Revisiting Point Cloud Classification: A New Benchmark Dataset and Classification Model on Real-World Data

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Visit our project page with datasets and code
https://hkust-vgd.github.io/scanobjectnn/

1. PROBLEM OVERVIEW

- In the recent years, deep learning for point cloud data have demonstrated great potentials in solving classical problems in 3D vision.
- Several recent methods have reported very high accuracies on object classification on CAD model datasets, such as ModelNet40.
- But, scans for real applications (eg. AR/VR) are very different from CAD.
- CAD vs Scans
  - CAD models are clean and synthetic.
  - Differences in low-level geometry caused by object clutter, occlusion, broken-ness, background, etc., present in scan data.

- ***Is point cloud classification close to being solved?***

2. CONTRIBUTIONS

SceneNN ScanNet

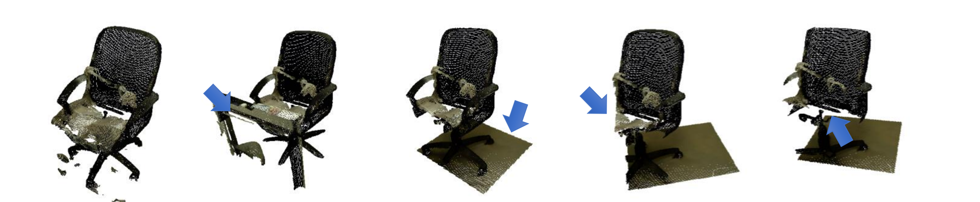
(1) We introduce a new object dataset of real-world scan data for point cloud classification by leveraging on state-of-the-art scene mesh datasets.

(2) We conduct a comprehensive benchmark on existing point cloud techniques on both synthetic and real-world data. Our benchmark also identifies three open problems: (i) ***handling object partiality***, (ii) ***handling background points***, and (iii) ***generalization between CAD and scan.***

(3) A new network architecture that is able to classify objects observed in a real-world setting by a joint learning of classification and segmentation.

3. SCANOBJECTNN

- ScanObjectNN contains **~15,000 objects** in **15 categories** with **2902 unique object instances.**
- Represented by a list of points with coordinates, normals, colors attributes and semantic labels.
- We also provide part annotations.

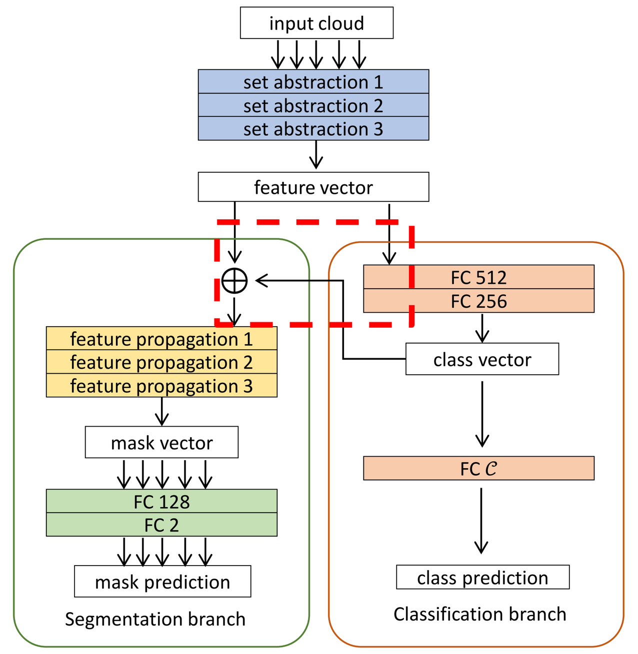


(a) OBJ_BG (b) PB_T25 (c) PB_T25_R (d) PB_T50_R (e) PB_T50_RS

Perturbation Variants

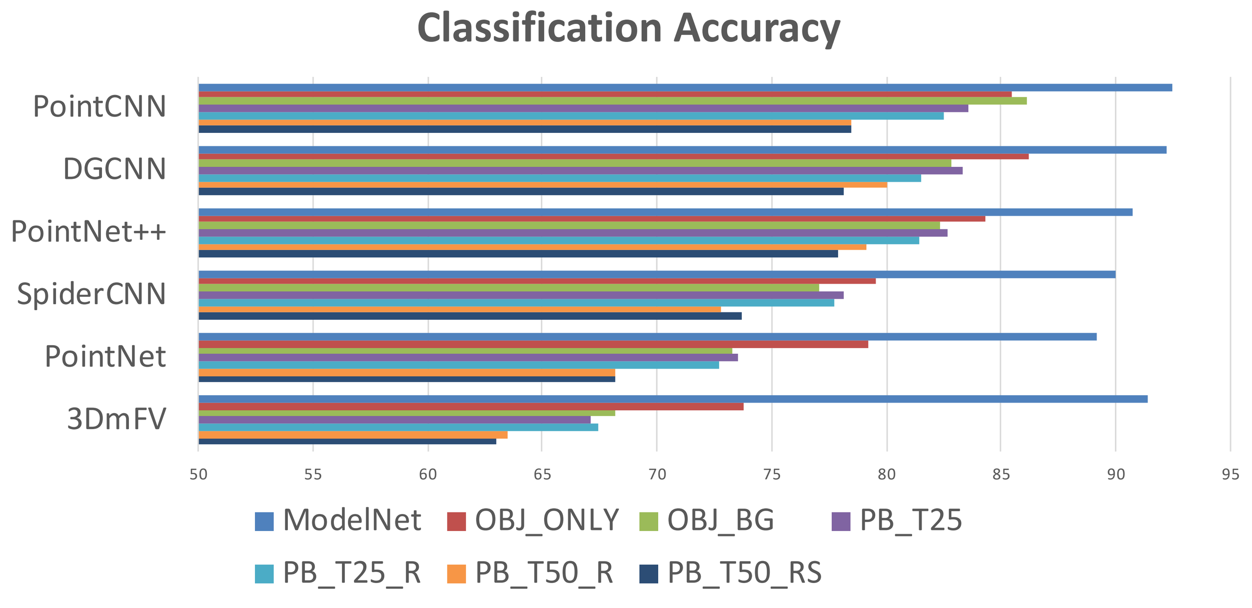
- Random translation, rotation and scale of the axis aligned bounding boxes.
- To introduce "noise" variations

4. OUR BACKGROUND-AWARE (BGA) MODEL



- The idea is to classify only based on object geometry and not on the background.
- Jointly classify and segment the point cloud to improve classification results on scans.
- Our **BGA-PN++** and **BGA-DGCNN** are based from PointNet++ and DGCNN.

5. EXPERIMENTS



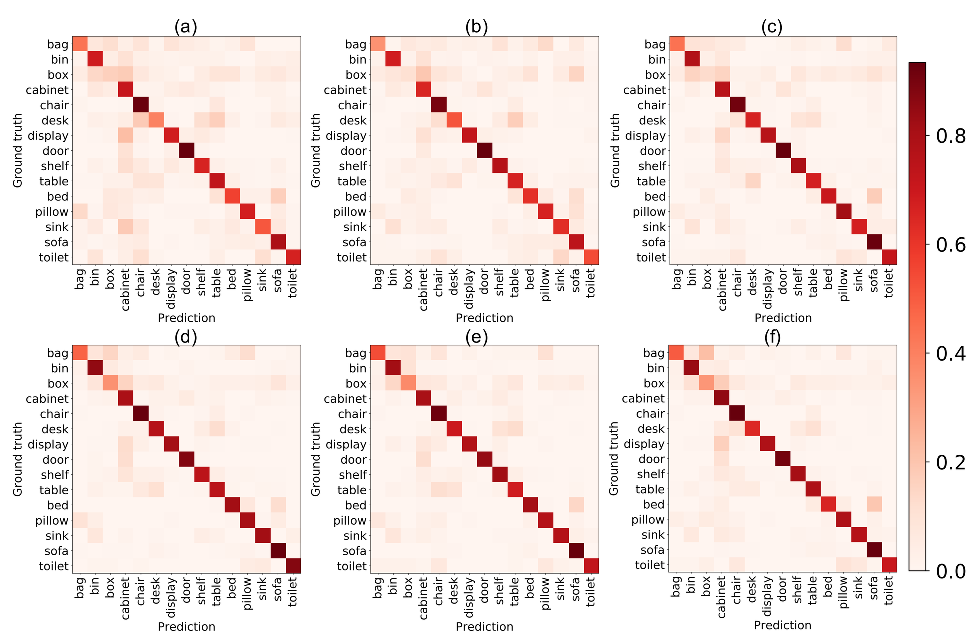
a.) Comparison between CAD and real performances

	OBJ_ONLY	PB_T25	PB_T25_R	PB_T50_R	PB_T50_RS
3DmFV [2]	30.9	28.4	27.2	24.5	24.9
PointNet [30]	42.3	37.6	35.3	32.1	31.1
SpiderCNN [44]	44.2	37.7	34.5	31.7	30.9
PointNet++ [32]	43.6	37.8	37.2	33.3	32.0
DGCNN [42]	49.3	42.4	40.3	36.6	36.8
PointCNN [25]	32.2	28.7	28.1	26.4	24.6

b.) Trained on CAD

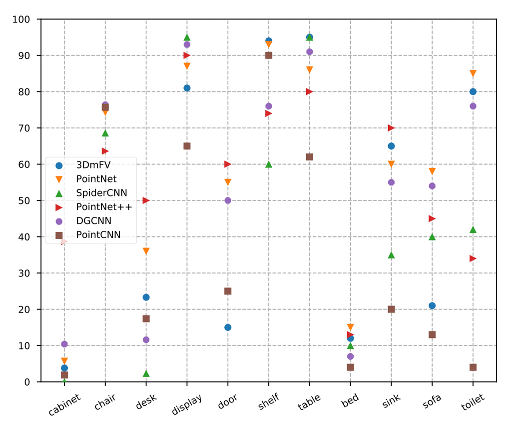
	OBJ_ONLY	OBJ_BG	PB_T25	PB_T25_R	PB_T50_R	PB_T50_RS
3DmFV [2]	73.8	68.2	67.1	67.4	63.5	63.0
PointNet [30]	79.2	73.3	73.5	72.7	68.2	68.2
SpiderCNN [44]	79.5	77.1	78.1	77.7	73.8	73.7
PointNet++ [32]	84.3	82.3	82.7	81.4	79.1	77.9
DGCNN [42]	86.2	82.8	83.3	81.5	80.0	78.1
PointCNN [25]	85.5	86.1	83.6	82.5	78.5	78.5

c.) Trained on ours

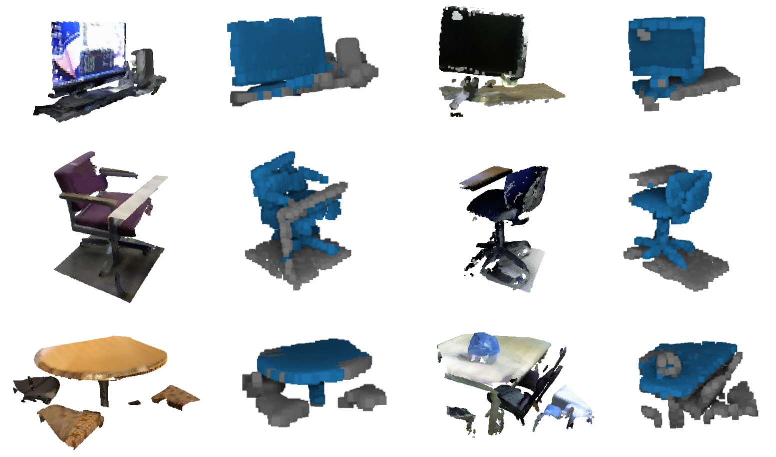


d.) Confusion matrices of the different methods on our hardest variant, *PB_T50_RS*

	cabinet	chair	desk	display	door	shelf	table	bed	sink	sofa	toilet
3DmFV [2]	20.8	67.1	**8.1**	75.0	75.0	86.0	97.0	10.0	50.0	21.0	64.0
PointNet [30]	**2.8**	72.1	43.0	83.0	100.0	98.0	93.0	**4.0**	35.0	23.0	26.0
SpiderCNN [44]	17.9	54.3	17.4	86.0	90.0	90.0	88.0	**7.0**	40.0	32.0	14.0
PointNet++ [32]	18.9	71.4	12.8	94.0	45.0	79.0	88.0	**2.0**	45.0	14.0	35.0
DGCNN [42]	47.2	75.7	11.6	94.0	85.0	83.0	100.0	**9.0**	45.0	42.0	12.0
PointCNN [25]	42.5	77.9	24.4	76.0	20.0	92.0	76.0	**4.0**	35.0	24.0	19.0



e.-f.) Per class accuracies on ModelNet common classes when trained on our *PB_T50_RS*. Results show **low accuracies** in classes (e.g. bed) where complete structures are never observed in scans.



g.) Segmentation results of our BGA-models.

	Ours		ModelNet40	
	OA	mAcc	OA	mAcc
3DmFV [2]	63.0	58.1	51.5	52.2
PointNet [30]	68.2	63.4	50.9	52.7
SpiderCNN [44]	73.7	69.8	46.6	48.8
PointNet++ [32]	77.9	75.4	47.4	45.9
DGCNN [42]	78.1	73.6	54.7	54.9
PointCNN [25]	78.5	75.1	49.2	44.6
BGA-PN++ (ours)	**80.2**	**77.5**	52.6	50.6
BGA-DGCNN (ours)	79.7	75.7	**56.5**	**57.6**

h.) Overall performances of the different models on our PB_T50_RS and ModelNet when trained only on PB_T50_RS. Results show the superior performance of our BGA models.