

Unet beats CNN in topology optimization

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Final project: Deep Learning

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How to create lighter and safer structures ?

❖ How to create optimal designs:

- ✓ As lightweight as possible
- ✓ Strong enough to ensure safety



Bridge

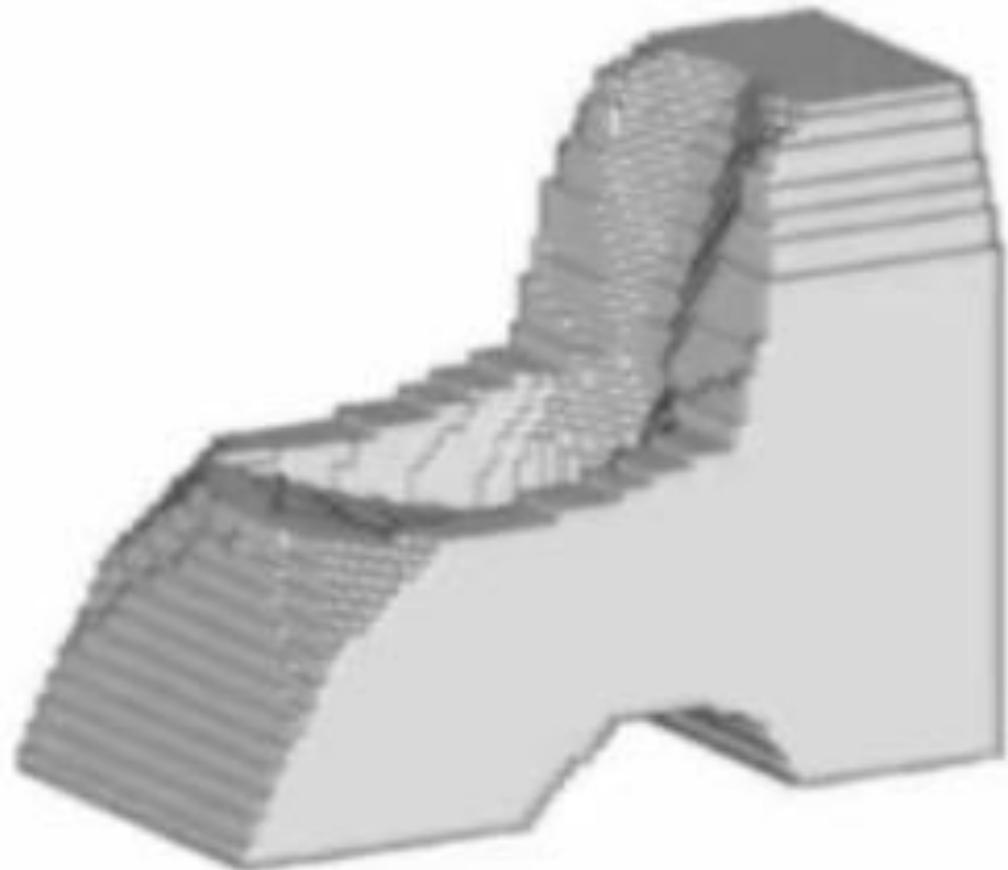
www.usa.skanska.com



Aircraft wings

<https://pilotinstitute.com/>

Topology optimization



Topology
optimization



Topology optimization process

Optimal design

Applications of topology optimization

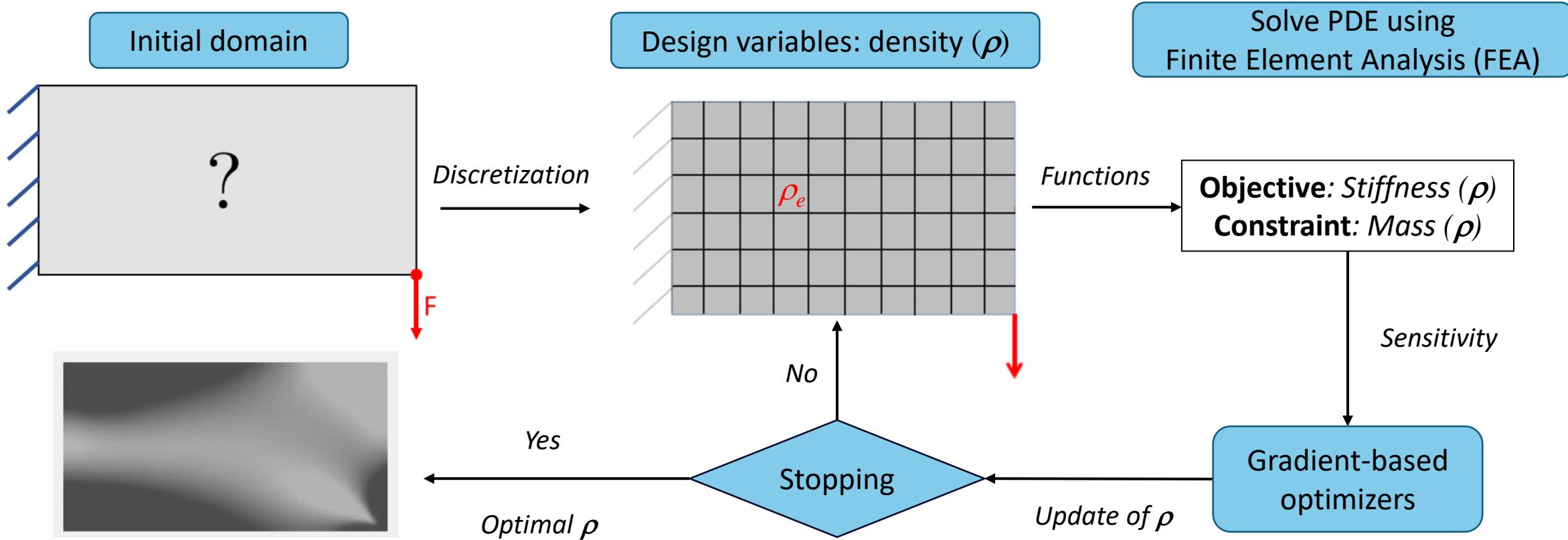


Optimal bridge design



Airbus uses topology optimization in aircraft wings
to save 1000 kg of weight

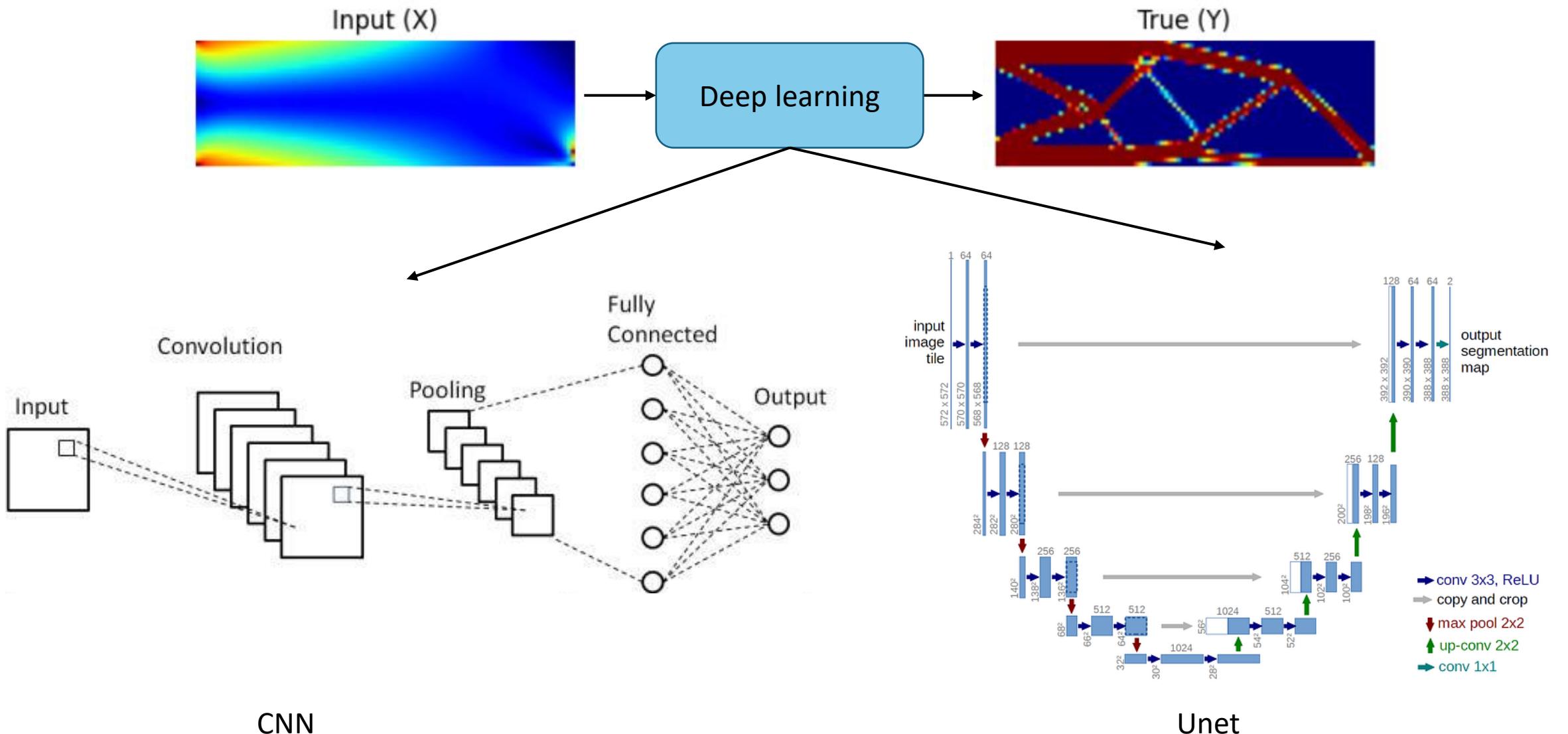
Challenges in Topology Optimization



- 03 main challenges in Topology Optimization (TO)

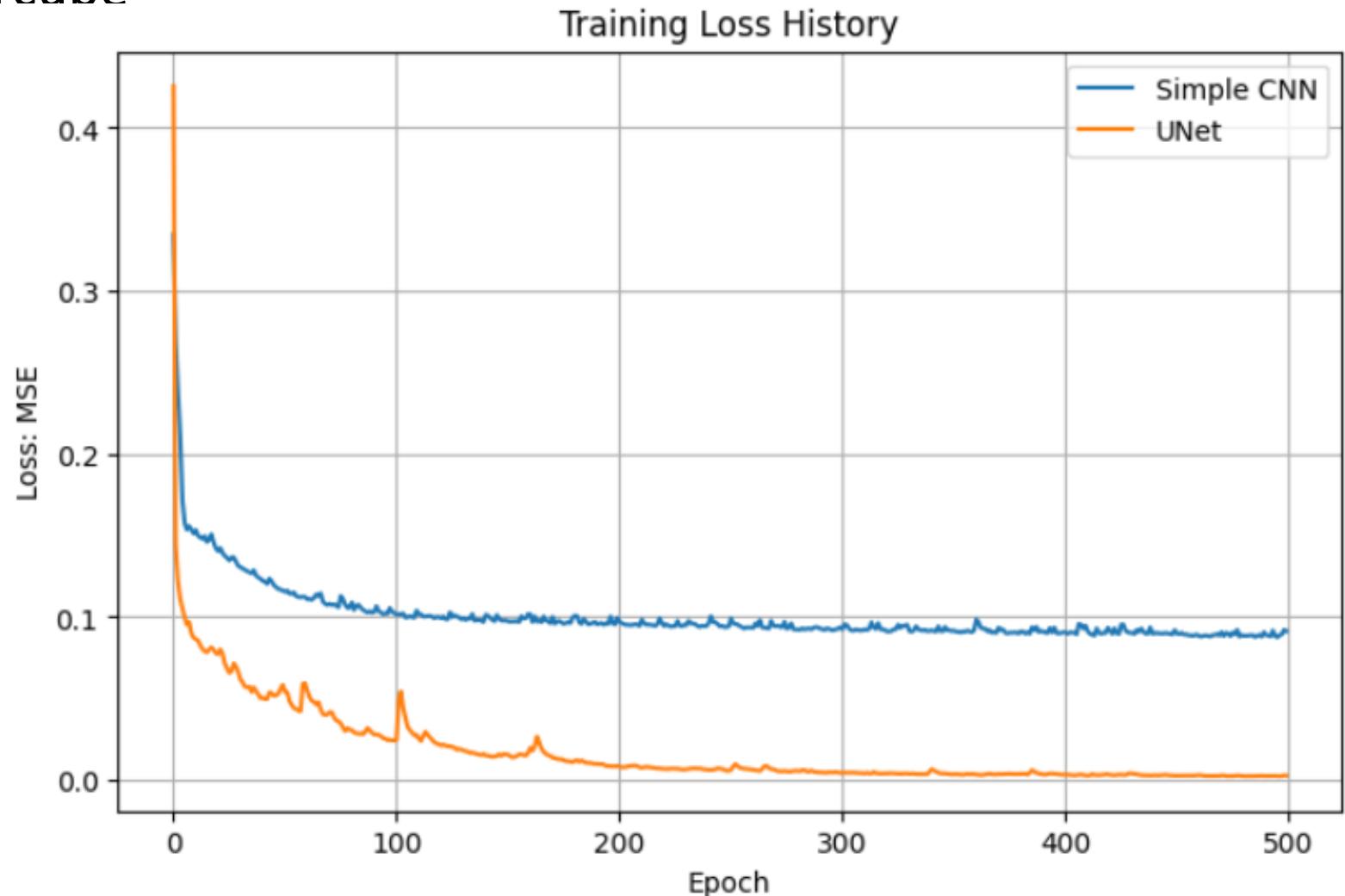
- *Solving PDE: Expensive*
- *Gradients: Error prone + Time consuming*
- *Iterative process: Expensive*

Proposed deep learning



Dataset and Training

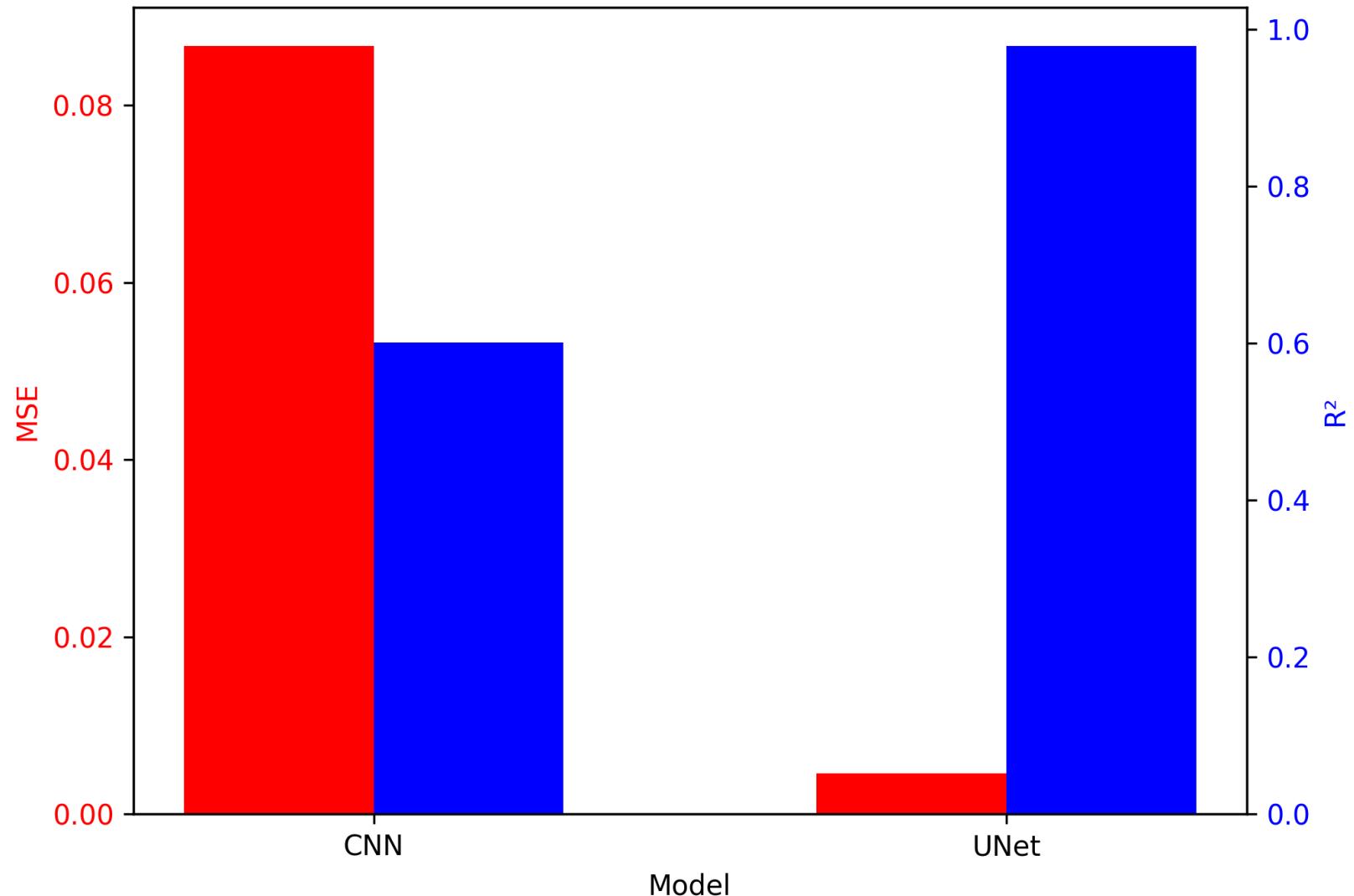
- ❖ 200 training: Latin Hypercube
- ❖ Input: 01 channel
- ❖ Output: 01 channel
- ❖ Parameters:
 - ✓ Stride = 1
 - ✓ Padding = 1
 - ✓ Learning rate = 1e-3
- ❖ Loss function: MSE
- ❖ Training time
 - ✓ CNN = 120s
 - ✓ Unet = 945s



Testing data

❖ 50 dataset

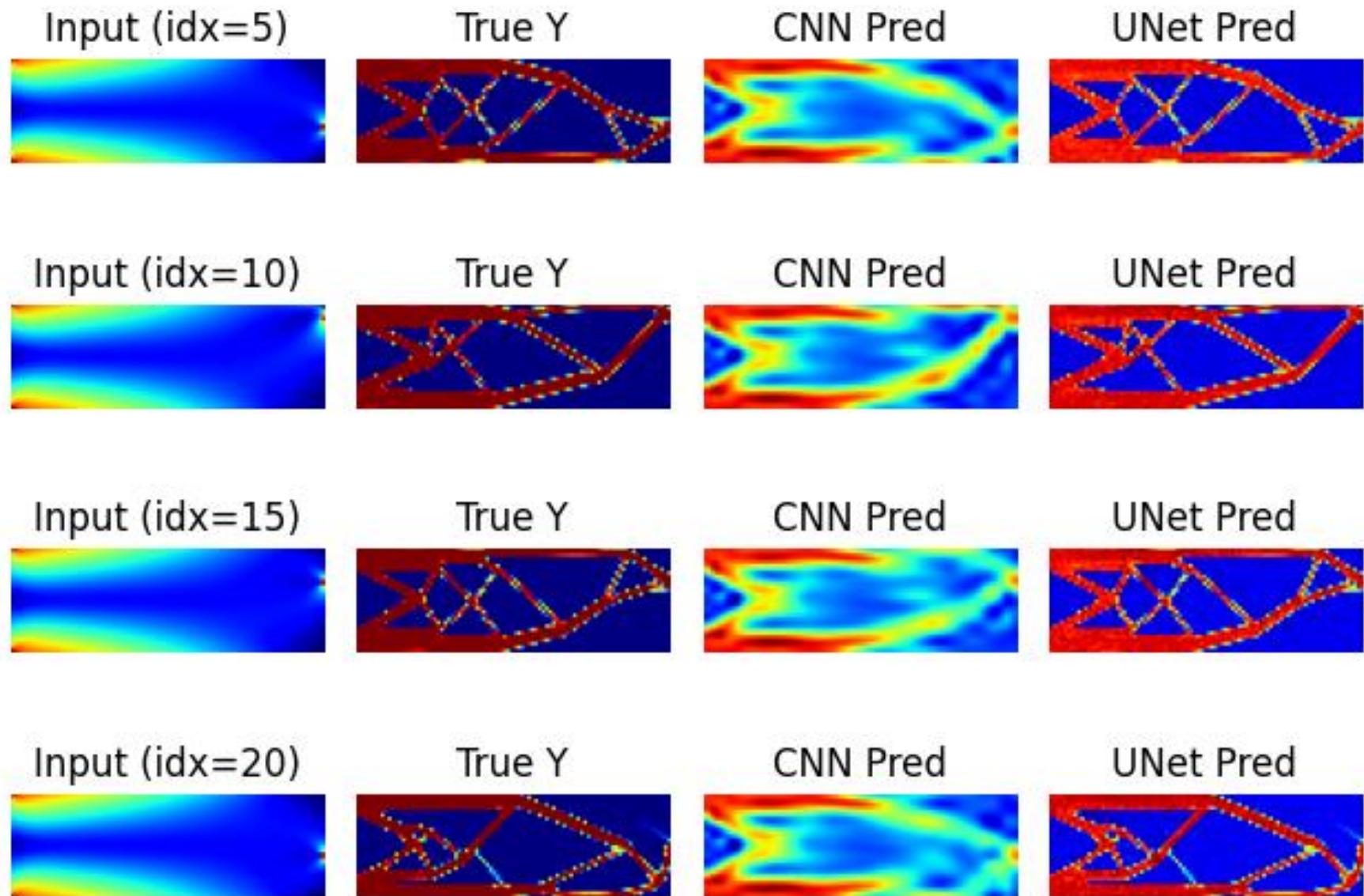
CNN vs UNet: MSE and R²



Prediction

❖ Times:

- ✓ TO = 137 s
- ✓ CNN = 0.005 s
- ✓ Unet = 0.001 s



Conclusion and future works

- ❖ Hyperparameter tuning
- ❖ Dataset
 - ✓ Increase number of dataset
 - ✓ 3D models
- ❖ Data augmentation: noise, rotation
- ❖ Different models:
 - ✓ Diffusions
 - ✓ Transformers
- ❖ My codes: https://github.com/sy-nguyen-van/Deep_Learning_Sy