

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

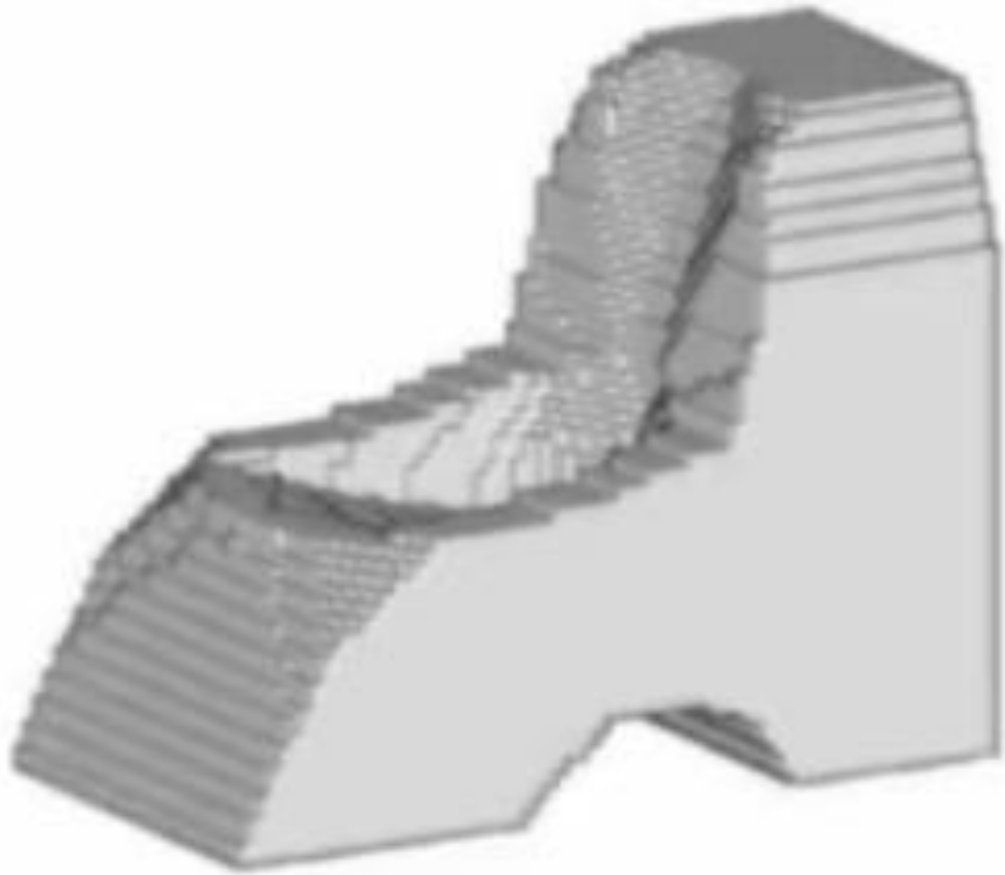
www.usa.skanska.com



Aircraft wings

<https://pilotinstitute.com/>

Topology optimization



Topology
optimization
→



Topology optimization process

Optimal design

Applications of topology optimization

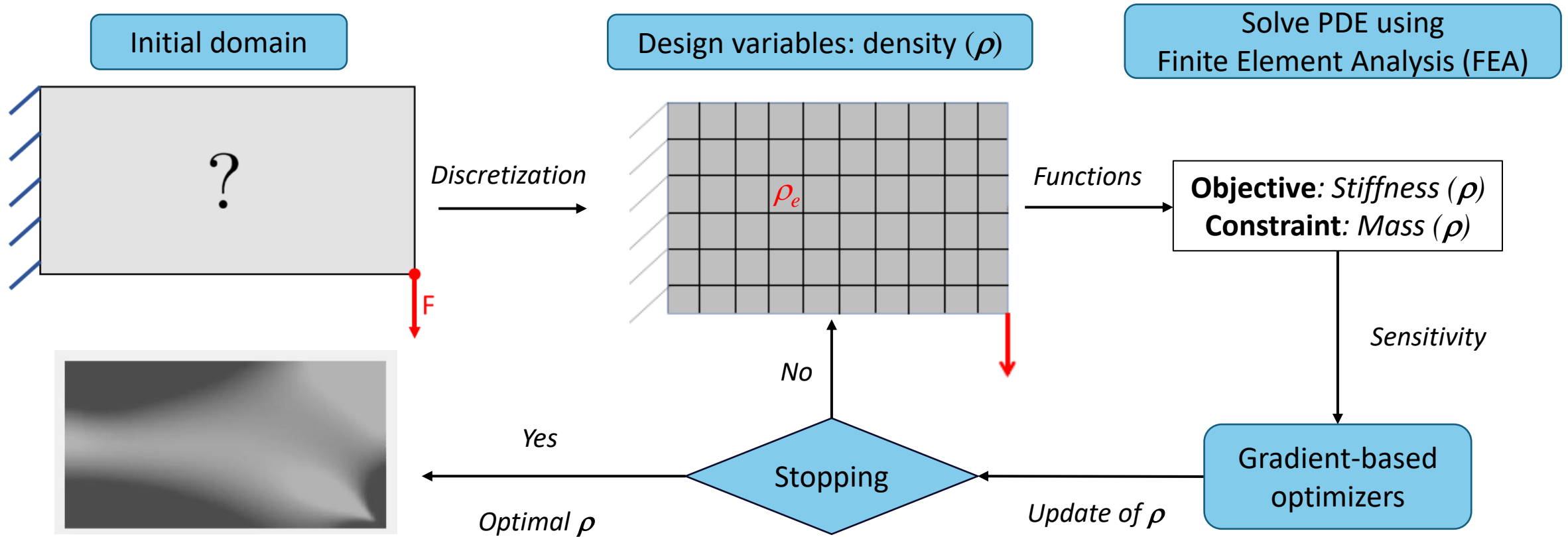


Optimal bridge design



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

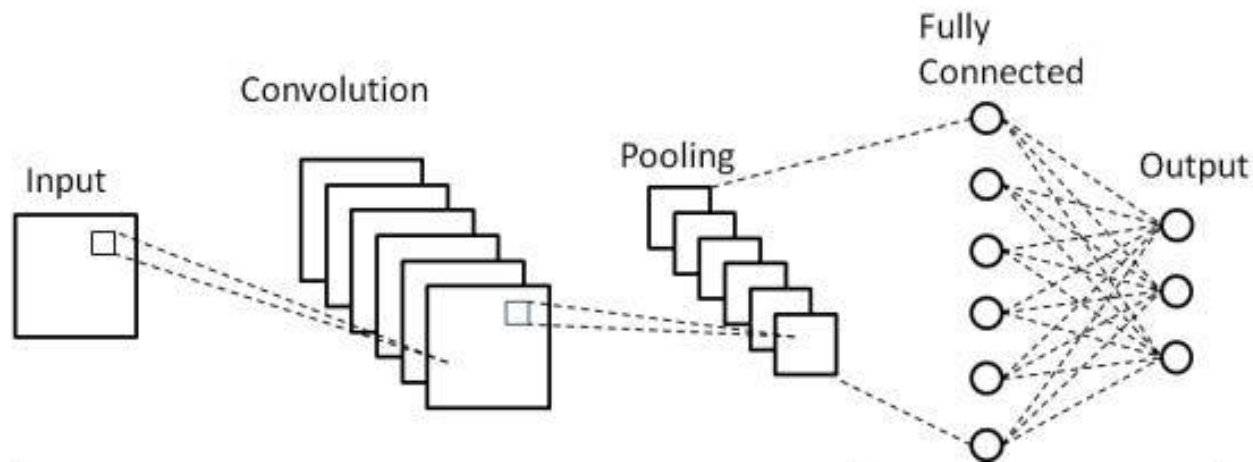
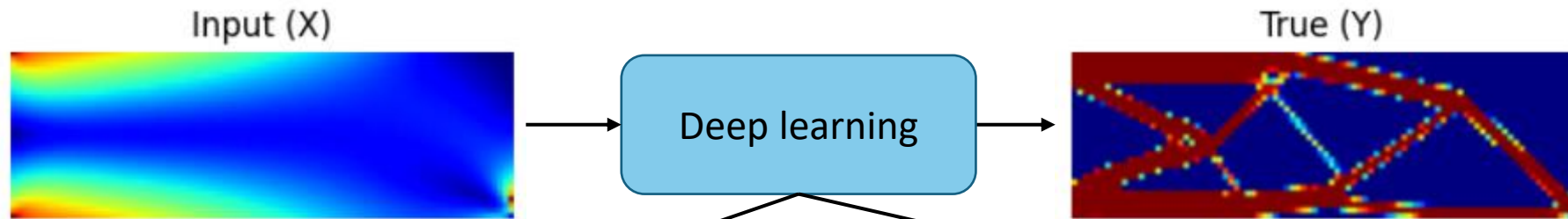
Challenges in Topology Optimization



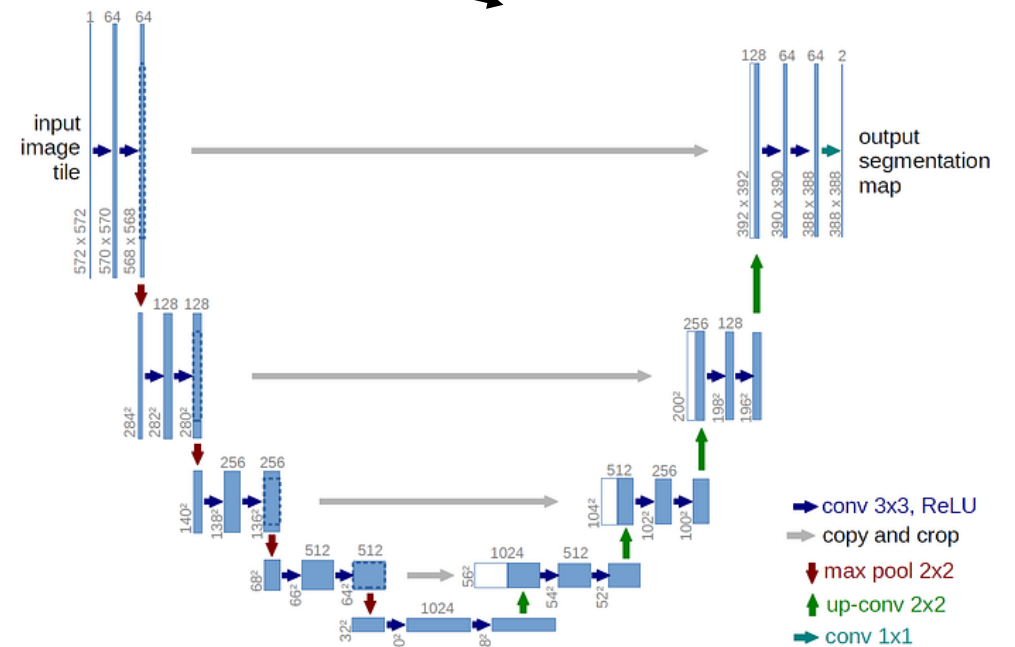
- 03 main challenges in Topology Optimization (TO)

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

Proposed deep learning



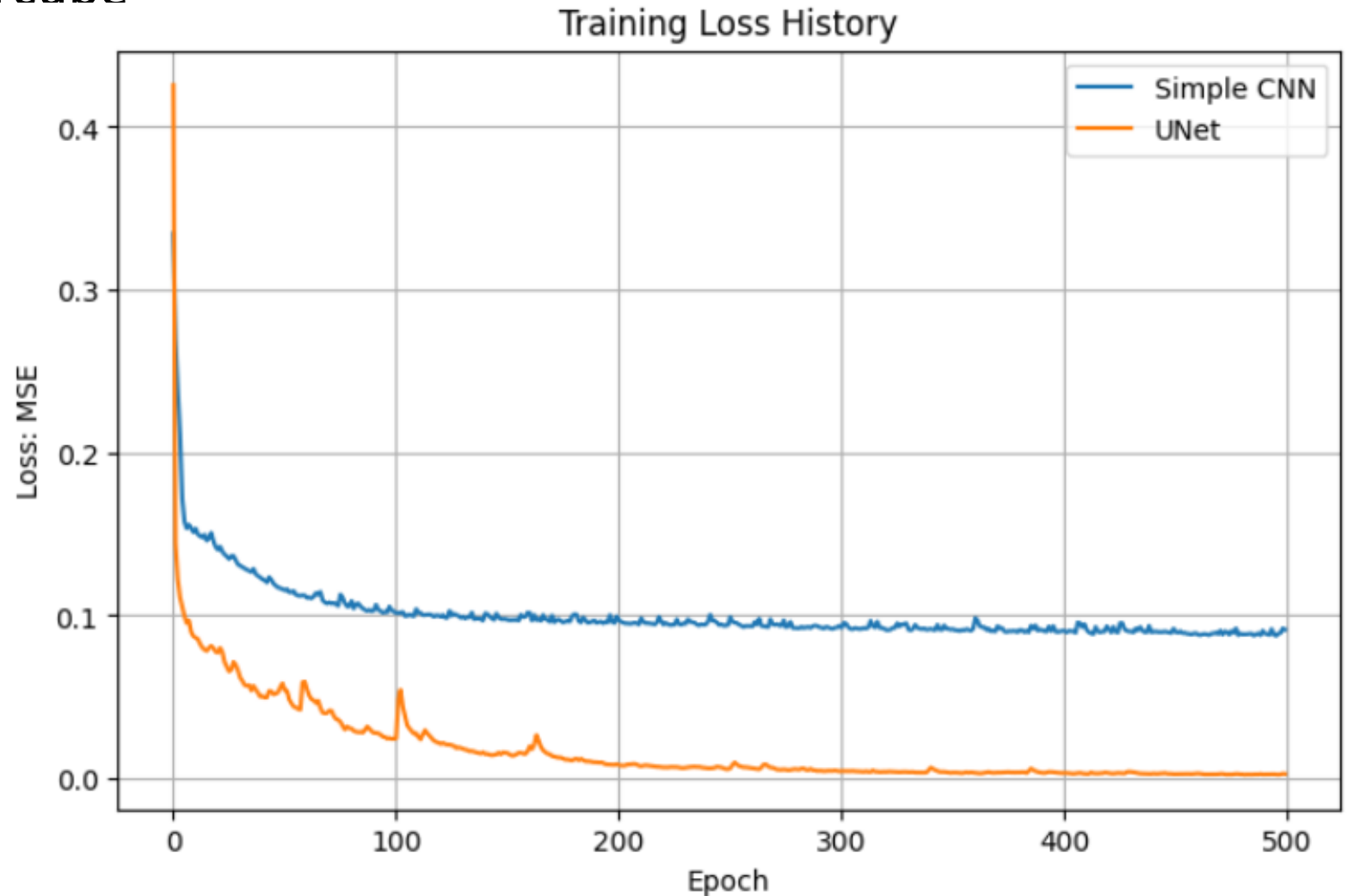
CNN



Unet

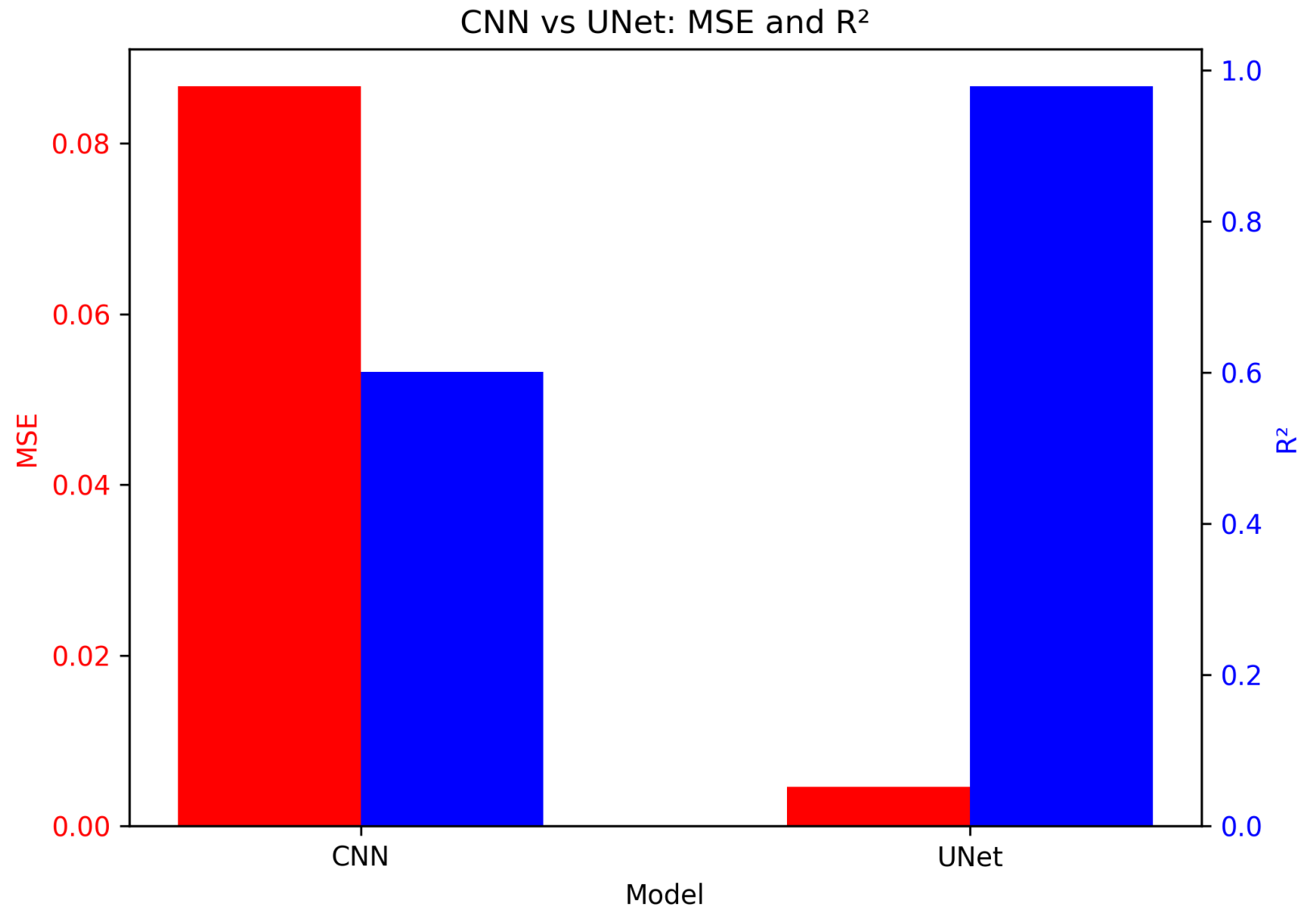
Dataset and Training

- ✧ 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

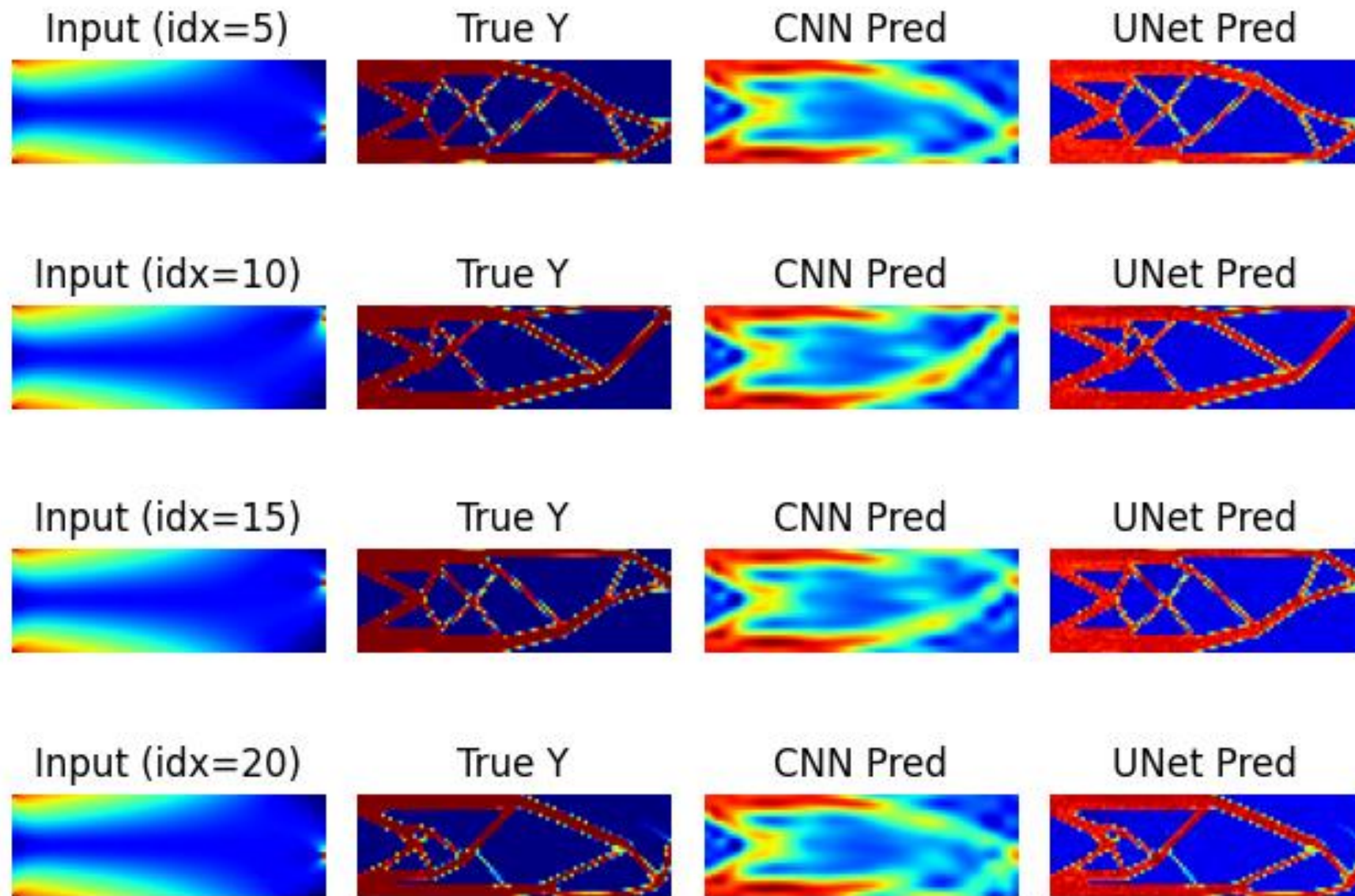
✧ 50 dataset



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