Implicit Autoencoder for Point-Cloud Self-Supervised Representation Learning

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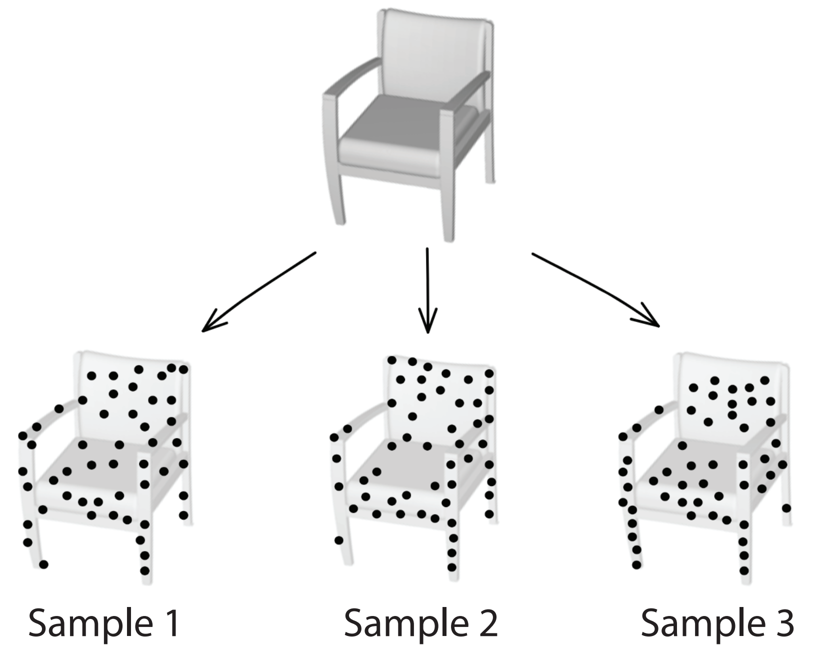
Introduction

This paper introduces the Implicit AutoEncoder (IAE), a simple yet effective method that advocates the use of implicit surface representation in autoencoder-based self-supervised 3D representation learning.

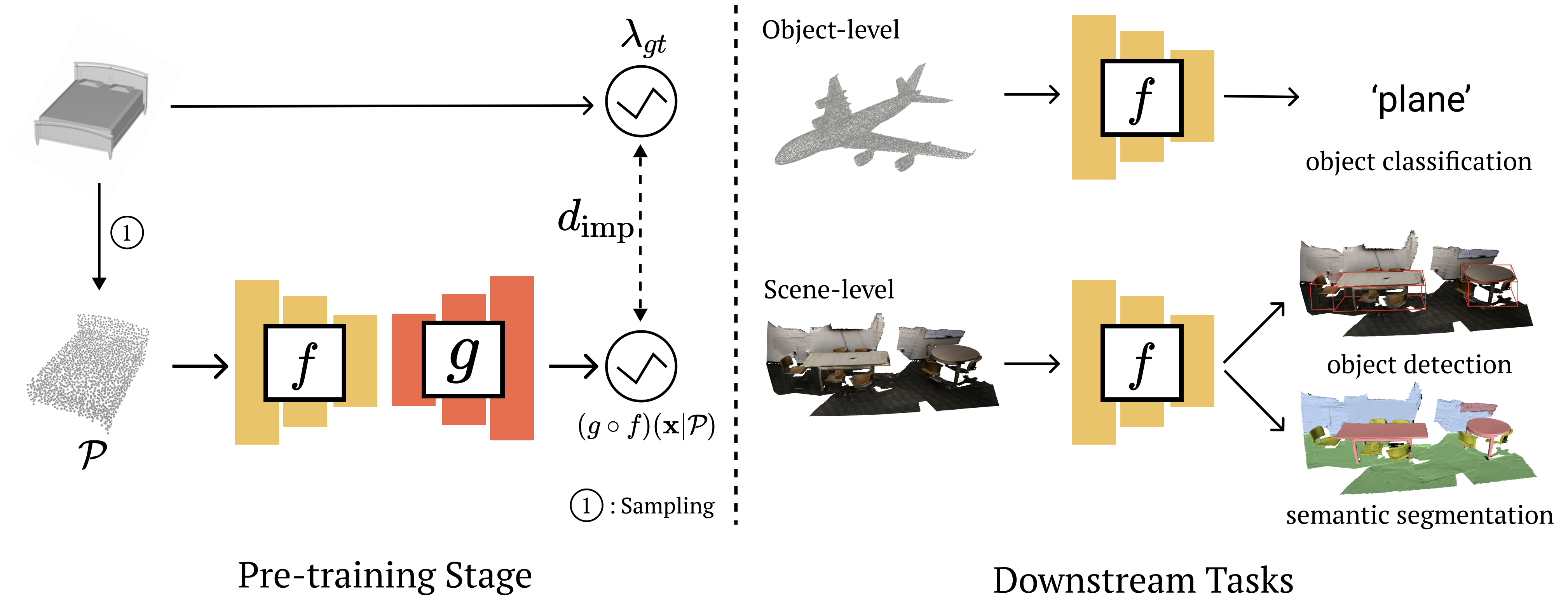
Motivation

Sampling Variation Problem



- Given a continuous 3D shape, there are infinitely many ways to sample a point cloud.
- In the standard autoencoding paradigm, the encoder is compelled to encode the specific discrete sampling of the 3D shape into the latent code.

Method



Experiment Results

Classification:

Method	#Params(M)	GFLOPS	ScanObjectNN			ModelNet40	
			OBJ_BG	OBJ_ONLY	PB_T50_RS	1k P	8k P
DGCNN	1.8	2.4	82.8	86.2	78.1	92.9	93.1
IAE (DGCNN)	1.8	2.4	**90.2**	**89.0**	**85.6**	**94.2**	**94.2**

Object Detection:

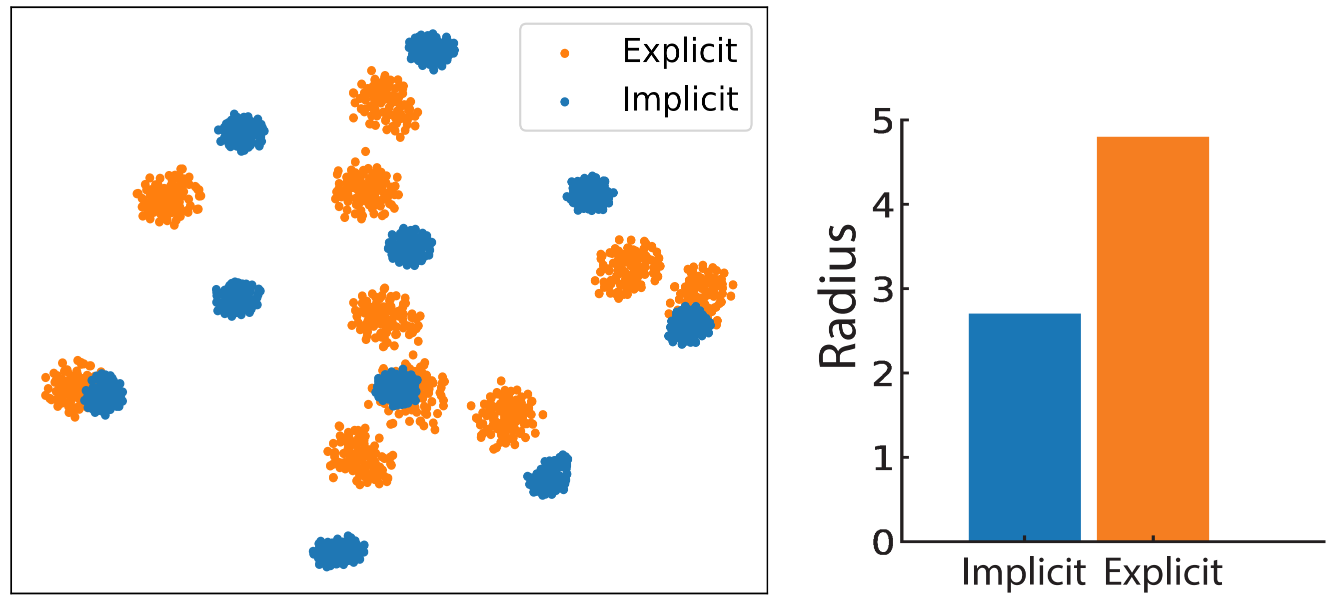
Method	ScanNet		SUN RGB-D	
	AP_{25}	AP_{50}	AP_{25}	AP_{50}
VoteNet	58.6	33.5	57.7	32.9
IAE (VoteNet)	**61.5**	**39.8**	**60.4**	**36.0**

Semantic Segmentation:

Method	S3DIS 6-Fold	
	OA	mIoU
DGCNN	84.1	56.1
IAE (DGCNN)	**85.9**	**60.7**

Codebase:

Experimental Analysis



(a) (b)

(a) T-SNE visualization for encoder latent codes of Implicit AE and Explicit AE

(b) The average cluster radius for IAE and EAE in (a).

Linear AE model Analysis

(1) Implicit autoencoding:

$$A^\star, Q^\star = \underset{A', Q' \in \mathbb{R}^{n\times m}}{\operatorname{argmin}} \sum_{k=1}^{N} \|A' Q'^T \boldsymbol{x}'_k - \boldsymbol{x}_k\|^2$$

$$s.t.\ Q'^T Q' = I_m,\ Q' \in \{C\}(X')$$

(2) Standard autoencoding:

$$\hat{A}^\star, \hat{Q}^\star = \underset{A', Q' \in \mathbb{R}^{n\times m}}{\operatorname{argmin}} \sum_{k=1}^{N} \|A' Q'^T \boldsymbol{x}'_k - \boldsymbol{x}'_k\|_{\mathcal{F}}^2$$

$$s.t.\ Q'^T Q' = I_m,\ Q' \in \{C\}(X')$$