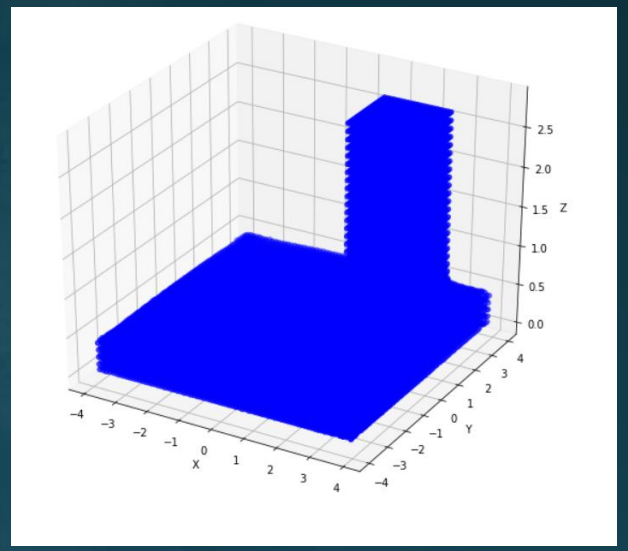
Deep learning on fluid simulation

2018.09.14

Progress



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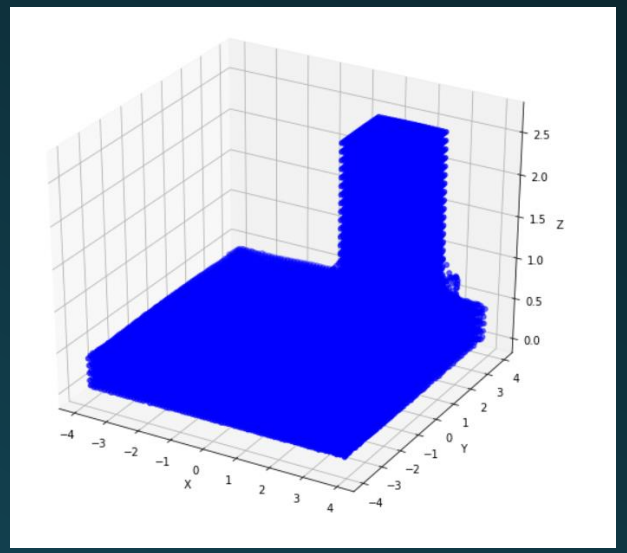
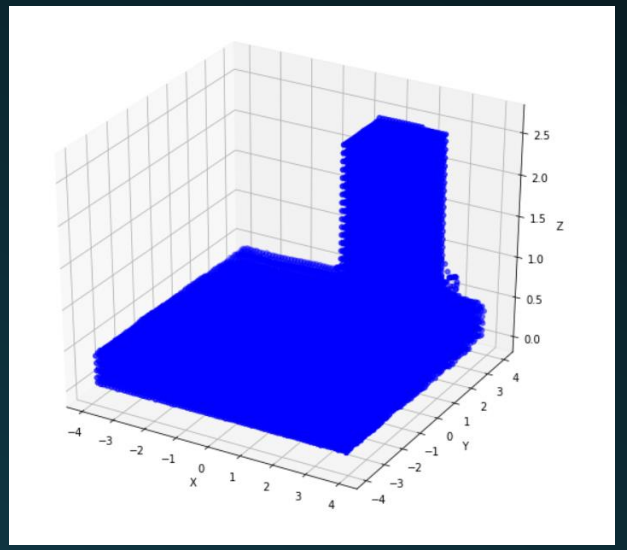
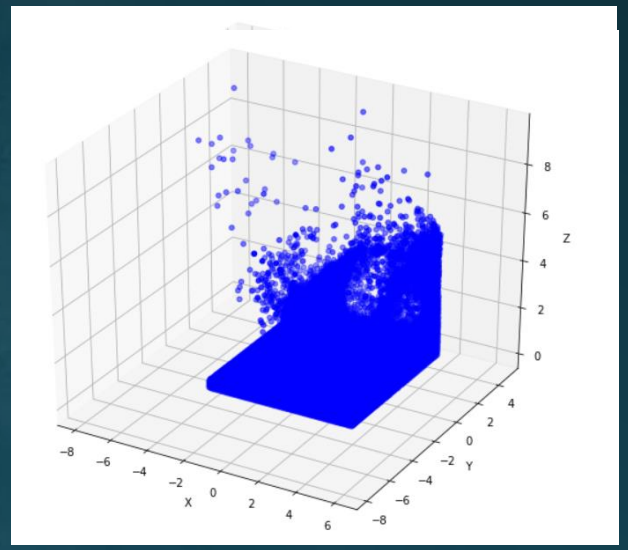


真实输出



预测输出

Progress



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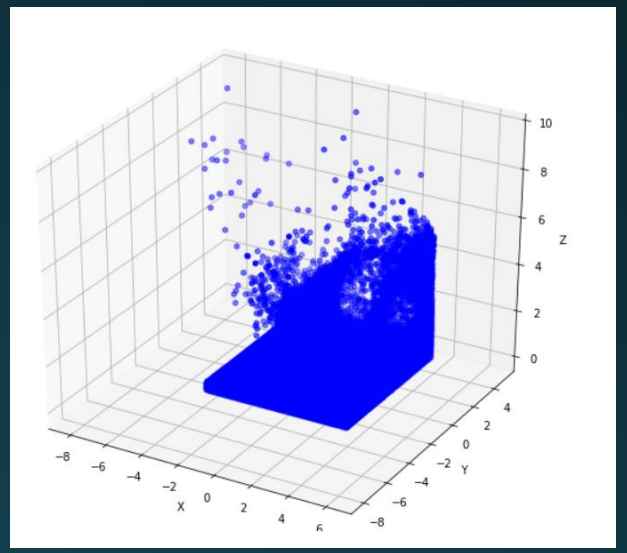

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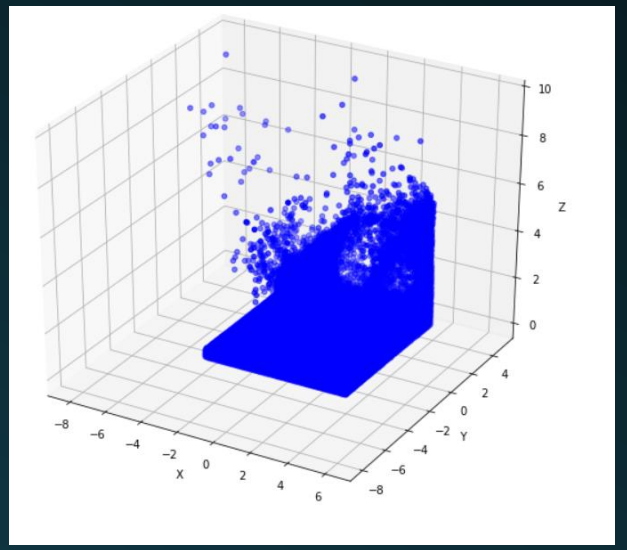

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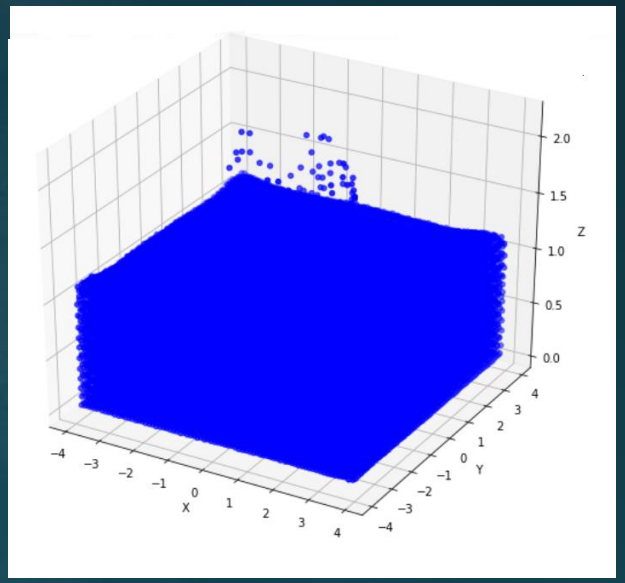

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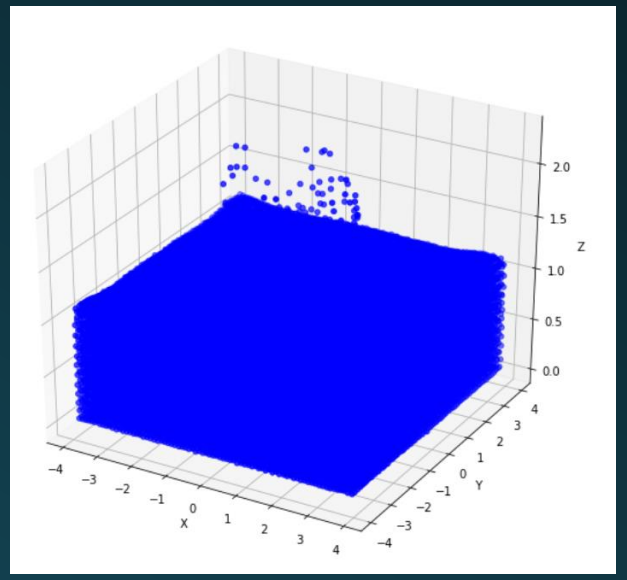

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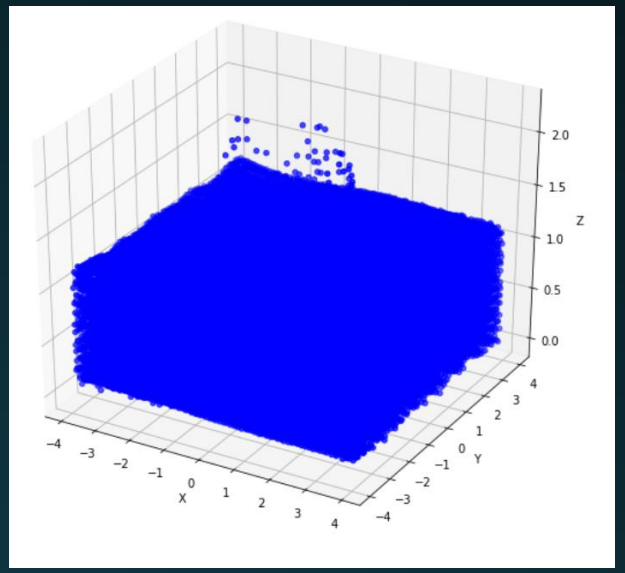


预测输出

Challenge

- 1. Make the model understand the input data
- 2. Make the model learn fluid simulation

Challenge

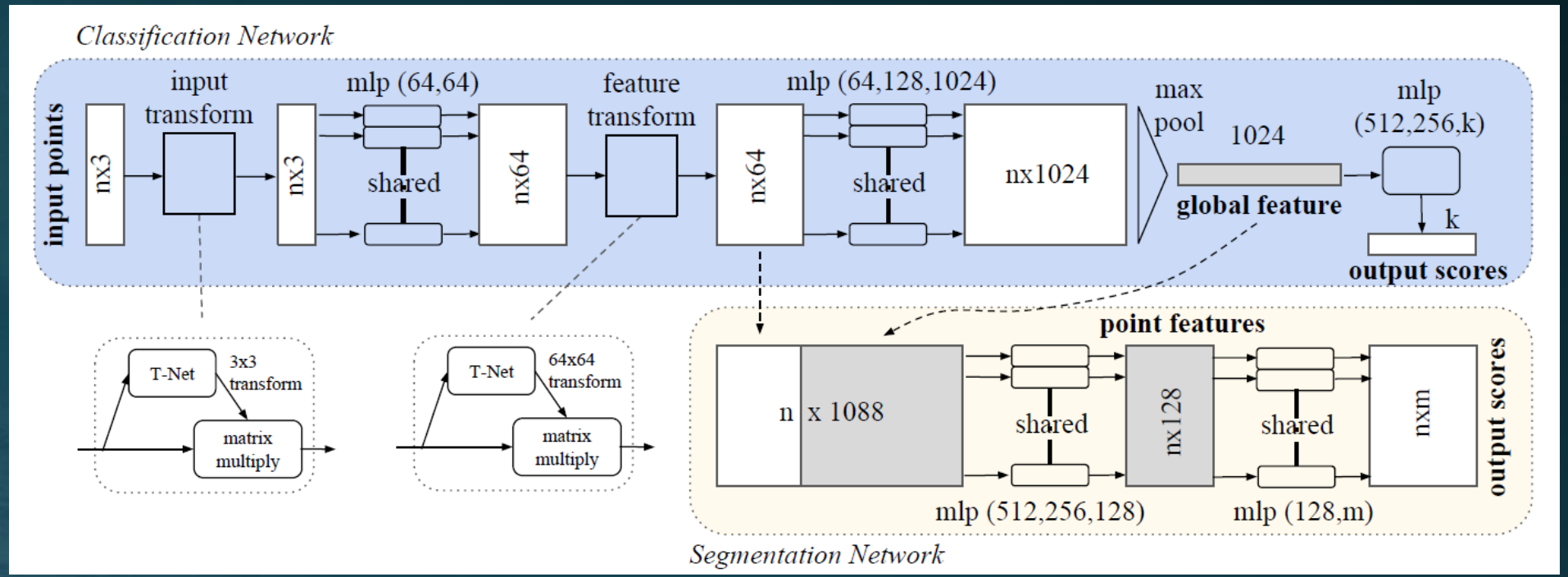
- 1. Make the model understand the input data
  - PointNet
  - PointNet++
  - VoxelNet

Make the model understand the input data

- PointNet
  - ✓ Unordered
  - ✓ Interaction among points
  - ✓ Invariance under transformations

Make the model understand the input data

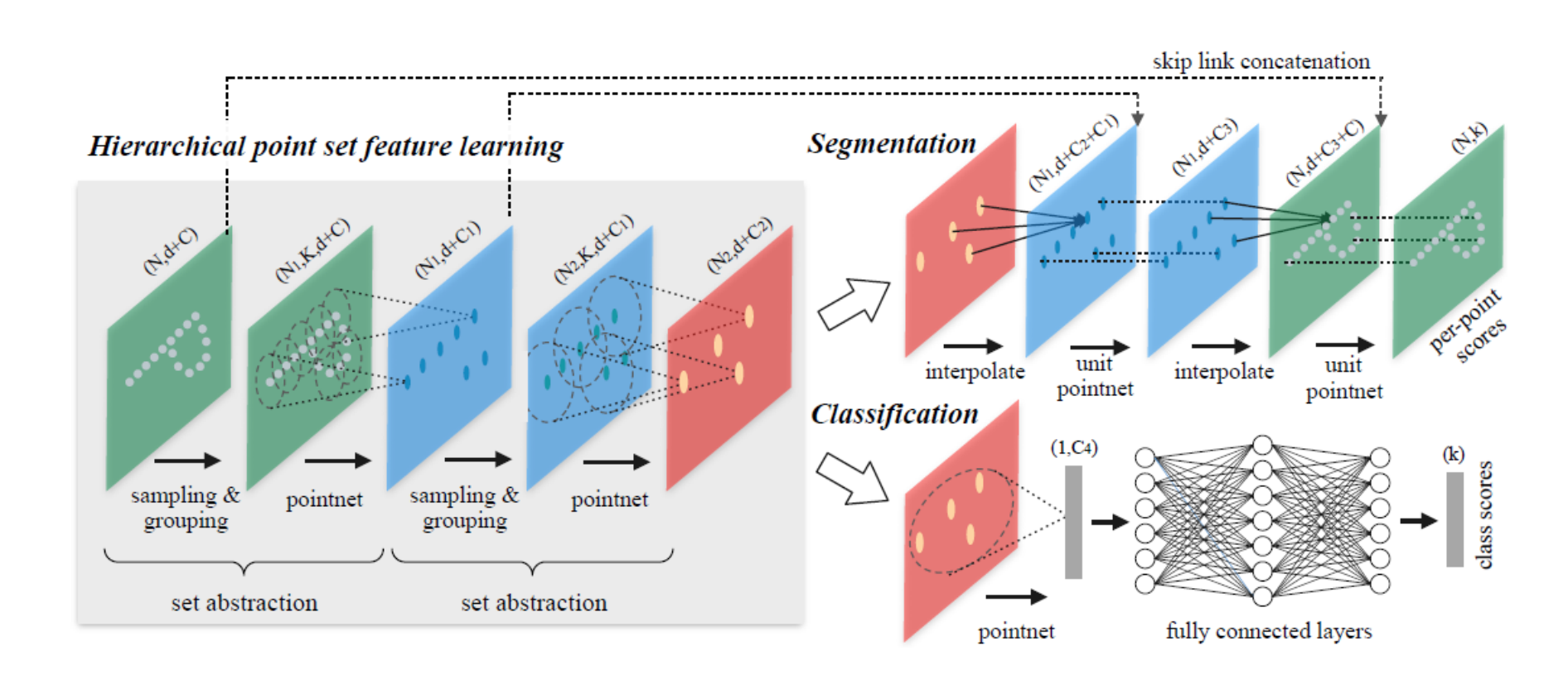
- PointNet



Qi C R, Su H, Mo K, et al. Pointnet: Deep learning on point sets for 3d classification and segmentation[J]. Proc. Computer Vision and Pattern Recognition (CVPR), IEEE, 2017, 1(2): 4.

Make the model understand the input data

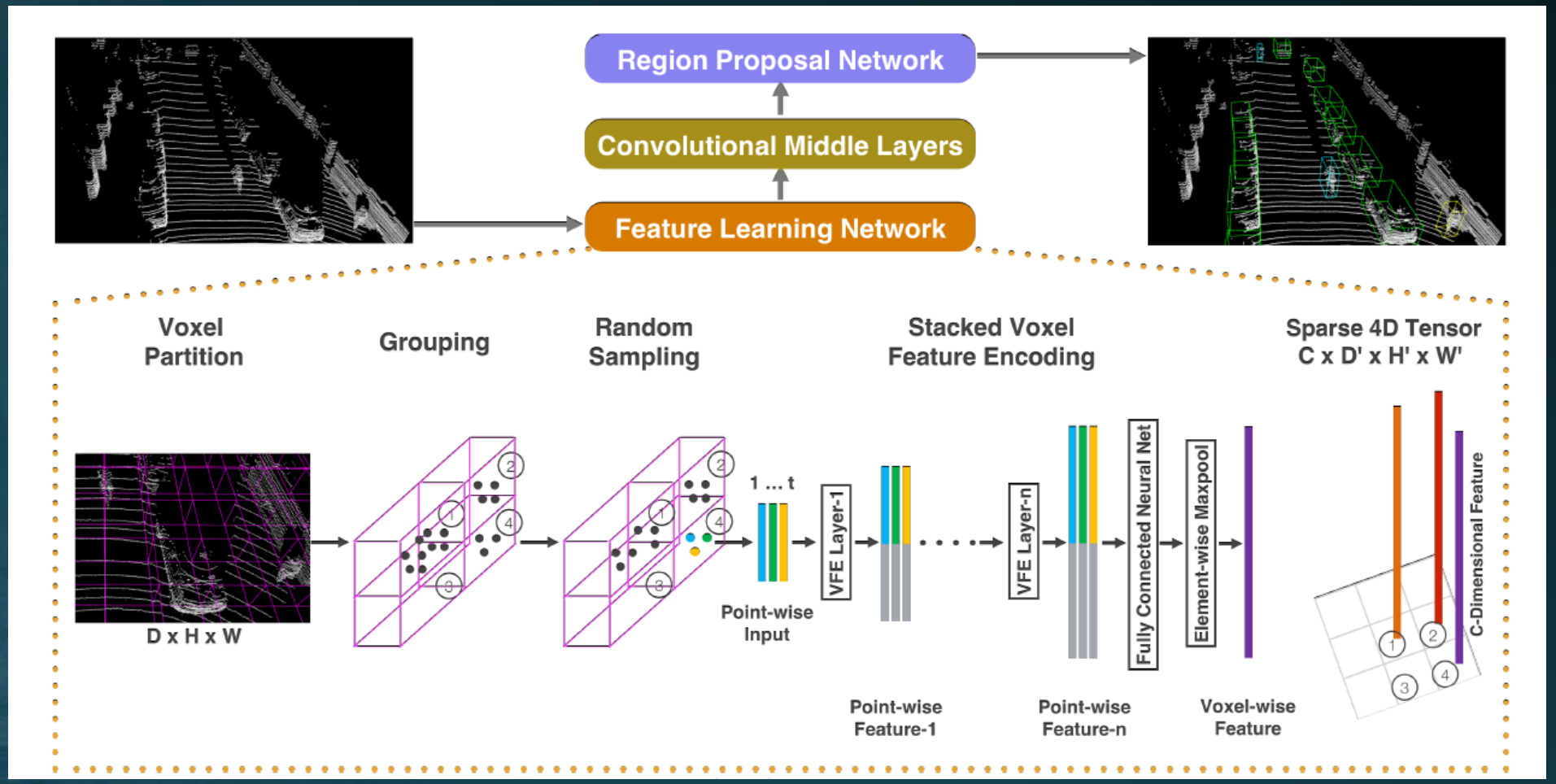
- PointNet++



Qi C R, Yi L, Su H, et al. Pointnet++: Deep hierarchical feature learning on point sets in a metric space[C]//Advances in Neural Information Processing Systems. 2017: 5099-5108.

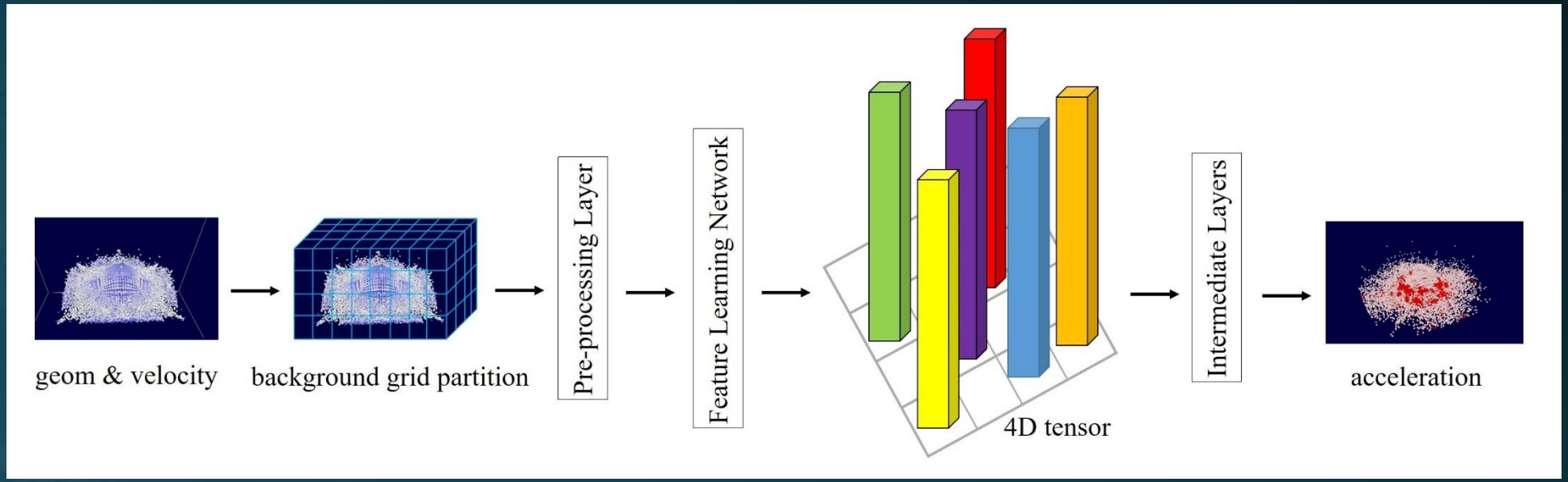
Make the model understand the input data

- VoxelNet

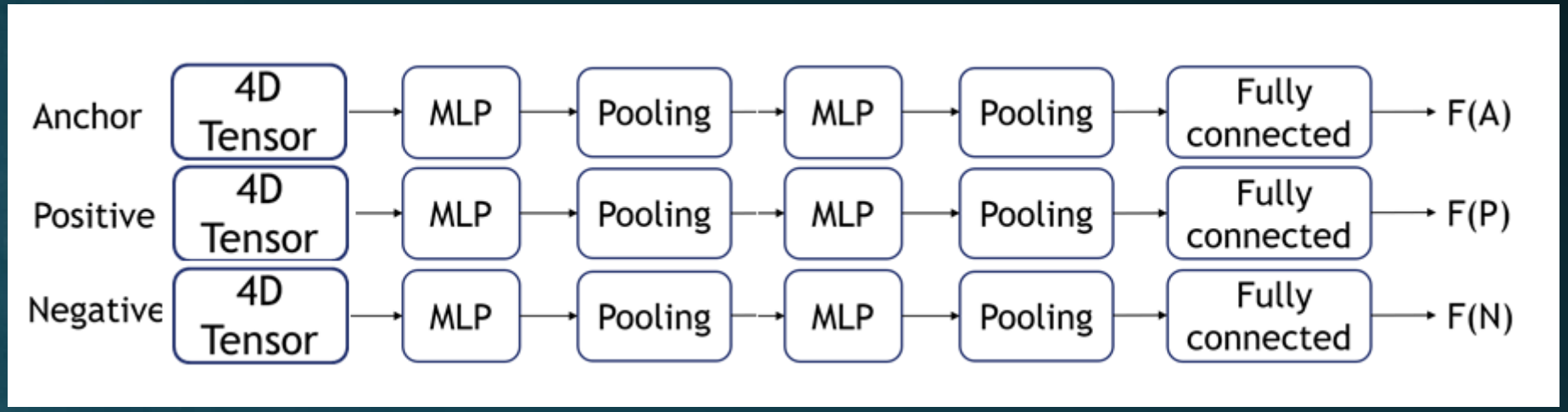


Zhou Y, Tuzel O. Voxelnet: End-to-end learning for point cloud based 3d object detection[J]. arXiv preprint arXiv:1711.06396, 2017.

Our model


geom & velocity
background grid partition
Pre-processing Layer
Feature Learning Network
4D tensor
Intermediate Layers
acceleration

Does the neural network working?



$$\mathrm{L}(A, P, N) = \max(\|f(A) - f(P)\|^2 - \|f(A) - f(N)\|^2 + \alpha, 0)$$

Challenge

- 2. Make the model learn fluid simulation
  - Accelerating Eulerian Fluid Simulation With Convolutional Networks
  - Data-Driven Synthesis of Smoke Flows with CNN-based Feature Descriptors
  - Generating Liquid Simulations with Deformation-aware Neural Networks
  - tempoGAN: A Temporally Coherent, Volumetric GAN for Super-resolution Fluid Flow
  - Latent-space Physics Towards Learning the Temporal Evolution of Fluid Flow

Make the model learn fluid simulation

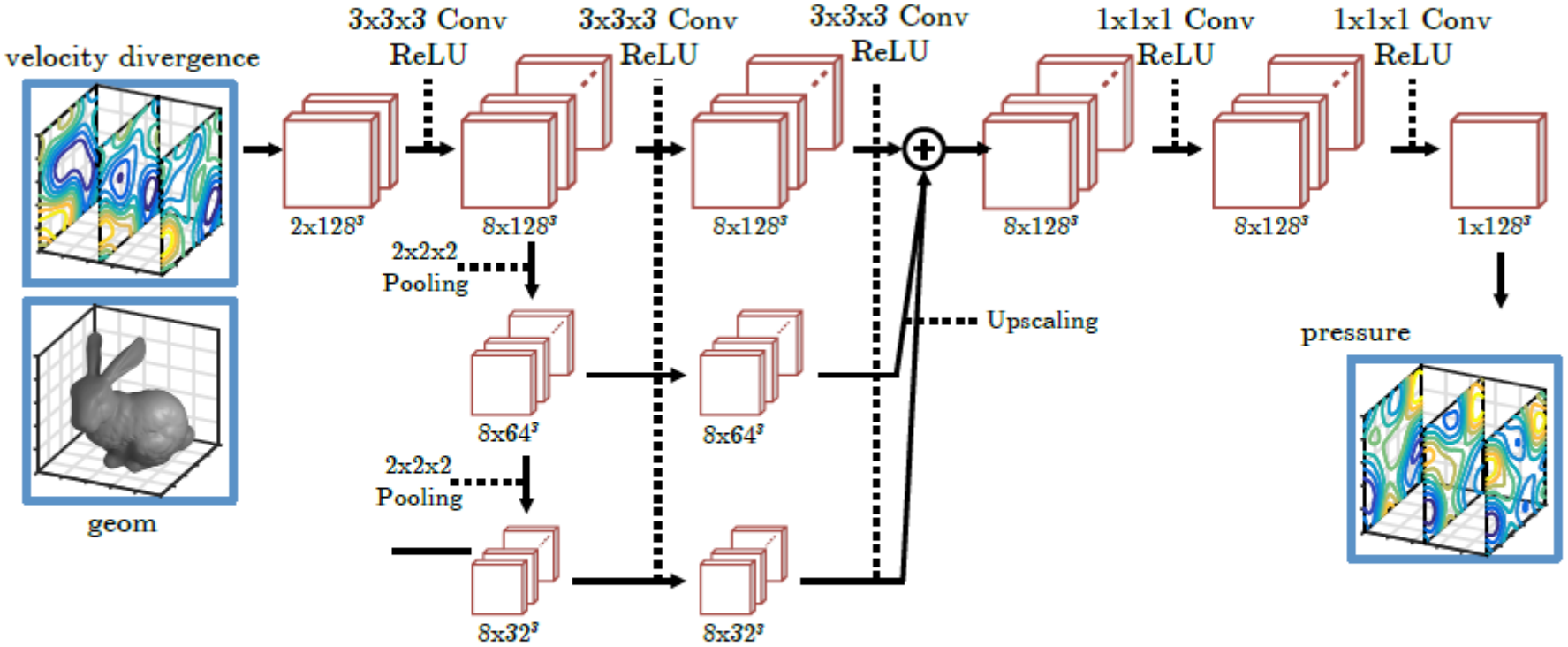
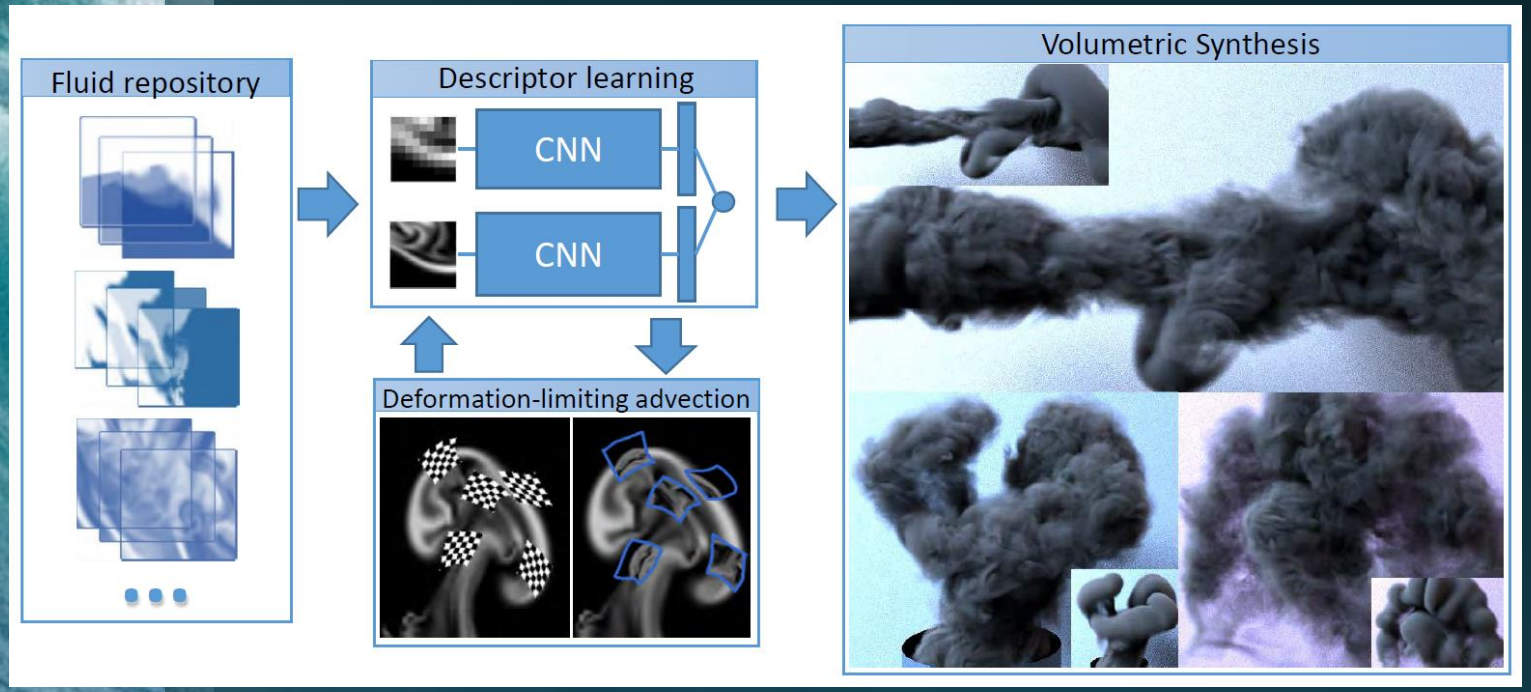
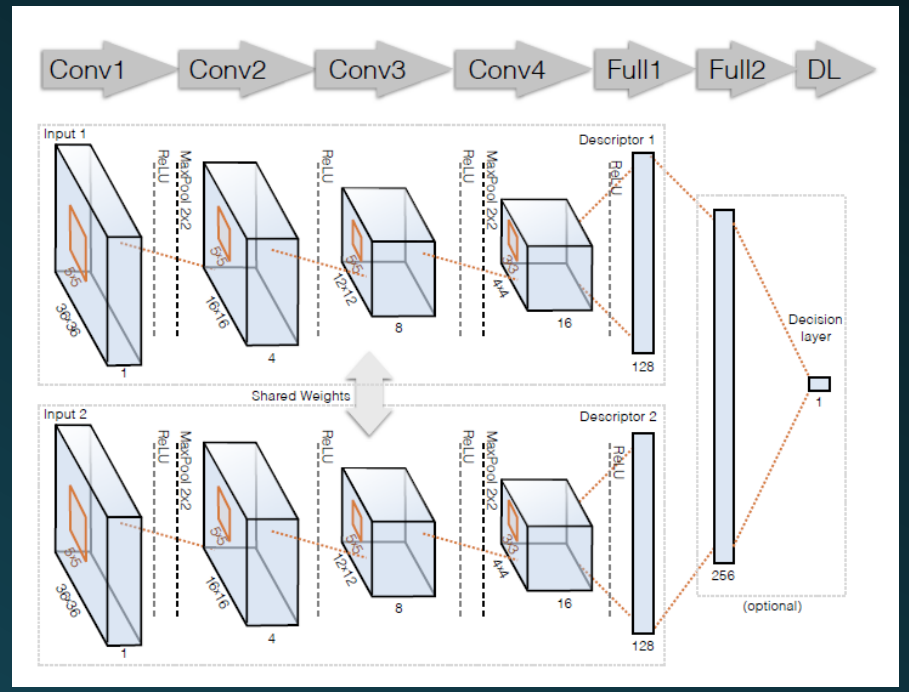


Figure 3. Convolutional Network for Pressure Solve

Make the model learn fluid simulation



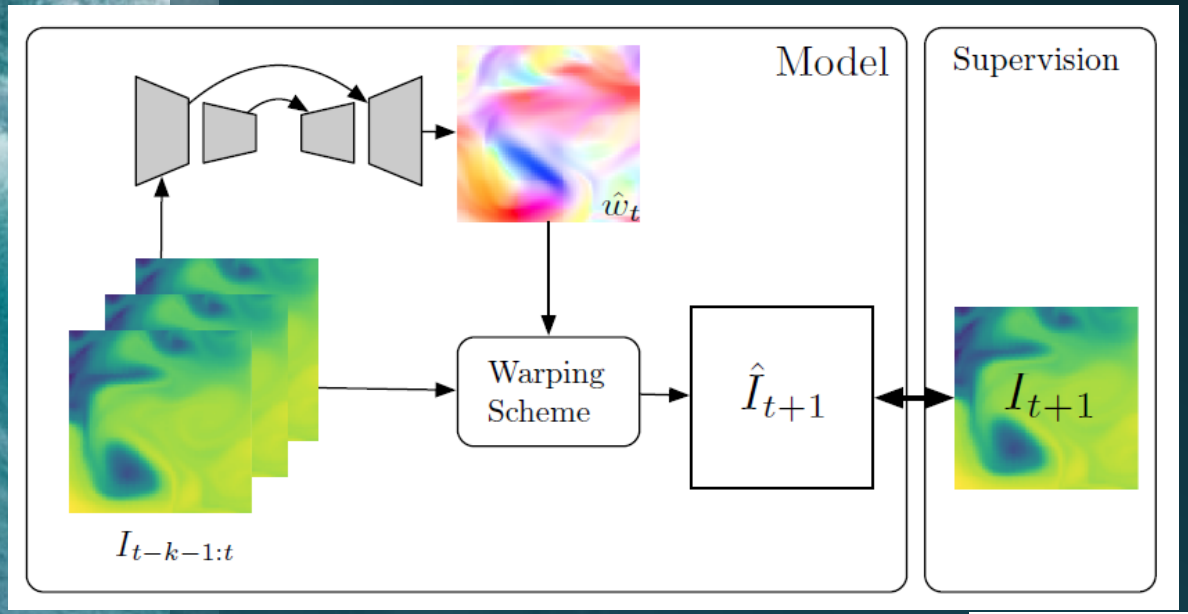


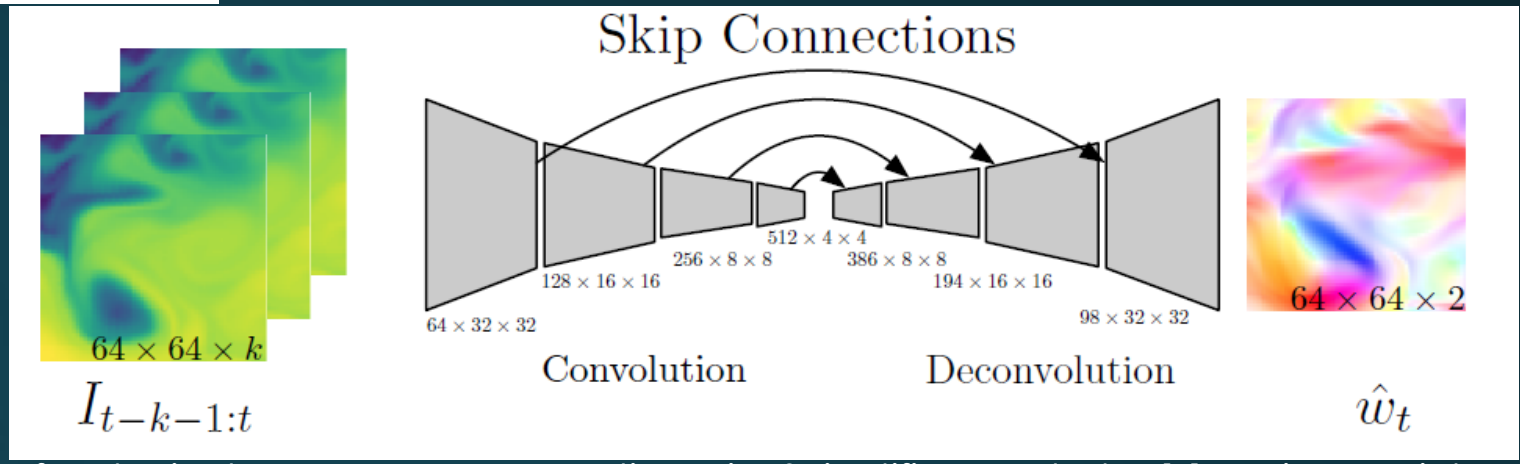
Chu M, Thuerey N. Data-driven synthesis of smoke flows with CNN-based feature descriptors[J]. ACM Transactions on Graphics (TOG), 2017, 36(4): 69.

Make the model learn fluid simulation

- Physical learning
  - Deep Learning for Physical Processes: Incorporating Prior Scientific Knowledge
  - Deep learning the physics of transport phenomena

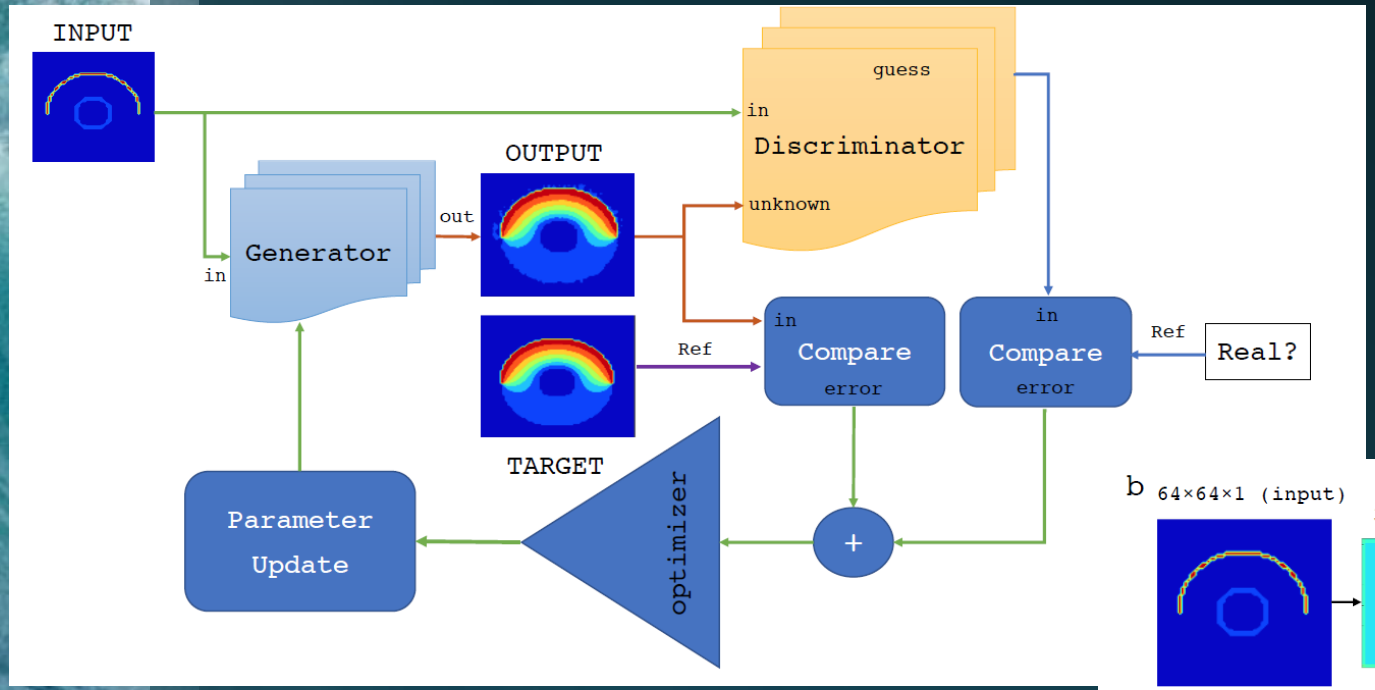
Make the model learn fluid simulation

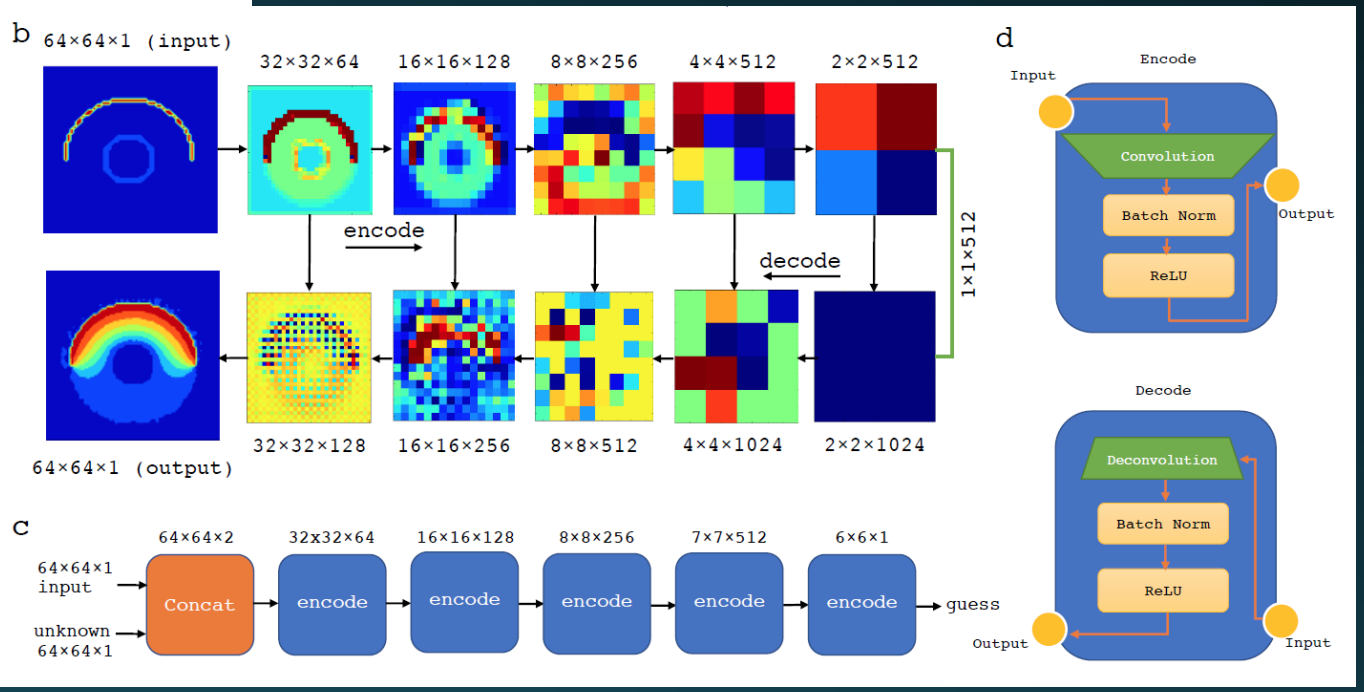




de Bezenac E, Pajot A, Gallinari P. Deep Learning for Physical Processes: Incorporating Prior Scientific Knowledge[J]. arXiv preprint arXiv:1711.07970, 2017

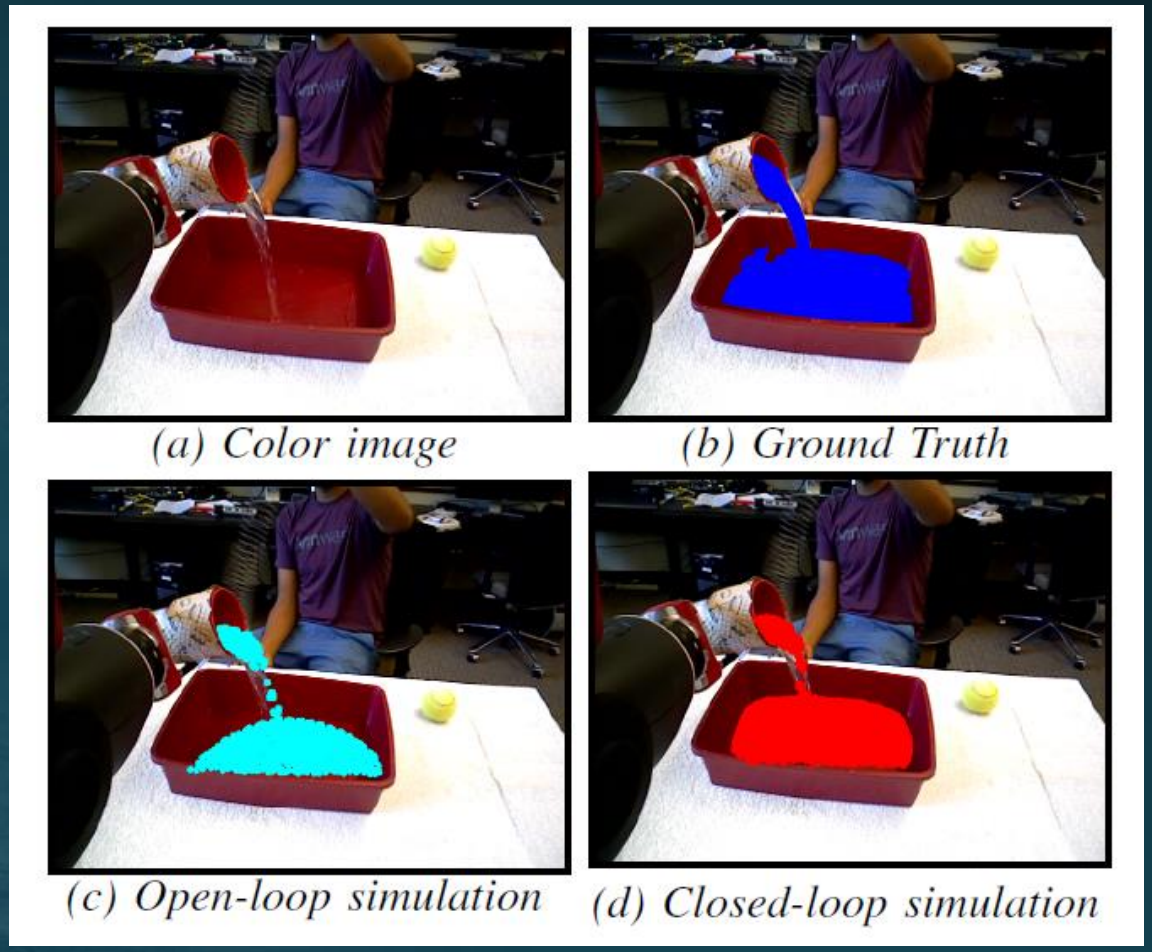
Make the model learn fluid simulation





Farimani A B, Gomes J, Pande V S. Deep learning the physics of transport phenomena[J]. arXiv preprint arXiv:1709.02432, 2017.

Analyze video data



Schenck C, Fox D. Reasoning about liquids via closed-loop simulation[J]. arXiv preprint arXiv:1703.01656, 2017.

Plan

- 1. Prove that the network is working and useful
- 2. Combine model with physical prior scientific knowledge
- 3. Learn the temporal evolution of fluid simulation