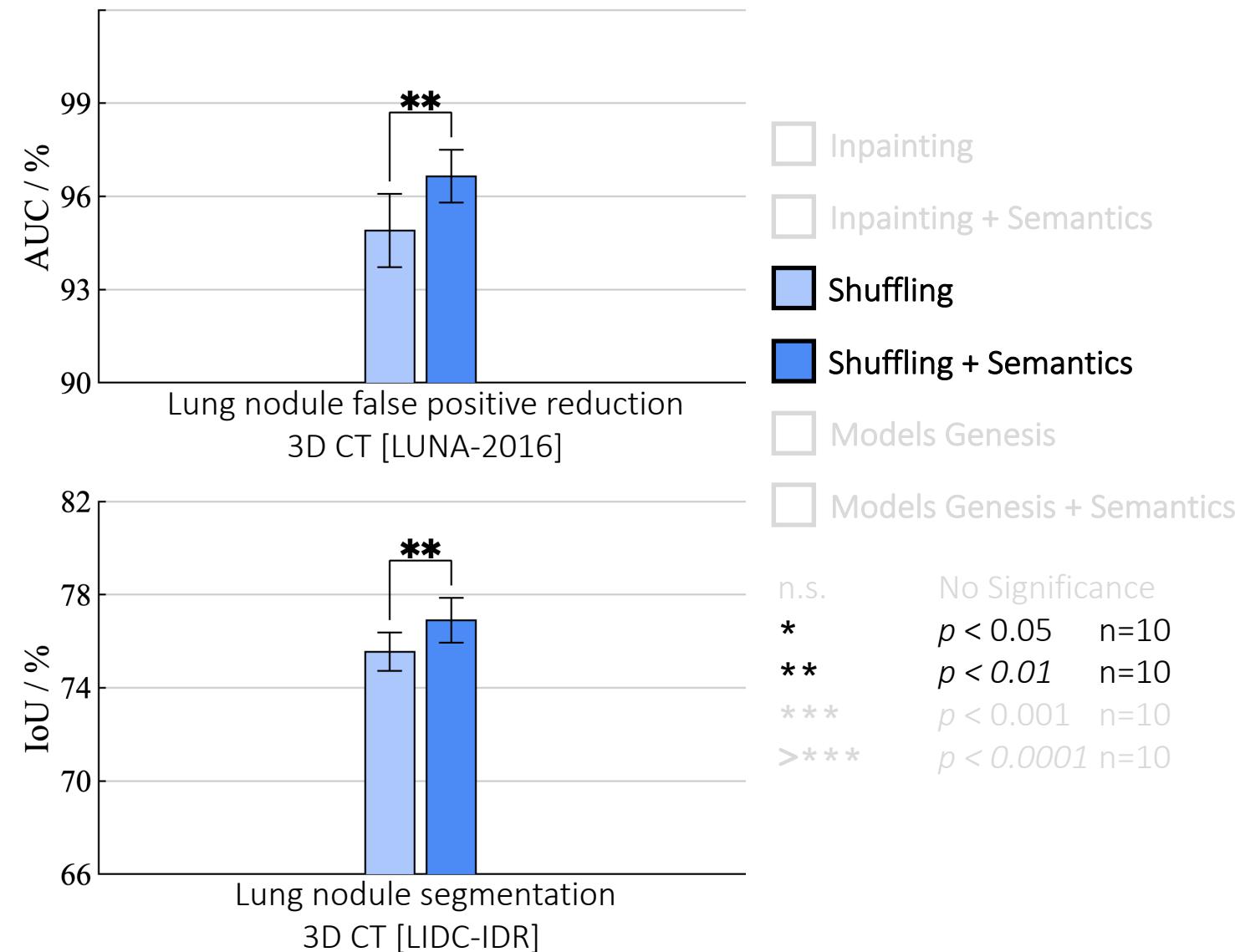
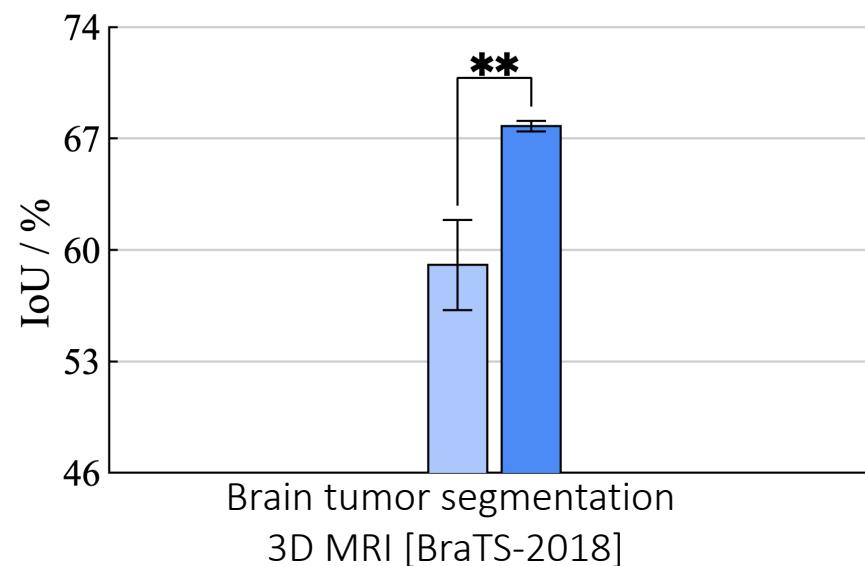
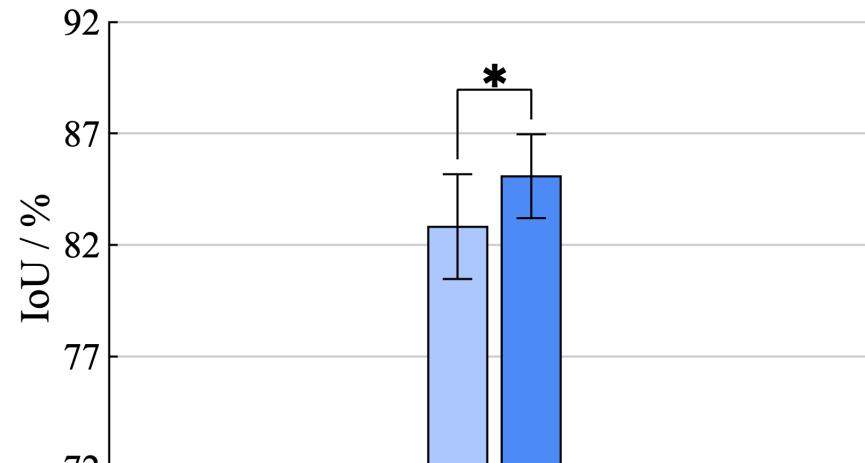


Enriching existing self-supervised methods

Result II: Learning semantics enriches existing self-supervised learning approaches

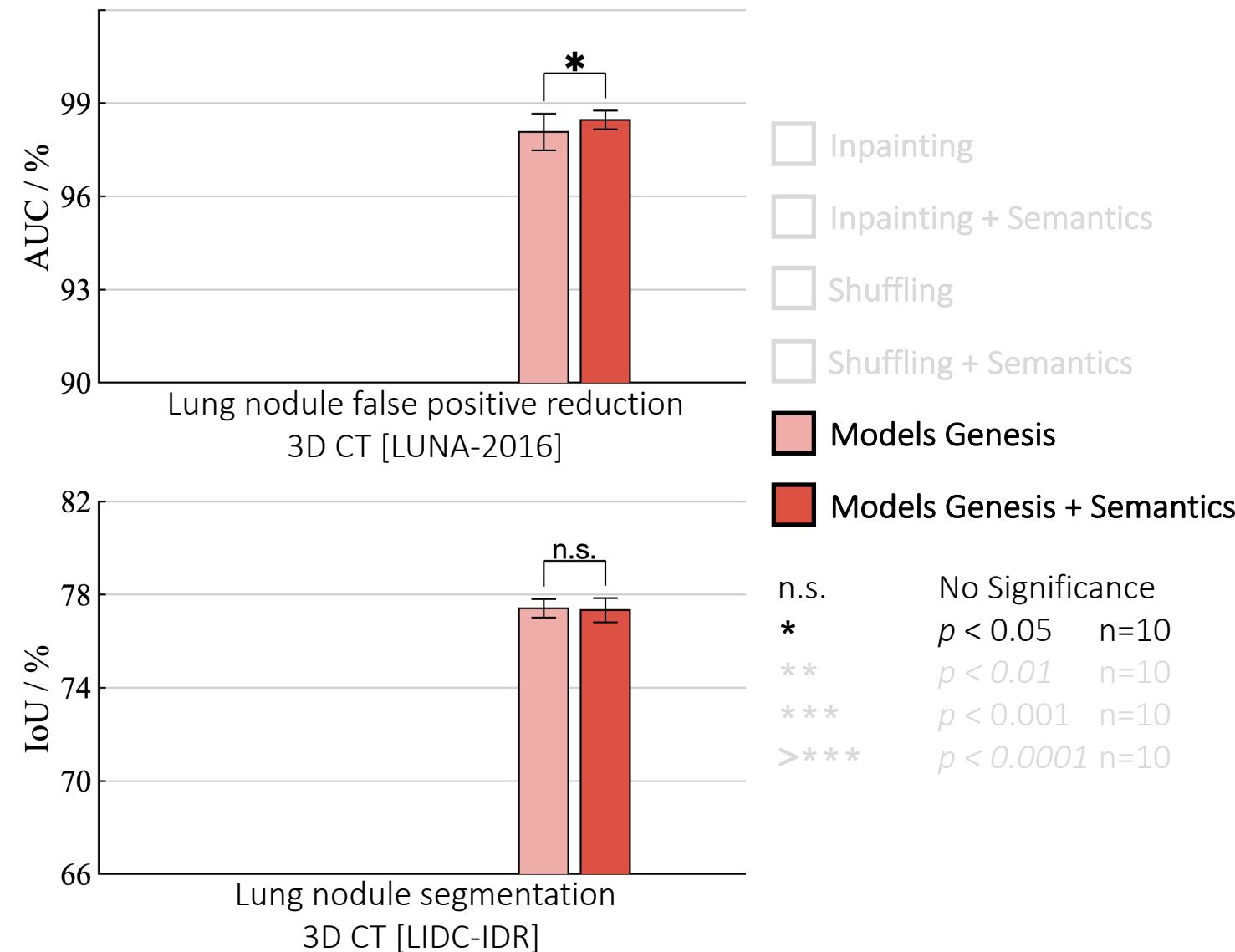
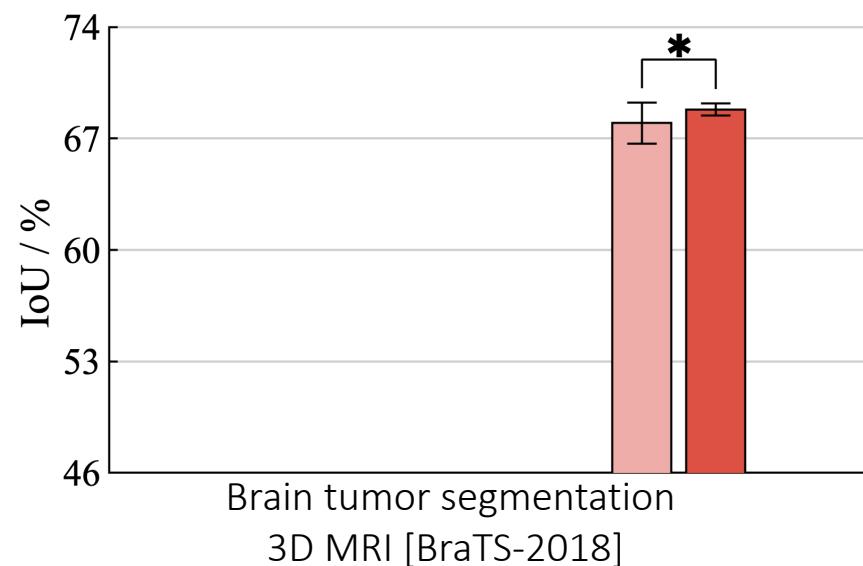
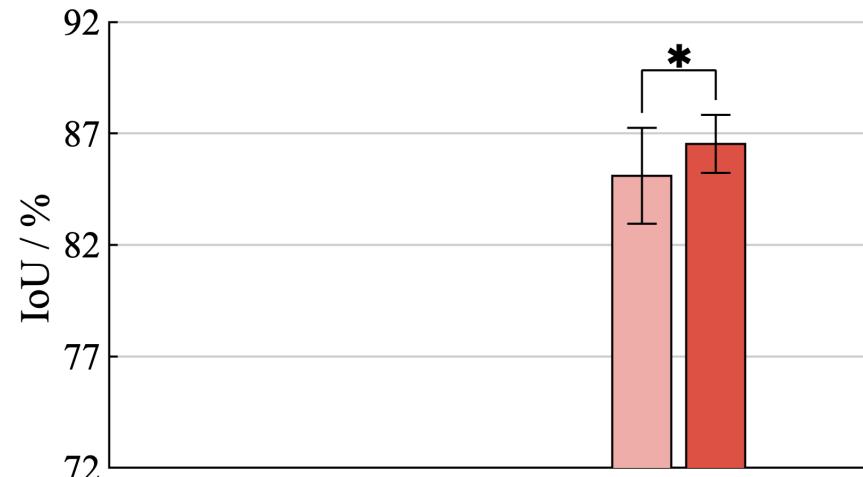


Result II: Learning semantics enriches existing self-supervised learning approaches



n.s. No Significance
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Result II: Learning semantics enriches existing self-supervised learning approaches



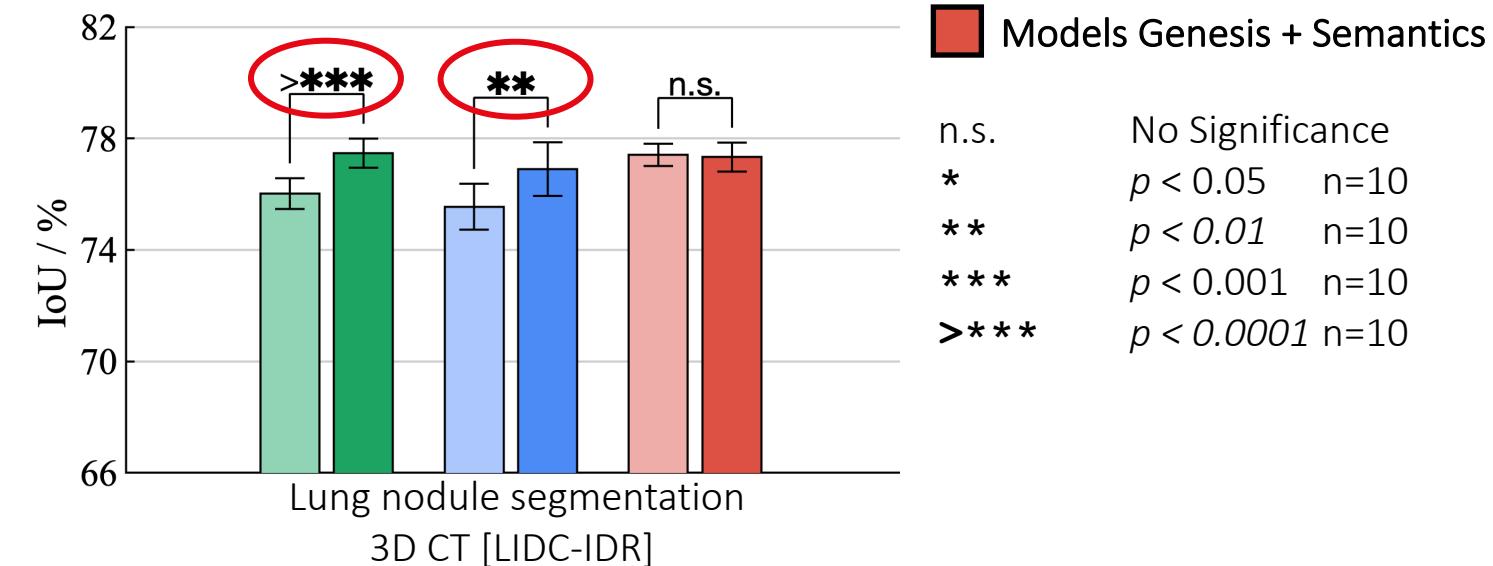
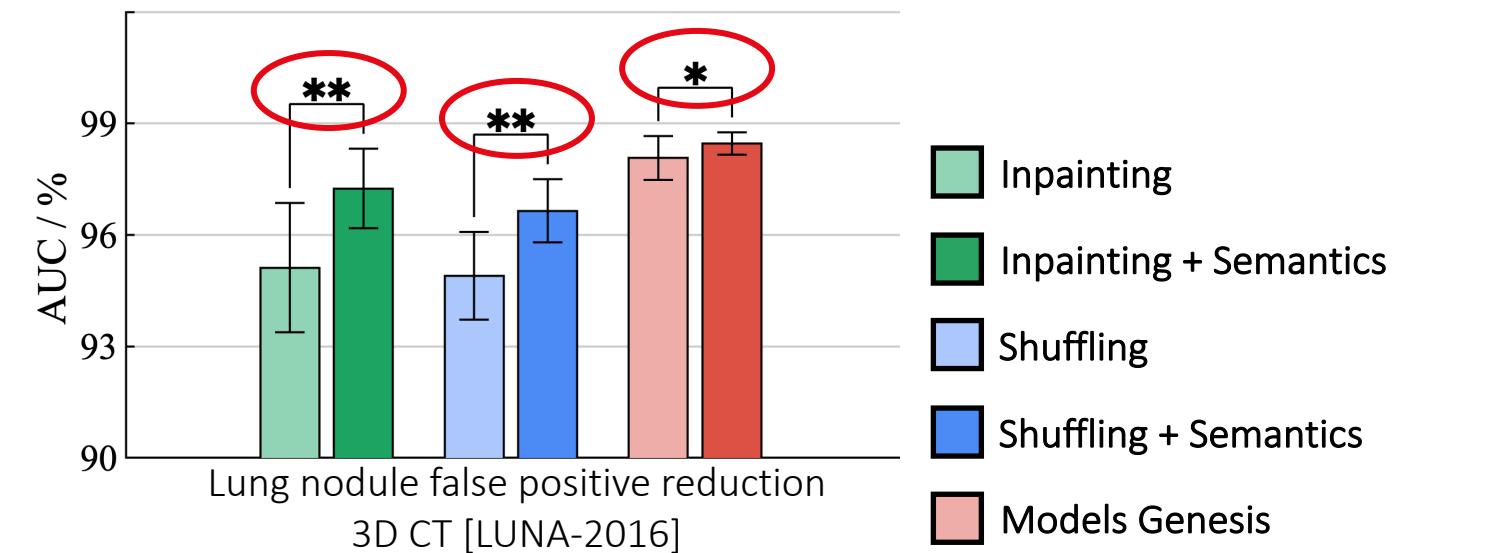
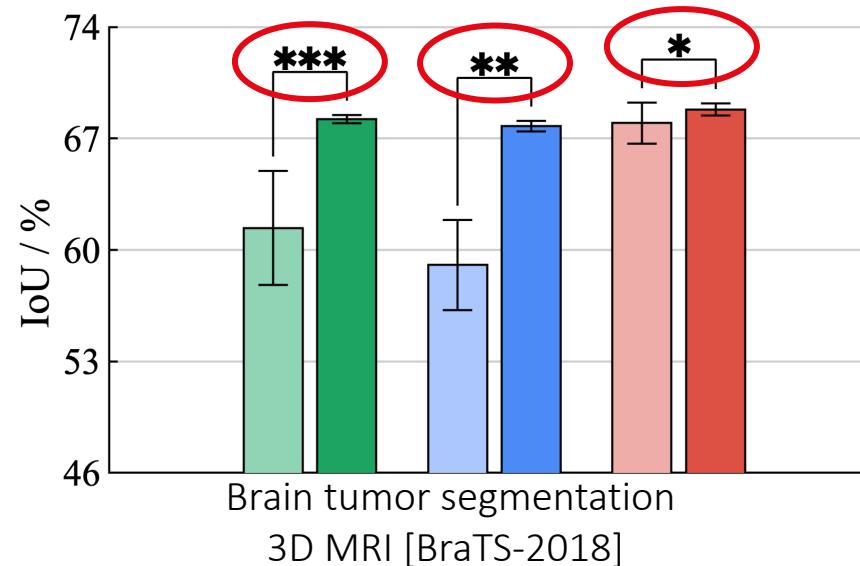
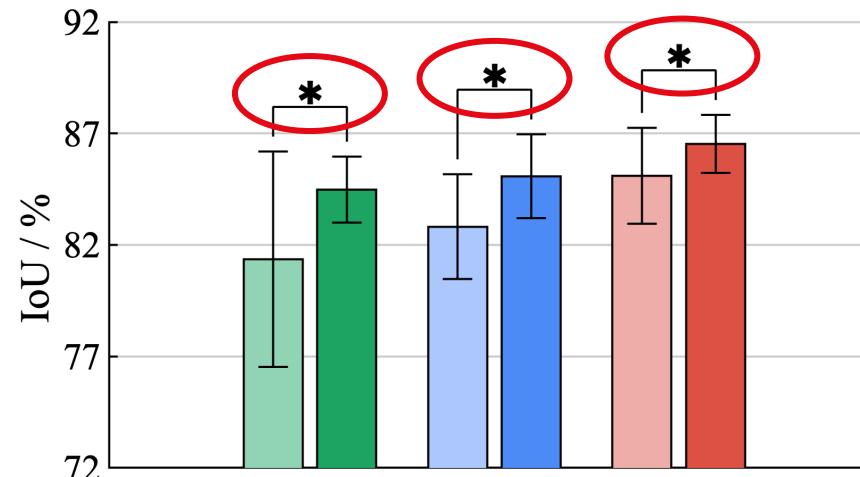
Legend:

- Inpainting
- Inpainting + Semantics
- Shuffling
- Shuffling + Semantics
- Models Genesis
- Models Genesis + Semantics

Significance levels:

- n.s. No Significance
- * $p < 0.05$ n=10
- ** $p < 0.01$ n=10
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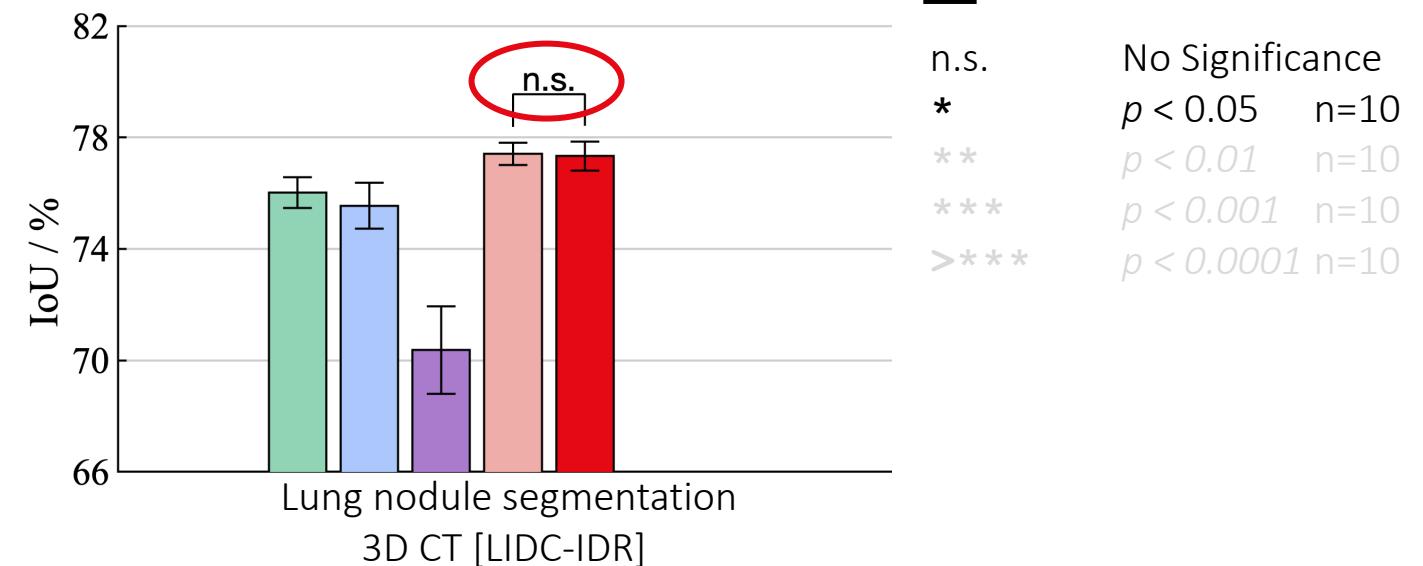
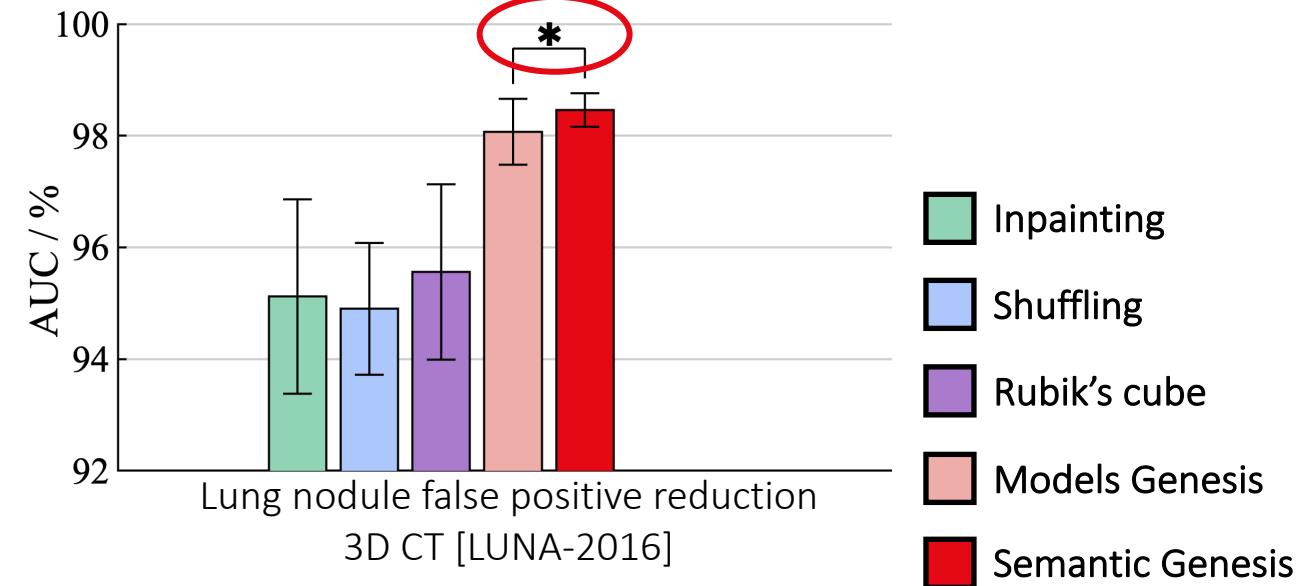
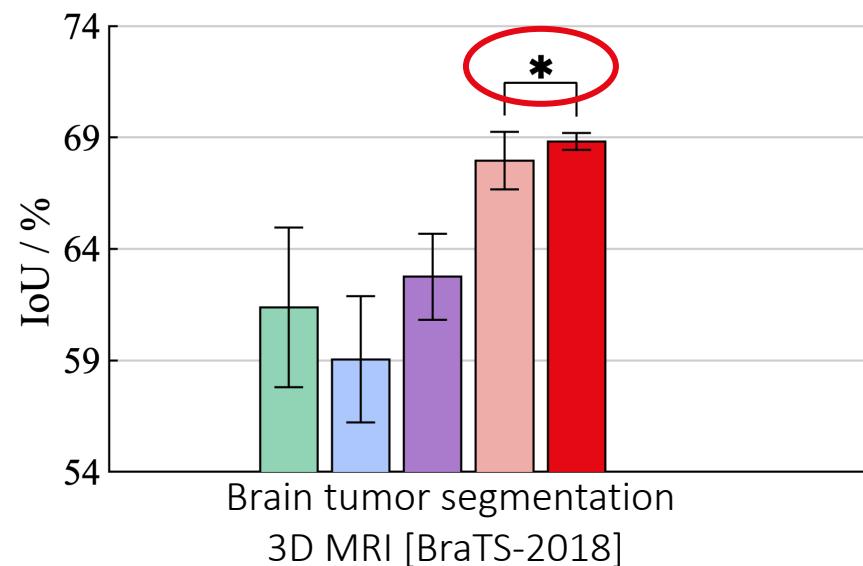
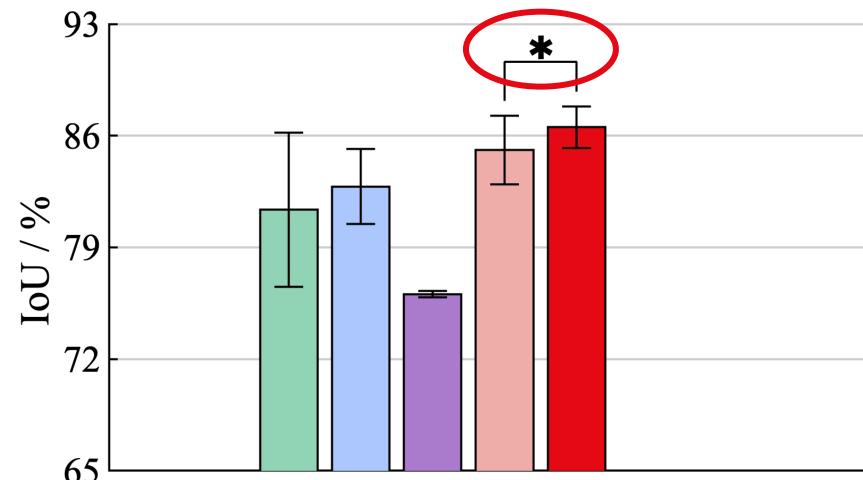
Result II: Learning semantics enriches existing self-supervised learning approaches



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Semantic Genesis outperforms existing pre-trained models
for 3D Medical Image Analysis

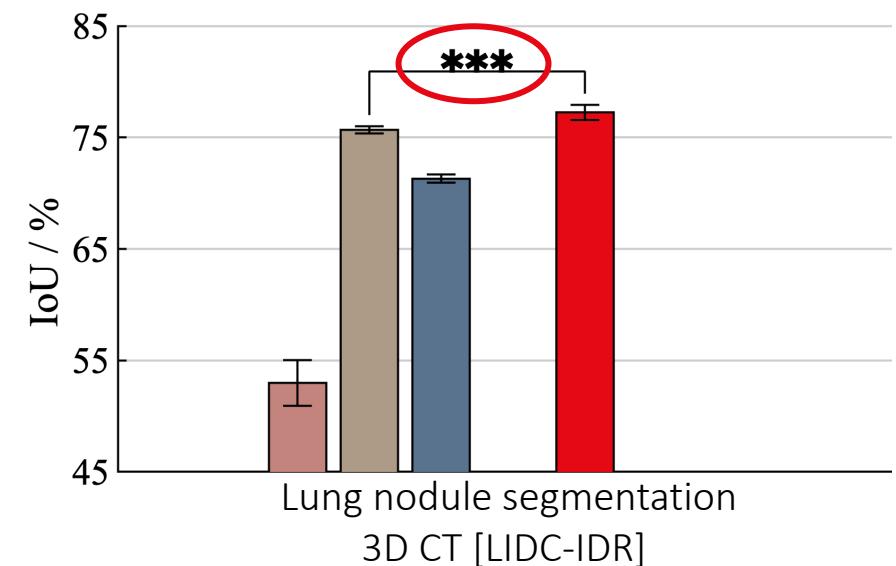
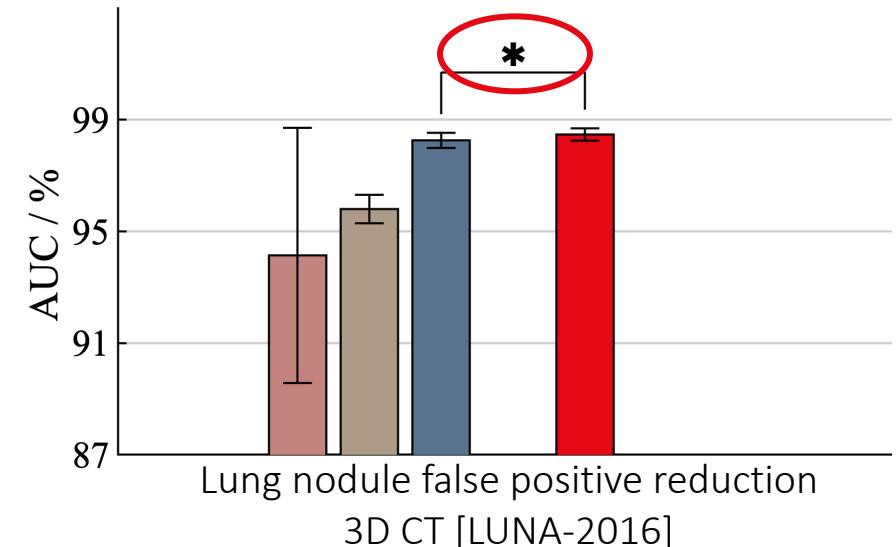
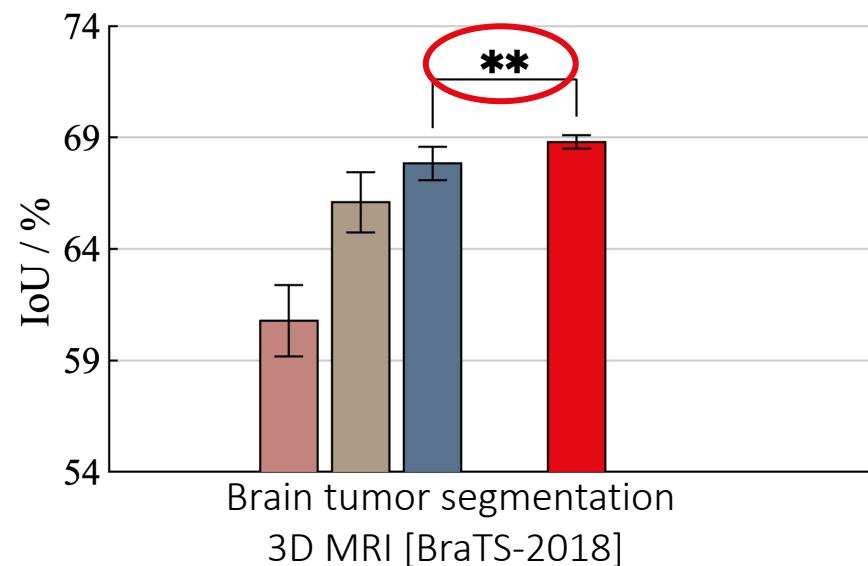
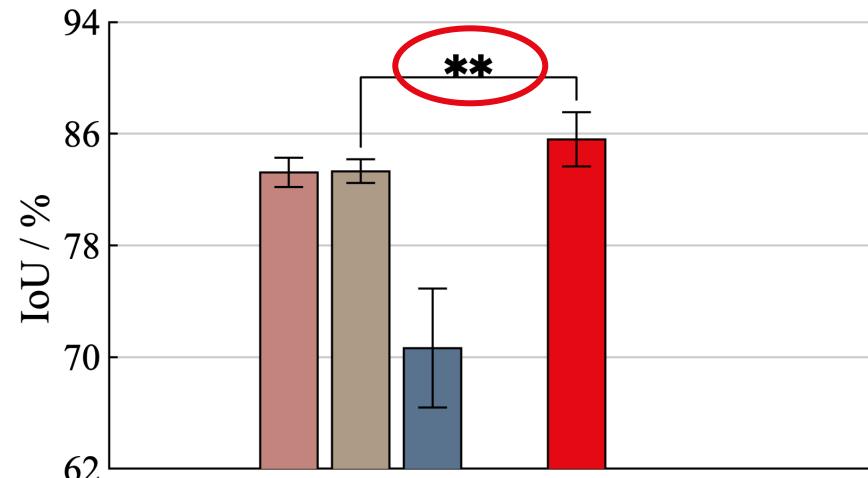
Result III: Semantic Genesis outperforms self-supervised pre-trained 3D models



Inpainting
Shuffling
Rubik's cube
Models Genesis
Semantic Genesis

n.s. No Significance
* $p < 0.05$ n=10
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>**** $p < 0.0001$ n=10

Result IV: Semantic Genesis outperforms supervised pre-trained 3D models



NiftyNet
MedicalNet
Inflated 3D (I3D)
Semantic Genesis

n.s.
* $p < 0.05$ n=10
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*** $p < 0.001$ n=10
>**** $p < 0.0001$ n=10

Semantic Genesis is superior to:

- ➊ 3D models trained from scratch
- ➋ 3D self-supervised pre-trained models
- ➌ 3D supervised pre-trained models



Semantic Genesis

Poster session

Tuesday, October 6
09:30 – 11:00 MST

Poster Session 4

Try it for yourself

Code, data, and models
are available online



github.com/JLiangLab/SemanticGenesis