3DOS: Towards Open Set 3D Learning

Benchmarking and Understanding Semantic Novelty Detection on Pointclouds

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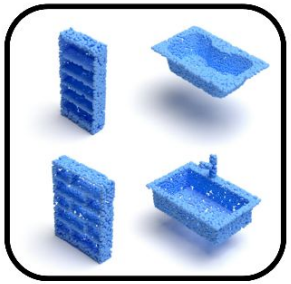
Settings

Synthetic
(samples from ModelNet40)

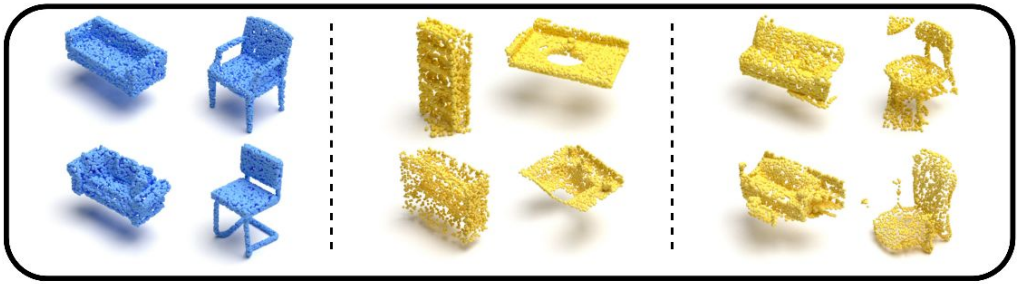
Real-World
(samples from ScanObjectNN)

OOD detection

Training Data



Test Data



Training Labels

known
in-distribution
bookshelf, sink

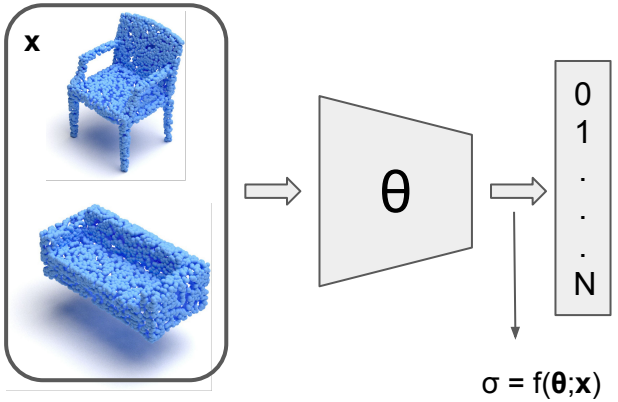
Task Expected Prediction

Unknown | Unknown | Unknown

Open Set - State of the art

Discriminative

- train classifier model θ with multi-class supervision
- normality score σ as a function of the network output at inference time



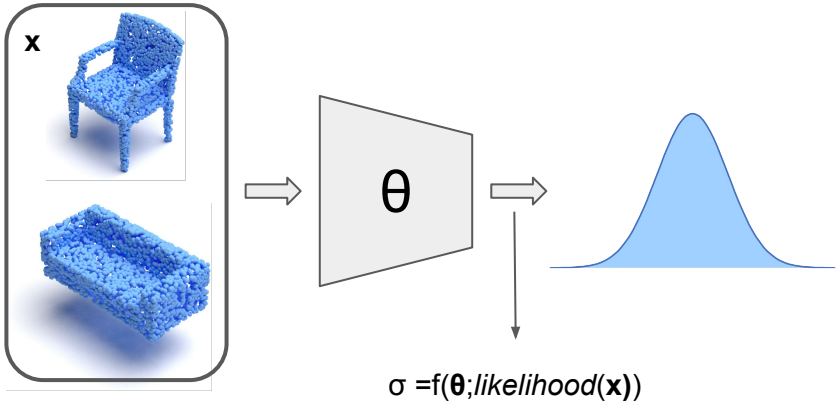
Categories

- **Discriminative**

Open Set - State of the art

Density and Reconstruction based

- train generative or hybrid model θ
- normality score σ as a function of the sample likelihood



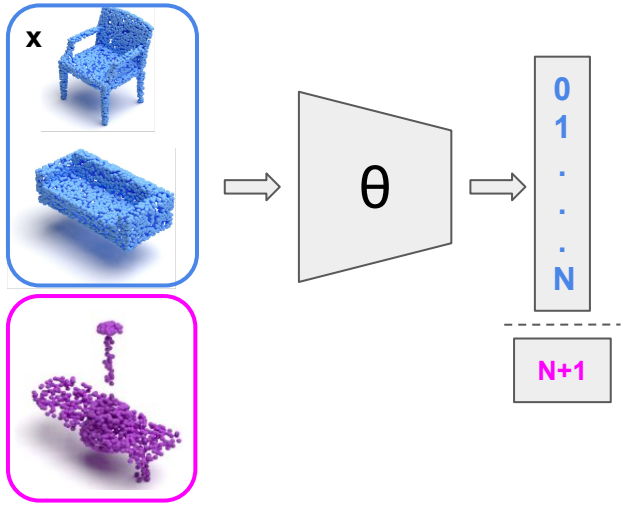
Categories

- Discriminative
- **Density and Reconstruction**

Open Set - State of the art

Outlier Exposure with OOD data

- train classifier model with multi-class supervision
- real or generated OOD data to force separation between ID and OOD



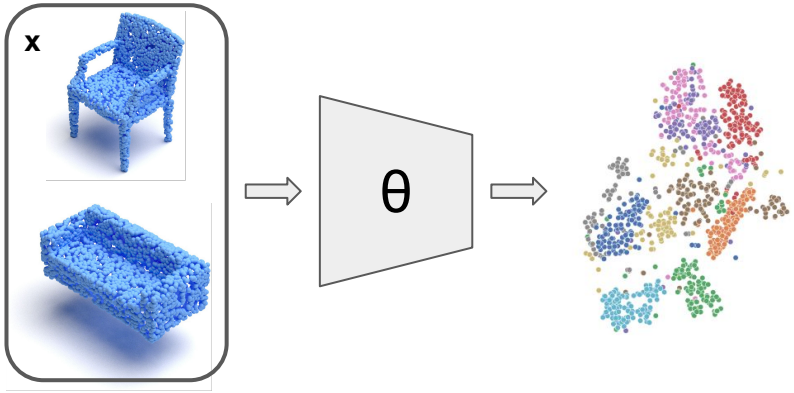
Categories:

- Discriminative
- Density and Reconstruction
- **Outlier Exposure**

Open Set - State of the art

Representation and Distance based

- learning representations of ID data on a task
- test sample normality score σ as function of the distance from training data



Categories:

- Discriminative
- Density and Reconstruction
- Outlier Exposure
- **Representation and Distance based**

Open Set - State of the art

Solutions studied only for 2D Computer Vision!

What about 3D?

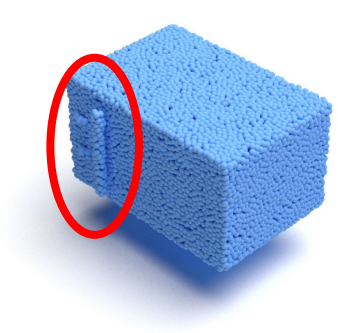
Categories:

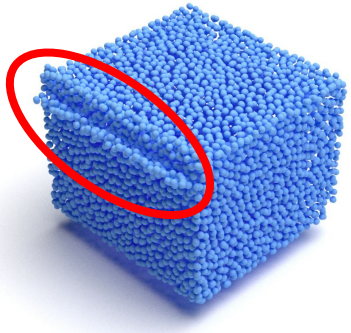
- Discriminative
- Density and Reconstruction
- Outlier Exposure
- Representation and Distance based

2D vs 3D

Microwave

Dishwasher

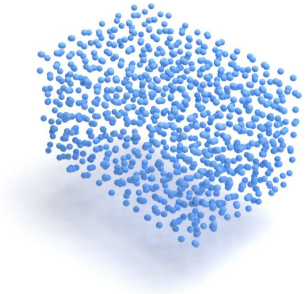




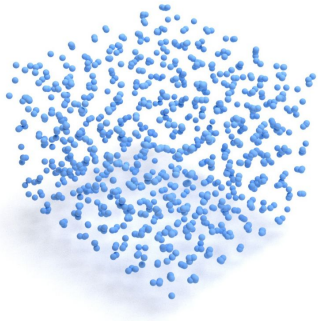
Details	Color	Scale	Context
✓	✓	✓	✓
✓	✗	✗	✗

2D vs 3D

Microwave



Dishwasher

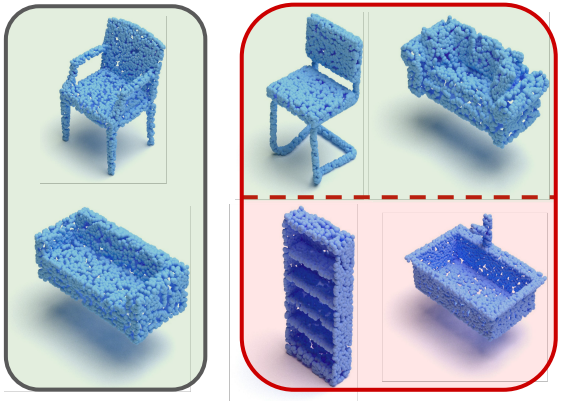


Details	Color	Scale	Context
✗	✓	✓	✓
✗	✗	✗	✗

3DOS - 3D Open Set Learning Benchmark

Synthetic

Train Data | Test Data

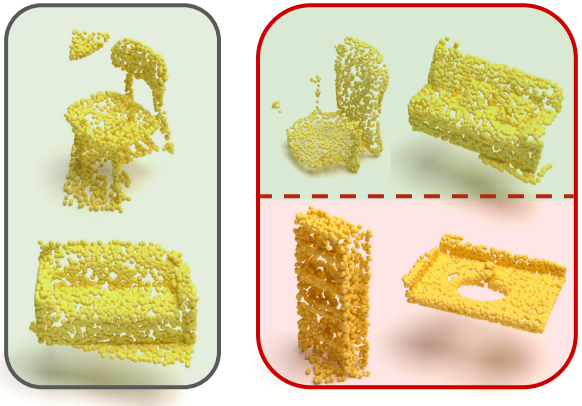


Semantic Shift ☑

Domain Shift ☐

Real to Real

Train Data | Test Data

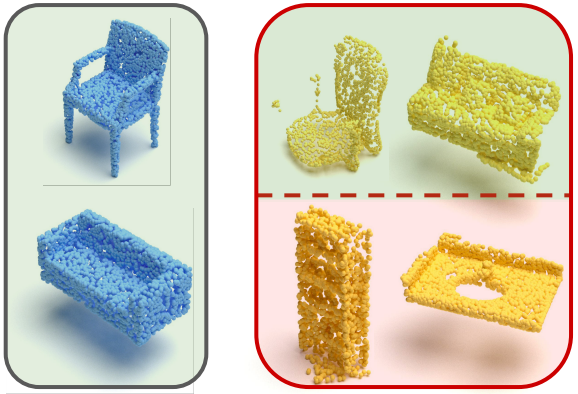


Semantic Shift ☑

Domain Shift ☐

Synthetic to Real

Train Data | Test Data

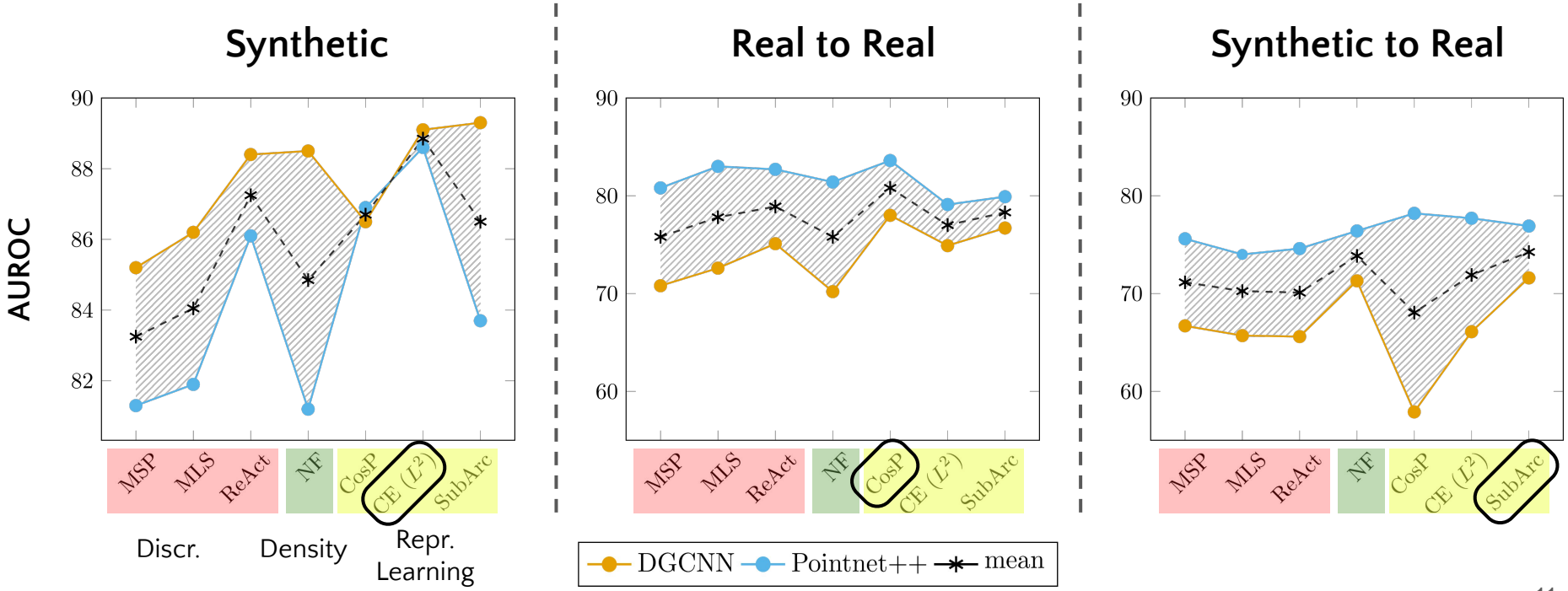


Semantic Shift ☑

Domain Shift ☑

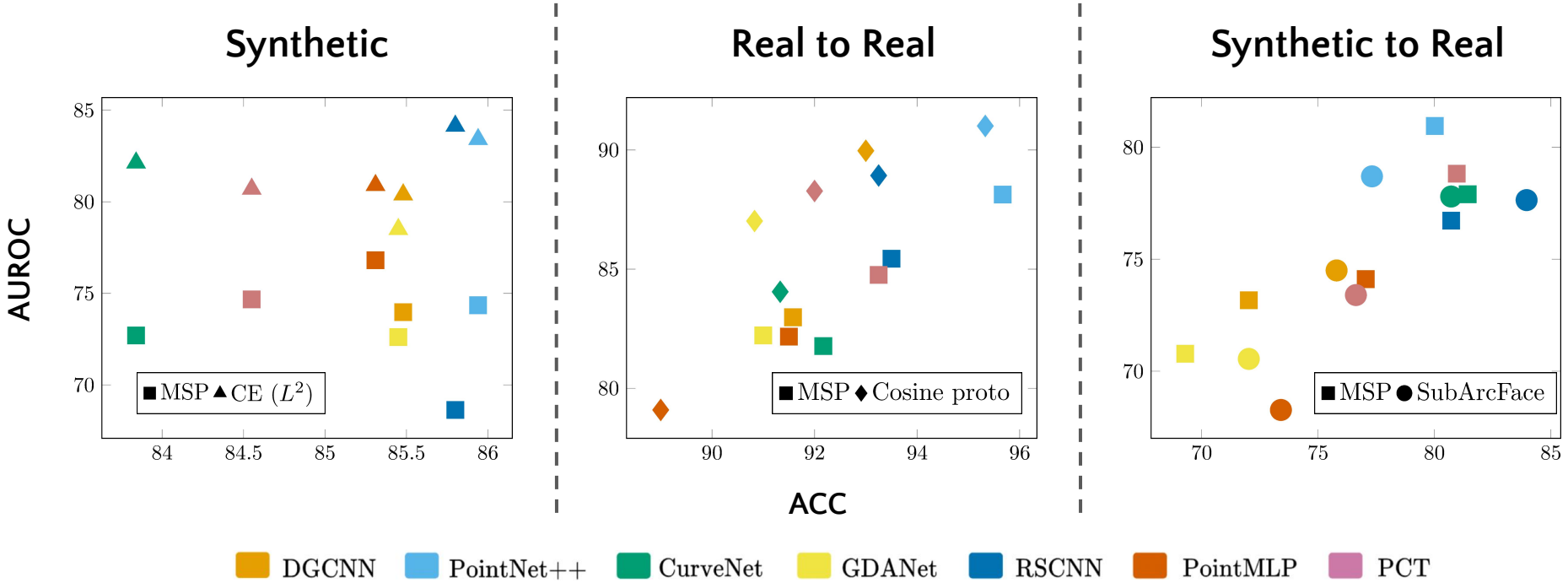
3DOS - Results

- Open Set performance (AUROC) on the three 3DOS tracks



3DOS - Results

- Open Set (AUROC) vs Closed Set (ACC) for different backbones (colors)



Conclusions

- **3DOS**: the first **3D O**pen **S**et Learning Benchmark
  - Three tracks with increasing levels of difficulty
  - Covers both semantic and domain shift

- We position several methods under the same coherent picture
  - **2D Open Set Methods do not transfer their state-of-the-art performance to 3D data**
  - **Representation learning approaches work the best:** CE (L^2), Cosine Proto, SubArcFace
  - **Closed Set (ACC) and Open Set (AUROC) performances are not strictly correlated**
  - **Backbone choice is fundamental**, especially for cross-domain scenarios

- ⇒ **Need for Open Set methods tailored for 3D data!**

Thanks!

github.com/antoalli/3D_OS

Code and Data available!

You can find me at

- antonio.alliegro@polito.it
- github.com/antoalli