FoldingNet: Point Cloud Auto-encoder via Deep Grid Deformation

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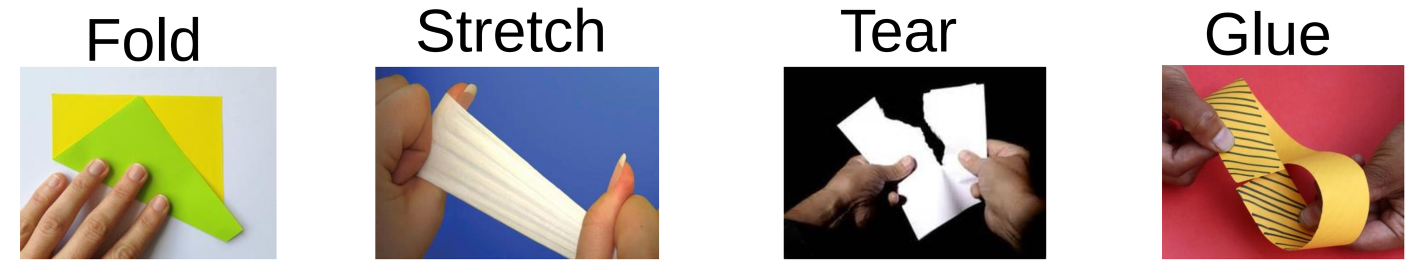
Problems and Motivations

- How to generate unstructured point sets?
- How to utilize the 2D manifold structures of object surfaces?
- How to embed a point cloud into a compact representation?

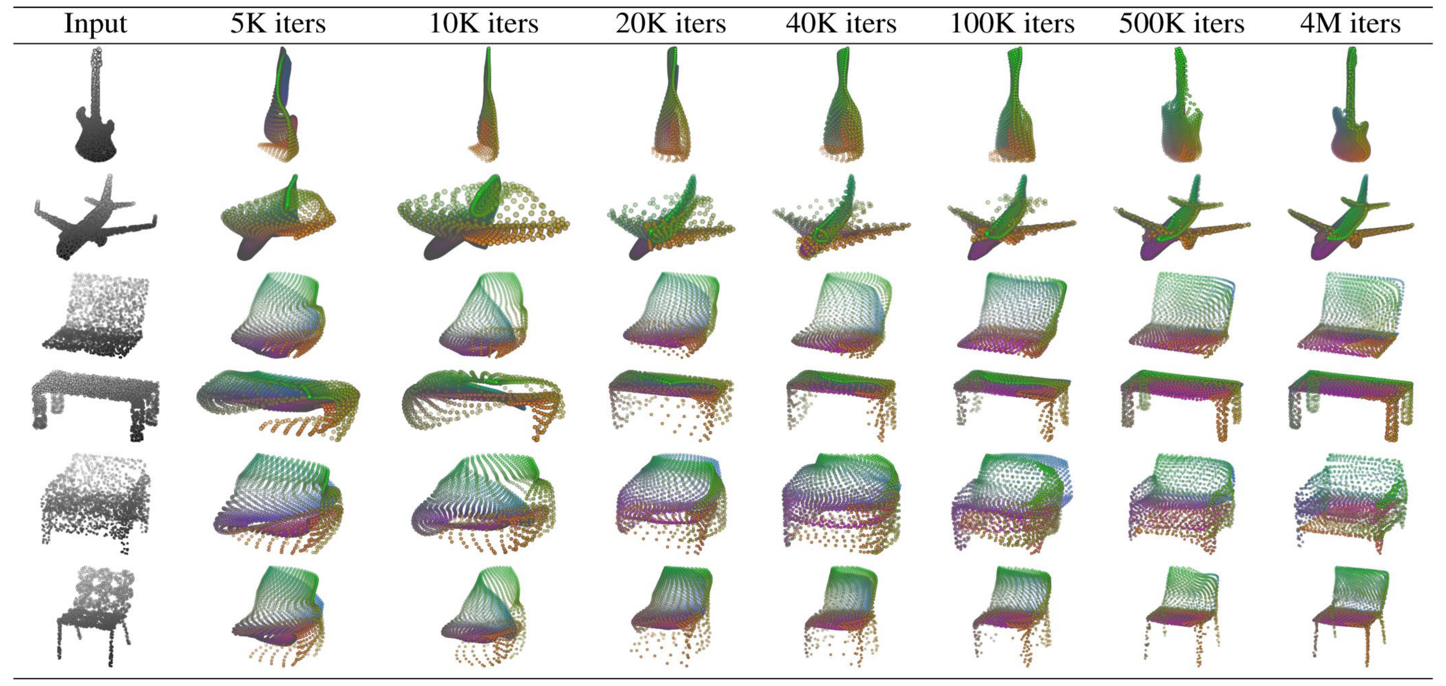
Related Works

- Input representation: Voxel/Multi-view/Points/Mesh
- Existing decoder structures: Fully-connected/Image-based
- Ours: Folding-based auto-encoder from grid deformation

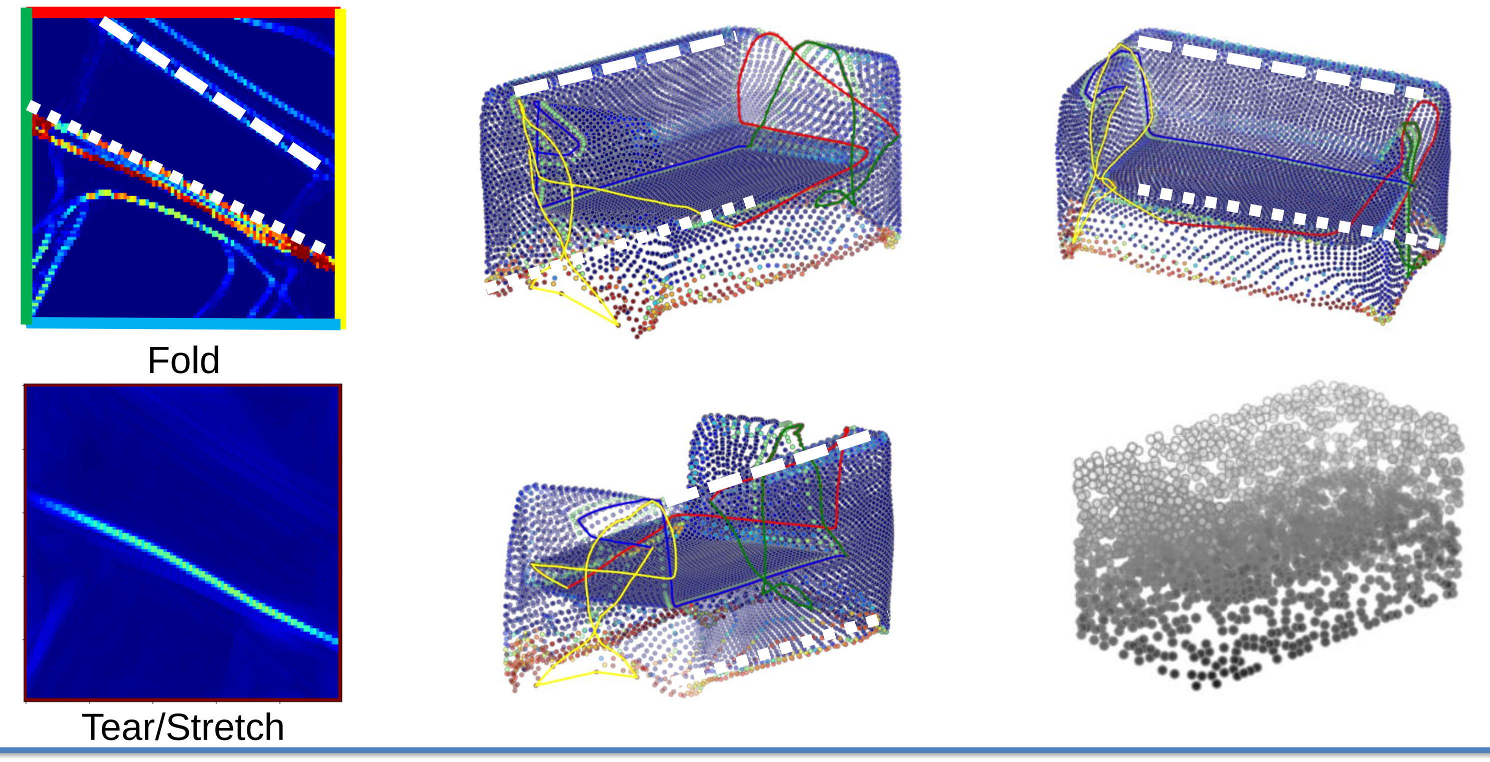
3D Unsupervised Learning using Paper Folding



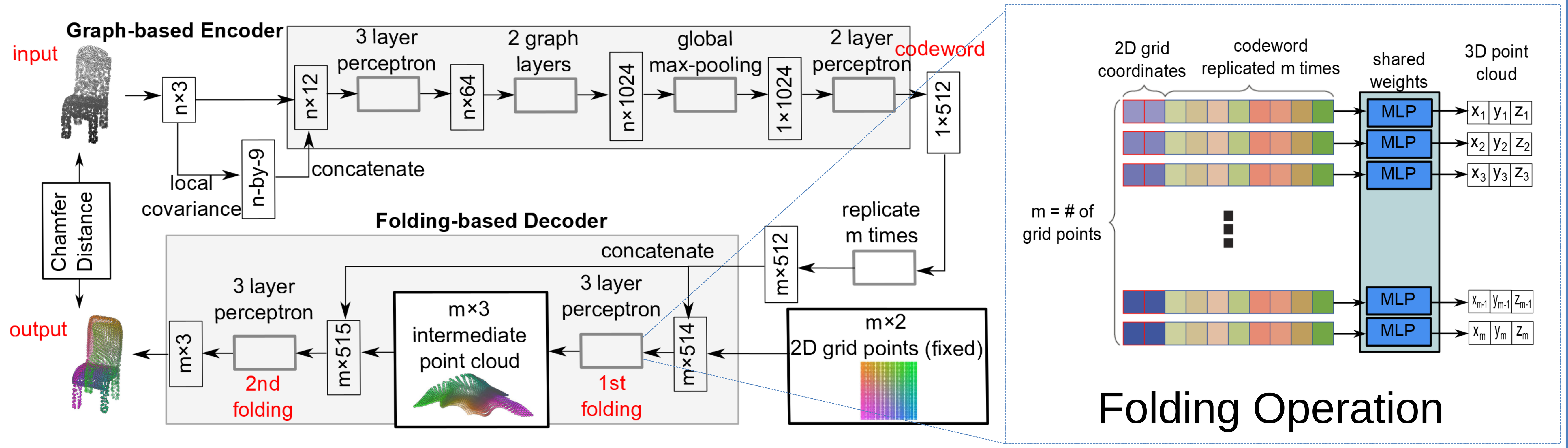
Learn to Fold Better during Training



Neural Networks Learn to Fold/Tear/Stretch



FoldingNet Architecture



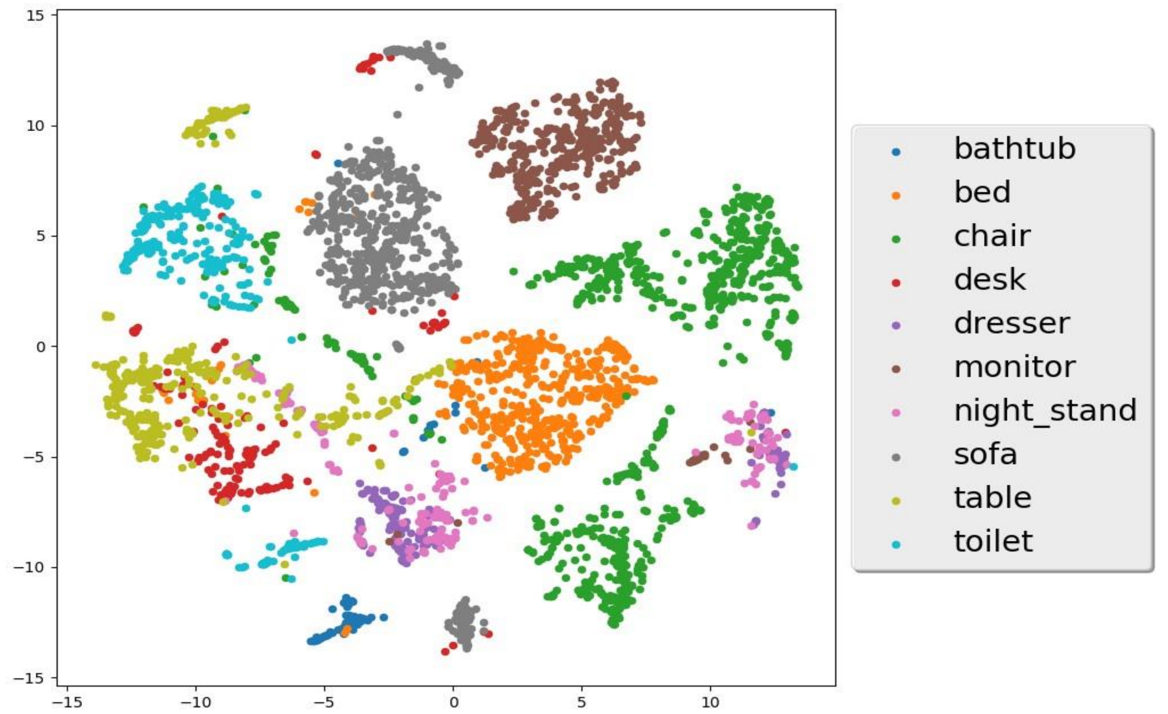
Universal approximation theorem

Different two-layer MLP can approximate different 2D → 3D mappings.

Our theorem

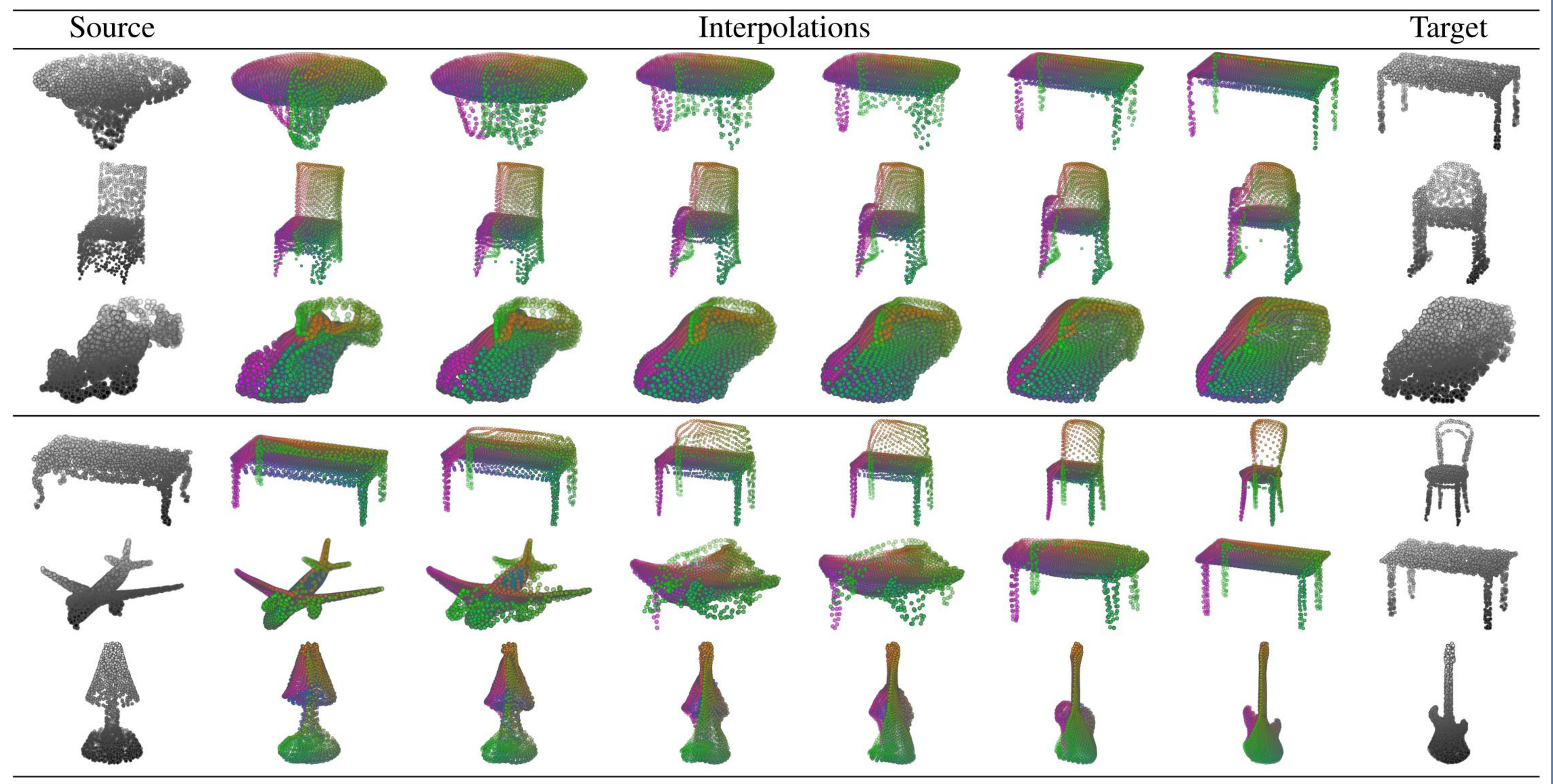
A single two-layer MLP can be tuned by the input "codeword" to approximate any arbitrary 2D → 3D mapping.

Generate Useful Representations



Features extracted by FoldingNet are useful in clustering .The results are obtained by applying T-SNE on codewords.

Generate Meaningful Interpolations

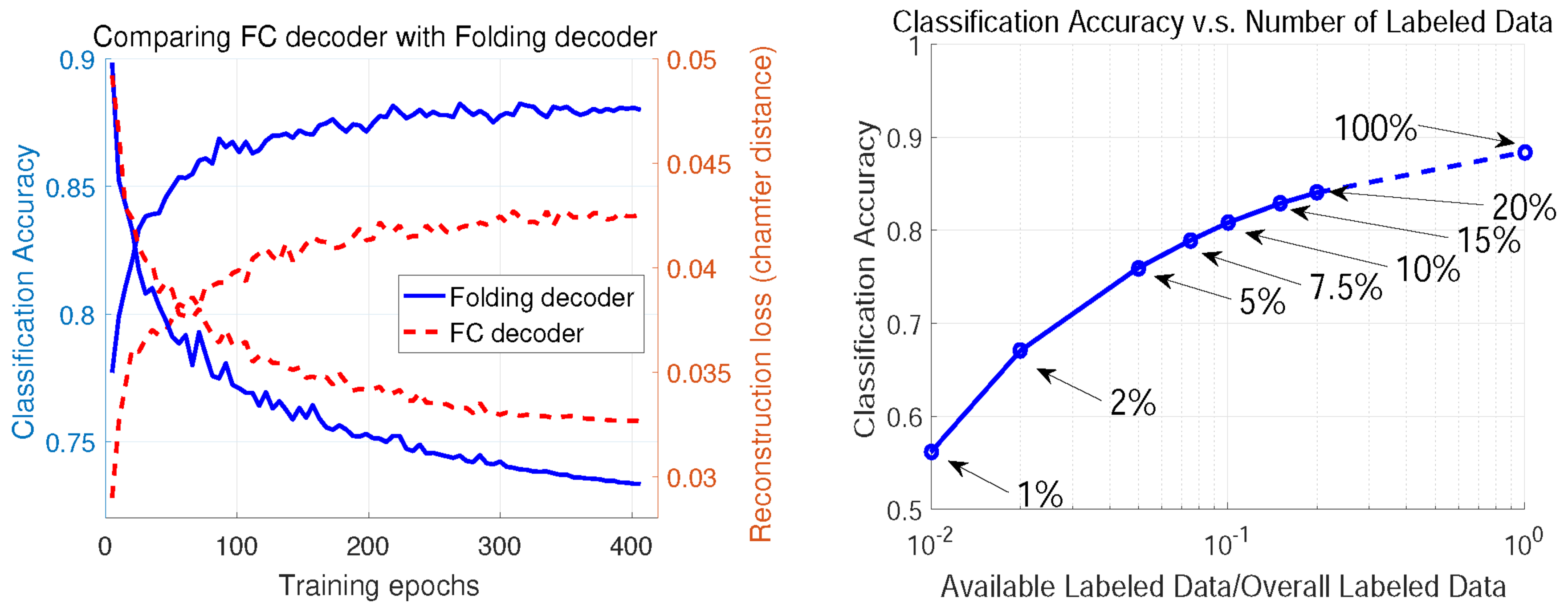


Upper: same model categories

Lower: different model categories

Generated using a single FoldingNet

Unsupervised and Semi-supervised Learning



Transfer Learning Using Linear SVM on ModelNet40

Method	Accuracy
SPH [Kazhdan, Funkhouser, Rusinkiewicz]	68.2%
LFD [Chen, Tian, Shen, Ouhyoung]	75.5%
T-L Network [Girdhar, Fouhey, Rodriguez, Gupta]	74.4%
VConv-DAE [Sharma, Grau, Fritz]	75.5%
3D-Gan [Wu, Zhang, Xue, Freeman, Tenenbaum]	83.3%
Latent-Gan [Achlioptas, Diamanti, Mitliagkas, Guibas]	85.7%
FoldingNet	88.4%

Ablation Study of the Decoder

Grid Setting	# Folds	Test Cls. Acc.	Test Loss
Regular 2D	2	88.25%	0.0296
regular 2D	3	88.41%	0.0290
regular 1D	2	86.71%	0.0355
regular 3D	2	88.41%	0.0284
uniform 2D	2	87.12%	0.0321

Different Folding Implementations

	Cls. Acc.	Test Loss	# Parameters
FoldingNet	88.41%	0.0296	1.0*10^6
Deconv	88.86%	0.0319	1.7*10^6