7TH IPRIA
INTERNATIONAL CONFERENCE ON PATTERN RECOGNITION AND IMAGE ANALYSIS

دانشگاه آزاد اسلامی
واحد لاهیجان

انجمن ماشین بینایی و پردازش تصویر ایران

Enhancing 3D Point Cloud Classification with **ModelNet-R** and **Point-SkipNet**

M. Saeid A. Salarpour P. MohajerAnsari

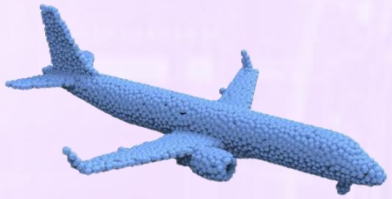
Sirjan University of Technology, Iran Clemson University, USA

Introduction

LiDAR

Introduction

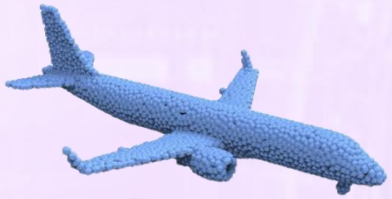
LiDAR



3D Points

Introduction

LiDAR



3D Points

Classifier

airplane

Introduction

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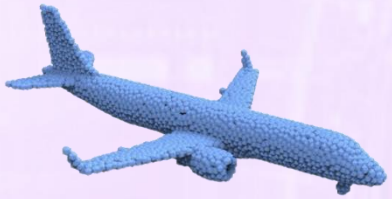


3D Points

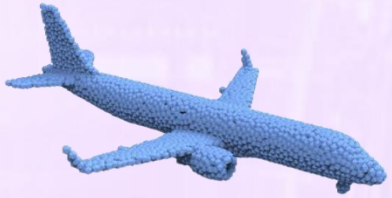
Autonomous Vehicles

Classifier

airplane

Introduction

LiDAR



3D Points

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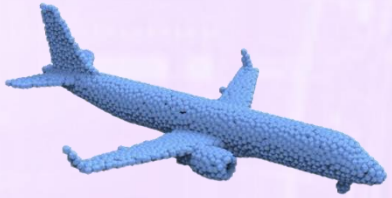
airplane

Autonomous Vehicles

Robotics

Introduction

LiDAR



3D Points

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airplane

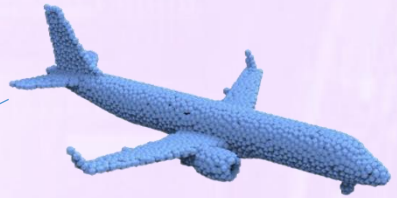
Autonomous Vehicles

Robotics

AR/VR

Research Motivation

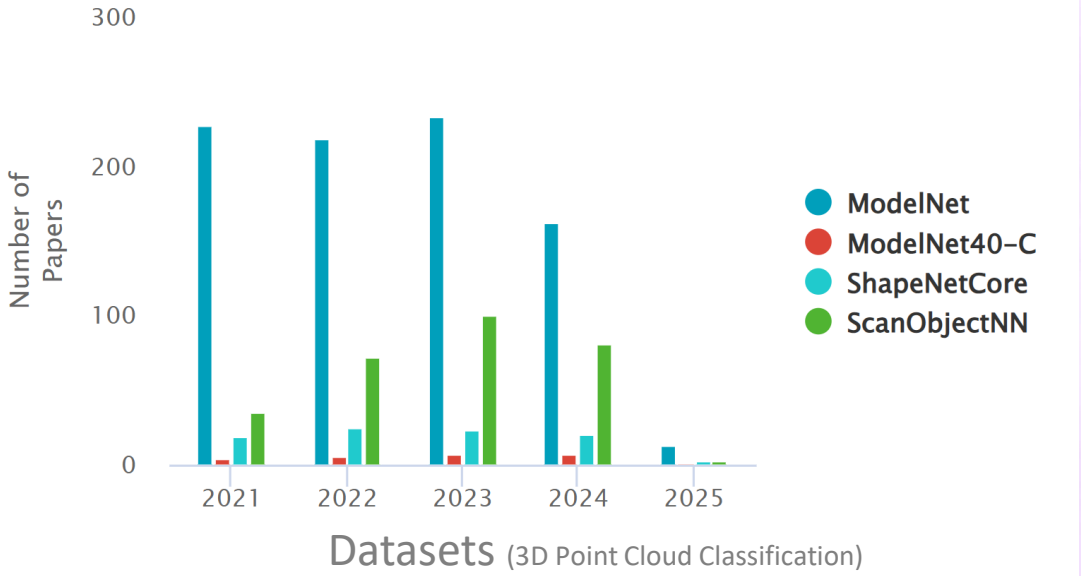
LiDAR



Classifier

Efficient Model

airplane



https://paperswithcode.com/dataset/modelnet

Research Motivation

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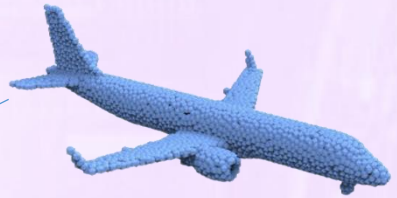
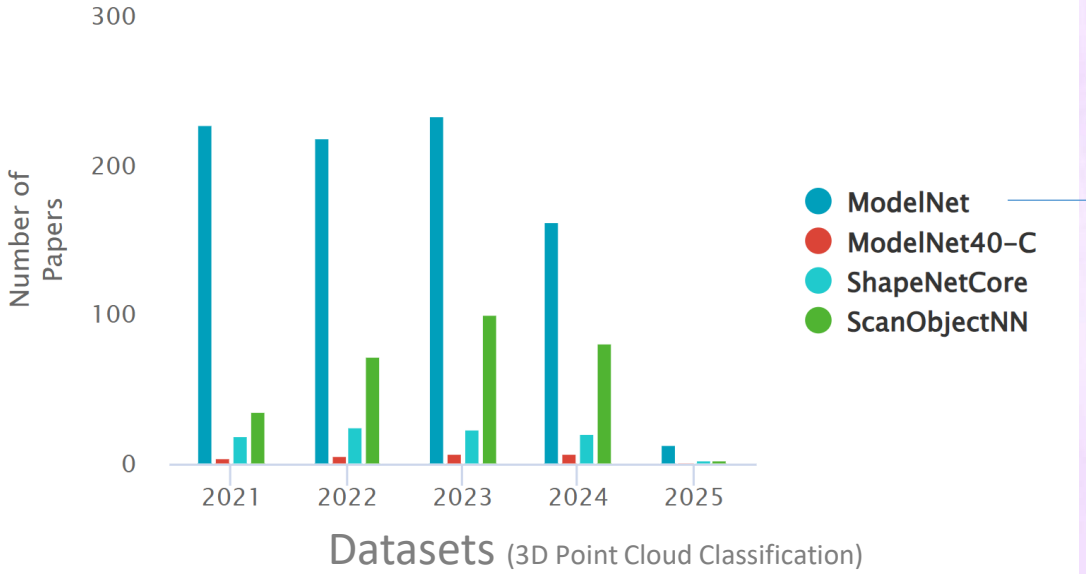


Classifier

airplane

Efficient Model



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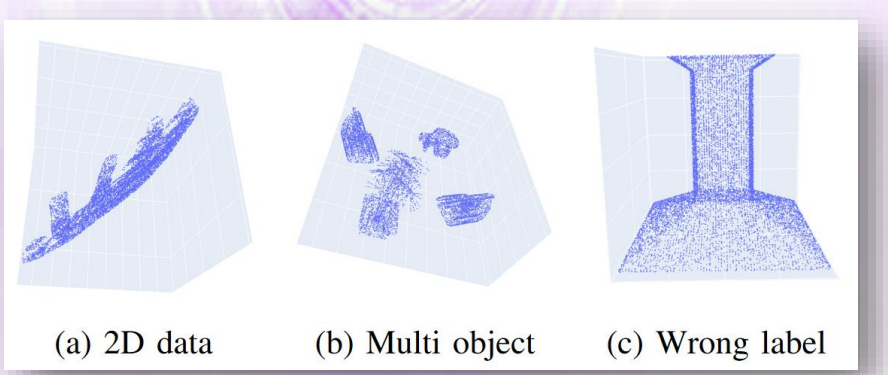
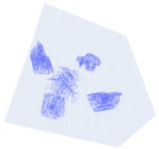
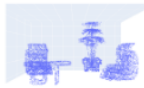
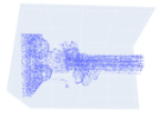
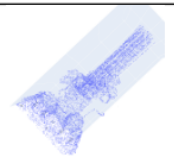
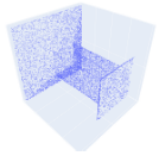
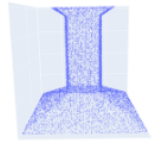


Contributions

- **ModelNet-R** (Refined dataset)
- **Point-SkipNet** (Efficient model)
- **Comprehensive evaluation on ModelNet and ModelNet-R**

ModelNet-R: Dataset Refinement

Instance		Modified Label	Label in the Dataset
		Remove	Plant
		Remove	Plant
		Range hood	Vase

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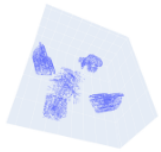
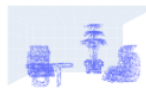
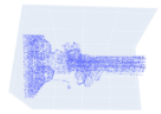
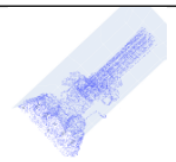
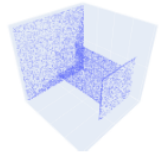
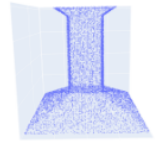
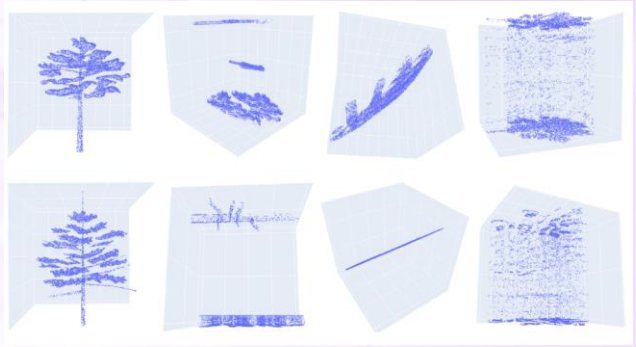
		Remove	Plant
		Remove	Plant
		Range hood	Vase



ModelNet-R: Dataset Refinement

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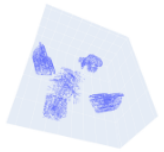
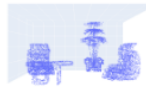
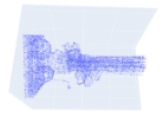
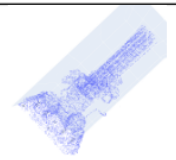
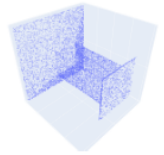
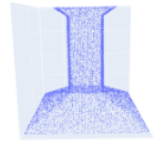
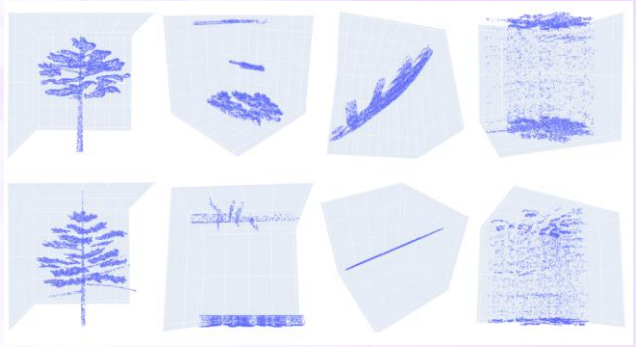
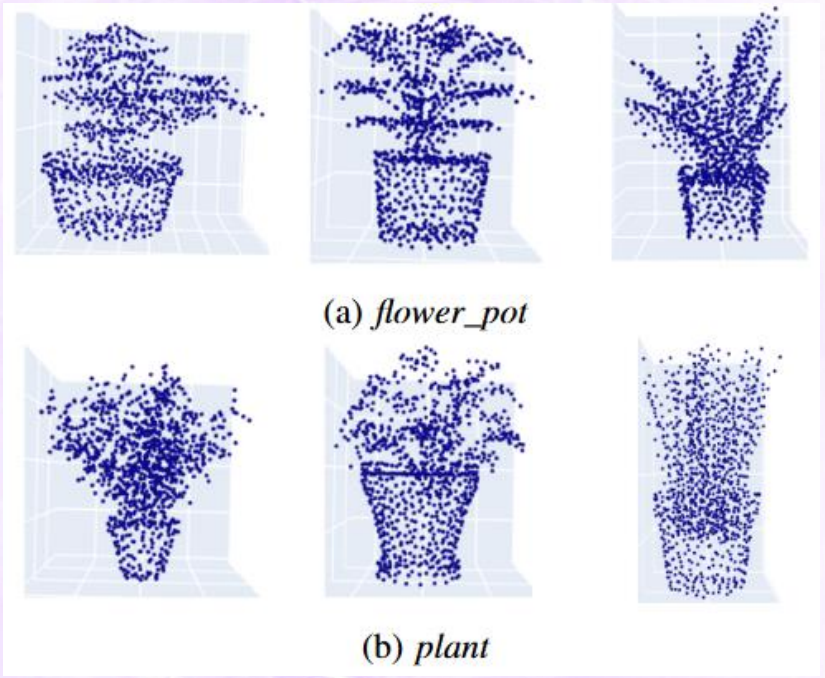
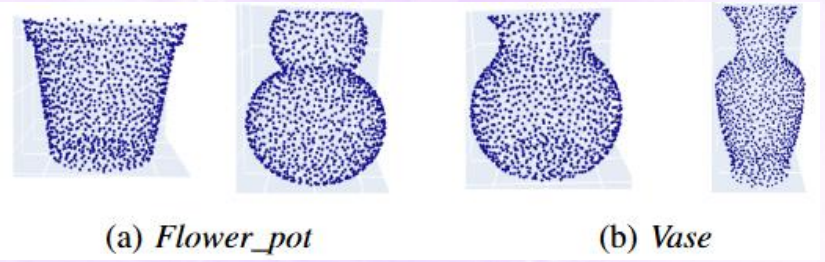
		Remove	Plant
		Remove	Plant
		Range hood	Vase





(a) *flower_pot*

(b) *plant*



(a) *Flower_pot* (b) *Vase*

ModelNet-R: Dataset Refinement

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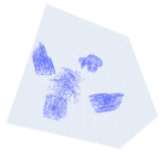
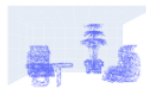
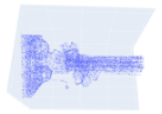
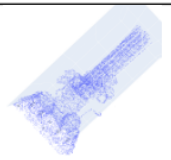
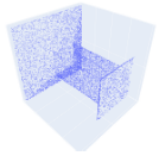
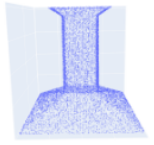
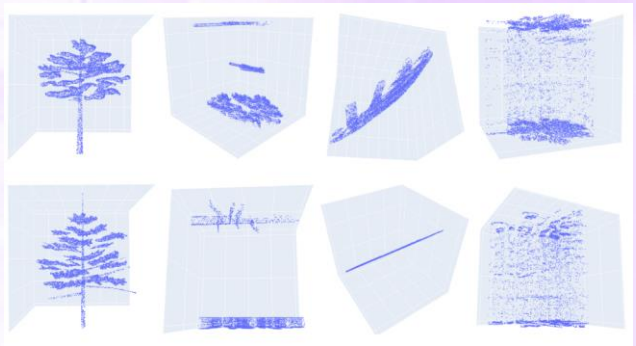
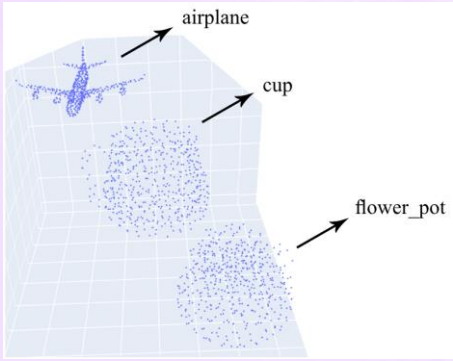
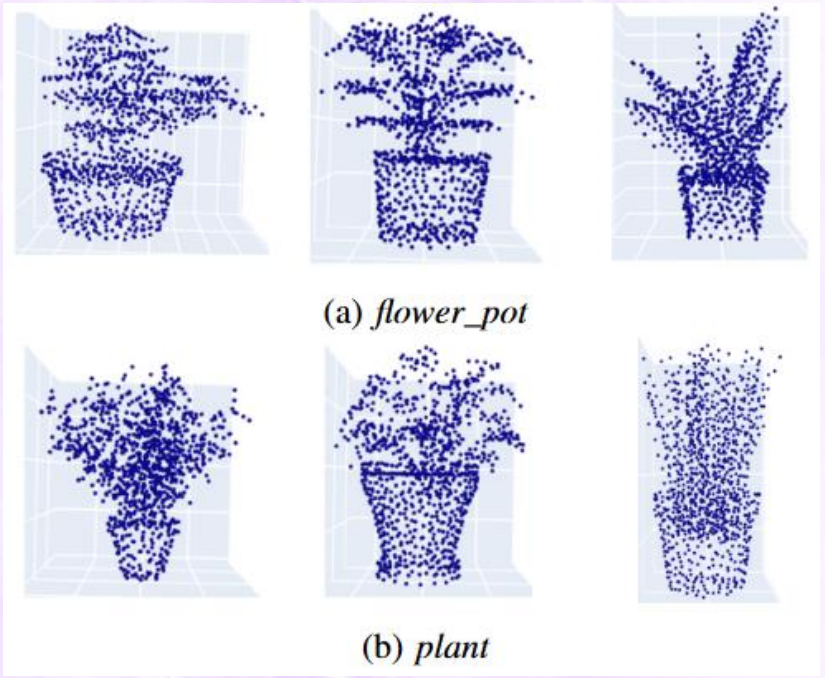
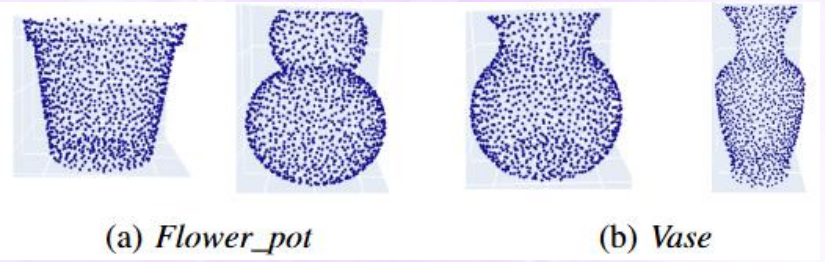
		Remove	Plant
		Remove	Plant
		Range hood	Vase







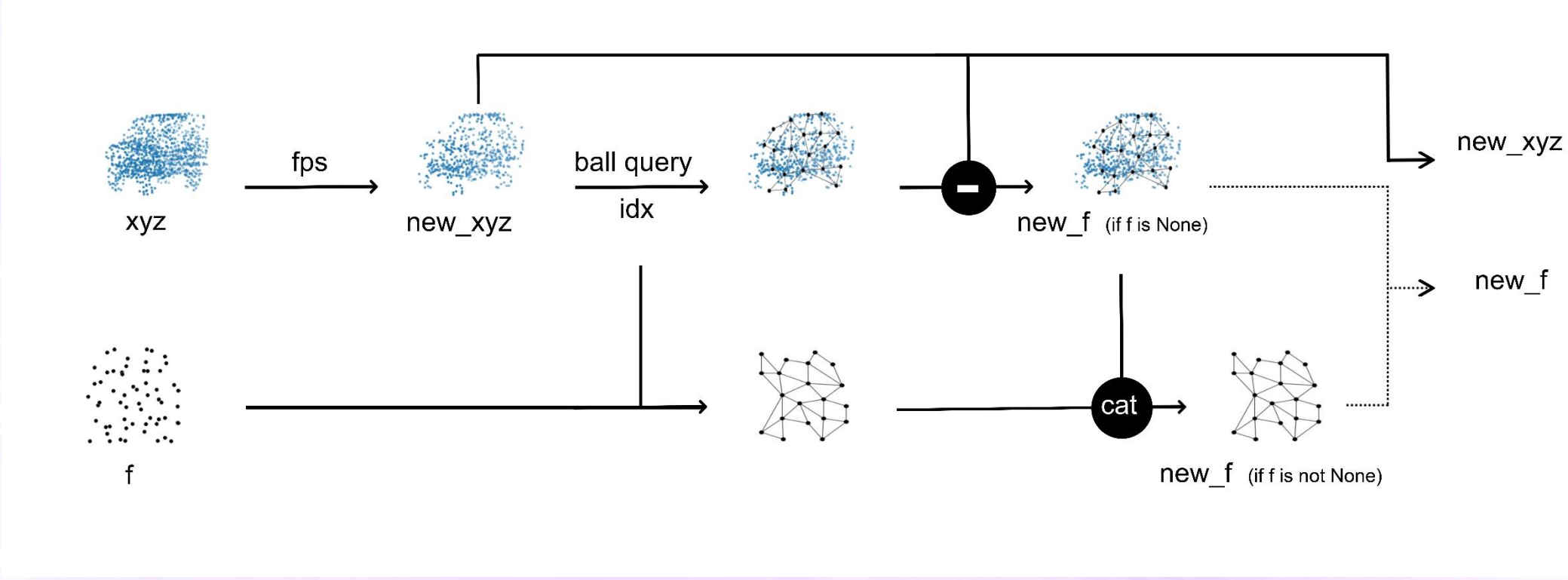


ModelNet-R: Dataset Refinement

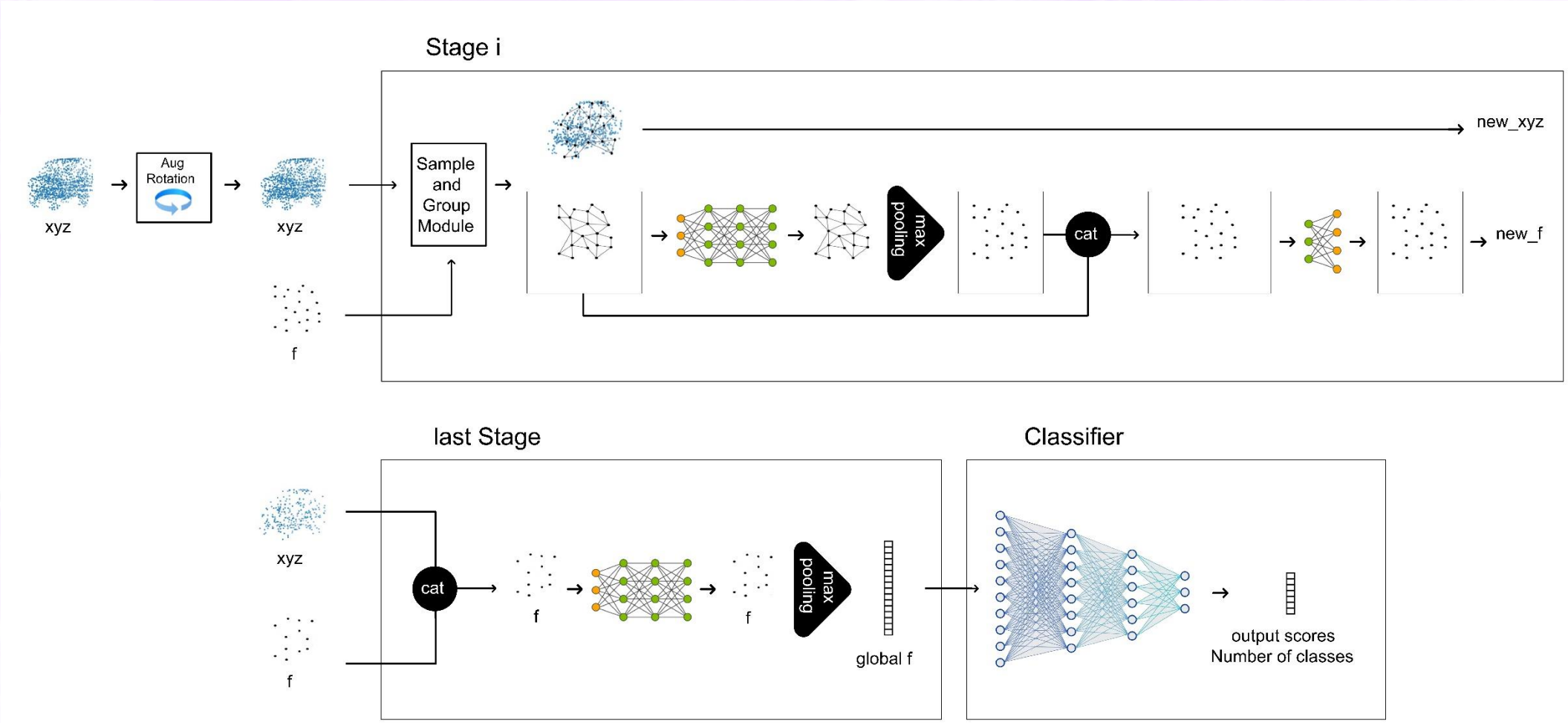
- **Plant**: Contains **only plant** samples
- **Flower Pot**: Includes **both the plant and the pot**
- **Vase**: Restricts objects to empty **pots without plants**
- **Cup**: Consists of **cups with handles**
- **Bowl**: Encompasses **wide, low-height hemispherical shapes**

Class	Flower_Pot	Plant	Vase	Cup	Bowl	Removed	Total
Flower_Pot	91	0	72	0	5	1	169
Plant	171	152	0	0	0	16	339
Vase	0	0	571	0	2	2	575
Cup	0	0	55	43	1	0	99
Bowl	0	0	24	0	60	0	84
Total	262	152	722	43	68	19	1266

Sample and Group Module



Point-SkipNet Architecture



Experimental Setup

Model
PointNet [30]
PointNet++ (SSG) [31]
PointNet++ (MSG) [31]
Point-NN [42]
DG-CNN [32]
CurveNet [38]
PointMLP [10]
Point-SkipNet (Proposed)

Experimental Setup

Model	Original Dataset	
	OA (%)	mAcc (%)
PointNet [30]	89.20	86.00
PointNet++ (SSG) [31]	-	-
PointNet++ (MSG) [31]	90.70	-
Point-NN [42]	81.80	-
DG-CNN [32]	92.90	90.20
CurveNet [38]	93.80	-
PointMLP [10]	94.10	91.10
Point-SkipNet (Proposed)	92.29	89.84

Experimental Setup

Model	Original Dataset		ModelNet-R	
	OA (%)	mAcc (%)	OA (%)	mAcc (%)
PointNet [30]	89.20	86.00	91.39	88.79
PointNet++ (SSG) [31]	-	-	94.02	92.40
PointNet++ (MSG) [31]	90.70	-	94.06	91.80
Point-NN [42]	81.80	-	84.75	77.65
DG-CNN [32]	92.90	90.20	94.03	92.64
CurveNet [38]	93.80	-	94.12	92.65
PointMLP [10]	94.10	91.10	95.33	94.30
Point-SkipNet (Proposed)	92.29	89.84	94.33	92.93

Experimental Setup

Model	Original Dataset		ModelNet-R		Performance Improvement	
	OA (%)	mAcc (%)	OA (%)	mAcc (%)	Δ OA (%)	Δ mAcc (%)
PointNet [30]	89.20	86.00	91.39	88.79	+2.19	+2.79
PointNet++ (SSG) [31]	-	-	94.02	92.40	+1.91	+4.16
PointNet++ (MSG) [31]	90.70	-	94.06	91.80	+3.36	+1.80
Point-NN [42]	81.80	-	84.75	77.65	+3.95	+2.58
DG-CNN [32]	92.90	90.20	94.03	92.64	+1.13	+2.44
CurveNet [38]	93.80	-	94.12	92.65	+0.32	+2.70
PointMLP [10]	94.10	91.10	95.33	94.30	+1.23	+3.20
Point-SkipNet (Proposed)	92.29	89.84	94.33	92.93	+2.04	+3.09

Experimental Setup

Model	Original Dataset		ModelNet-R		Performance Improvement		Parameters (M)
	OA (%)	mAcc (%)	OA (%)	mAcc (%)	Δ OA (%)	Δ mAcc (%)	
PointNet [30]	89.20	86.00	91.39	88.79	+2.19	+2.79	3.47
PointNet++ (SSG) [31]	-	-	94.02	92.40	+1.91	+4.16	1.47
PointNet++ (MSG) [31]	90.70	-	94.06	91.80	+3.36	+1.80	1.74
Point-NN [42]	81.80	-	84.75	77.65	+3.95	+2.58	0.00
DG-CNN [32]	92.90	90.20	94.03	92.64	+1.13	+2.44	1.80
CurveNet [38]	93.80	-	94.12	92.65	+0.32	+2.70	2.04
PointMLP [10]	94.10	91.10	95.33	94.30	+1.23	+3.20	12.60
Point-SkipNet (Proposed)	92.29	89.84	94.33	92.93	+2.04	+3.09	1.47

Ablation Study

TABLE V: Impact of Data Augmentation Techniques

Augmentation Mode	OA (%)	mAcc (%)
Main	93.72	92.56
All Augmentations	93.49	92.25
Anisotropic Scaling	93.76	92.59
Jitter	93.56	92.19
Rotation	93.93	92.55
Translation	93.75	92.49

TABLE VI: Effect of Skip Connection Modes

Skip Connection Mode	OA (%)	mAcc (%)
Concatenation	93.79	92.49
Addition	93.64	92.09

Limitations and Future Work

- Refinement applied to only **5 of 40 ModelNet40 classes** > Extend dataset refinement to **all ModelNet40 classes**
- **Size-related information** lost in normalization > techniques that **retain size-related information**
- Model only tested on **ModelNet** and **ModelNet-R** > ScanObjectNN

Conclusion

- **ModelNet-R improves dataset reliability**
- **Point-SkipNet achieves high accuracy with lower computational cost**
- **High-quality datasets are crucial for improving 3D models**

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Thank You!
Questions and Answers