A Survey on 3D Point Cloud Compression Using Machine Learning Approaches

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Outline

- Introduction
- Autoencoders
- Fully Connected Neural Networks
- Recurrent Neural Networks
- Conclusion

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INTRODUCTION

- What is a Point cloud?
  - Geometry -> 3D coordinates
  - Attributes -> color information or normal vectors

Point Cloud	
Geometry	Attribute

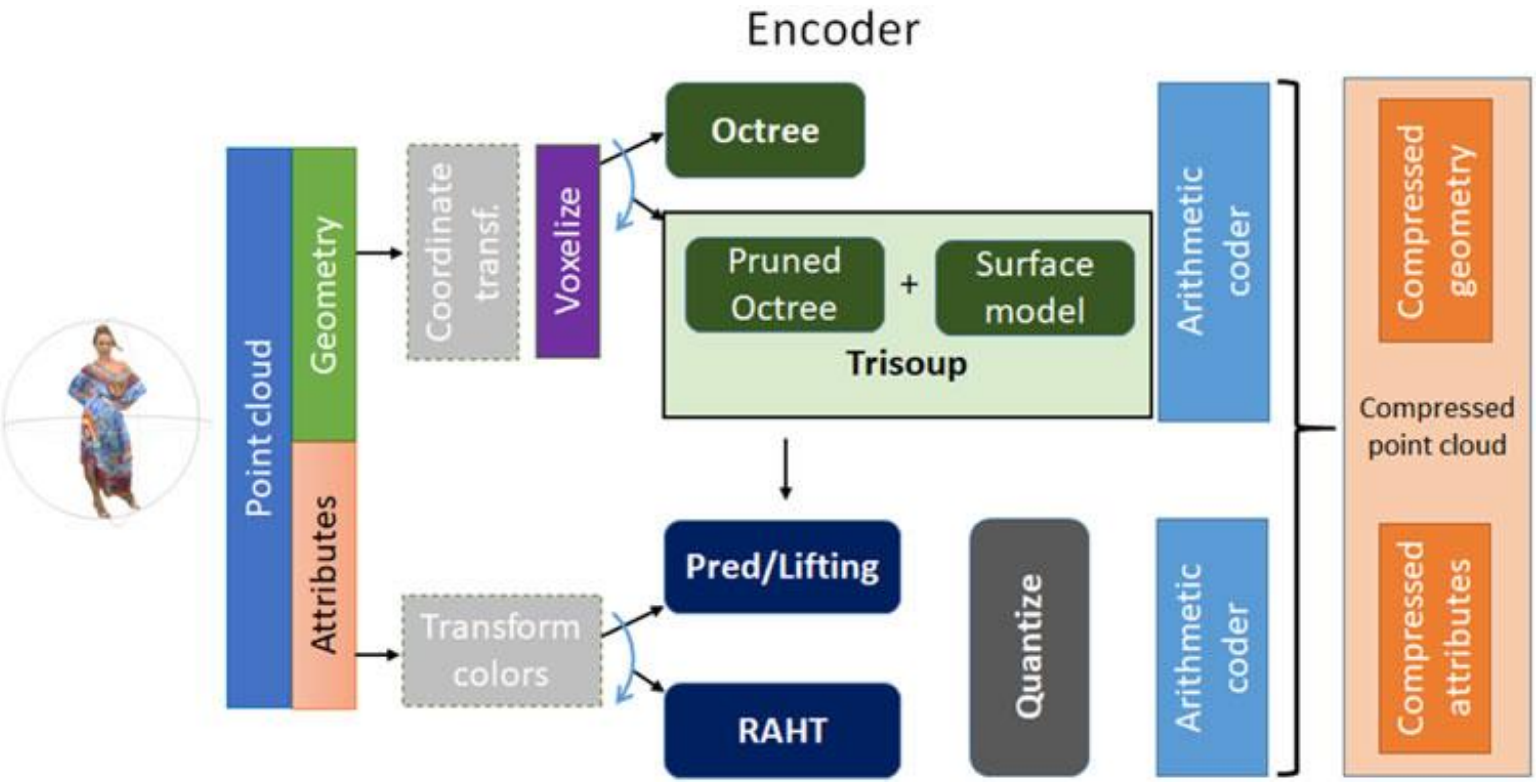
- Applications: Cultural heritage, Autonomous driving, Robotics etc.
- Need of Point Cloud Compression.
- MPEG PCC standardization:

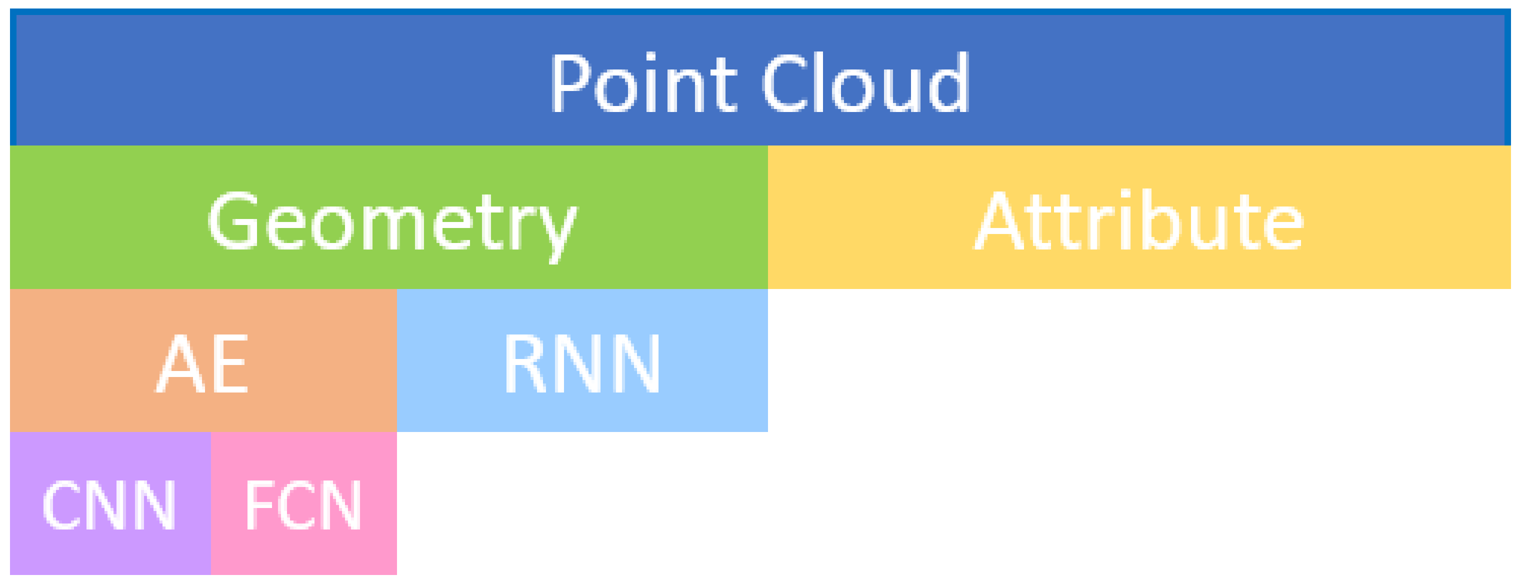
PCC

V-PCC G-PCC

OVERVIEW

- Machine learning for media applications.
- Traditional Vs Machine learning based techniques.





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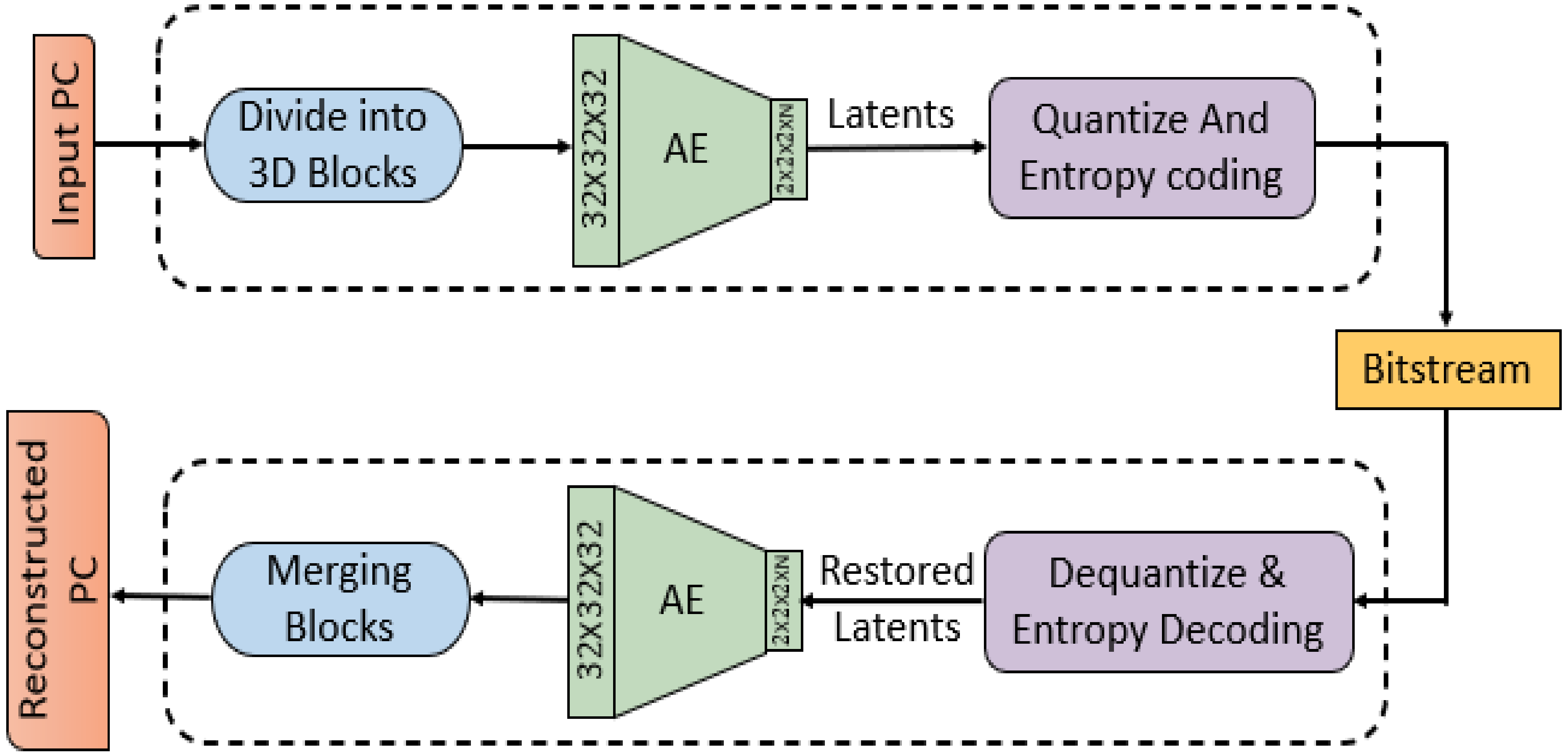
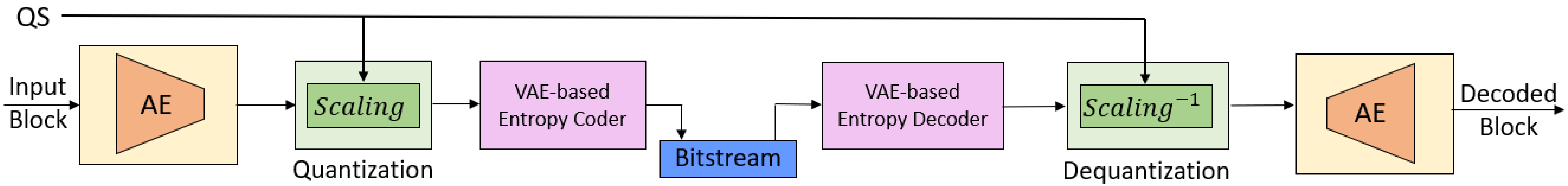
POINT CLOUD GEOMETRY AUTOENCODER

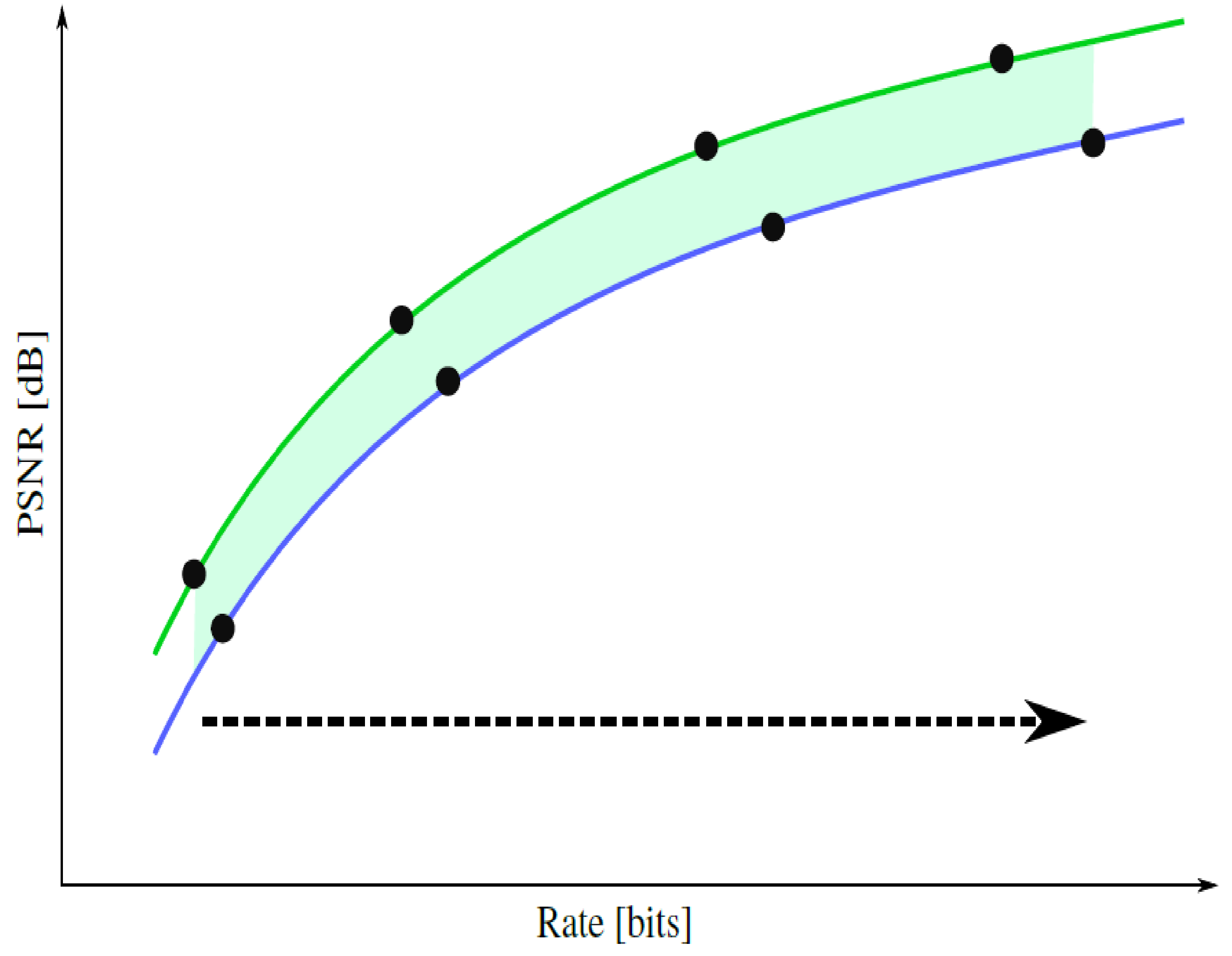
- CNNs: Most effective in extracting features.
- Characteristics found in images and videos.
- PCG-AE: Basic implementation.
- Occupancy signaled by ‘1’ and ‘0’.
- Adaptive forward and Inverse Transform.
- Four models, for N = 32, 64, 96 and 128.
- MPEG dataset, PCL as benchmark, RD performance.



RD CONTROL THROUGH IMPLICIT AND EXPLICIT QUANTIZATION



- Implicit ($Loss = dist + \lambda \times rate$) Vs Explicit (QS).
- Solves the multiple models training problem.
- Cover wide range of bitrates.
- Reduces training complexity and memory requirements.



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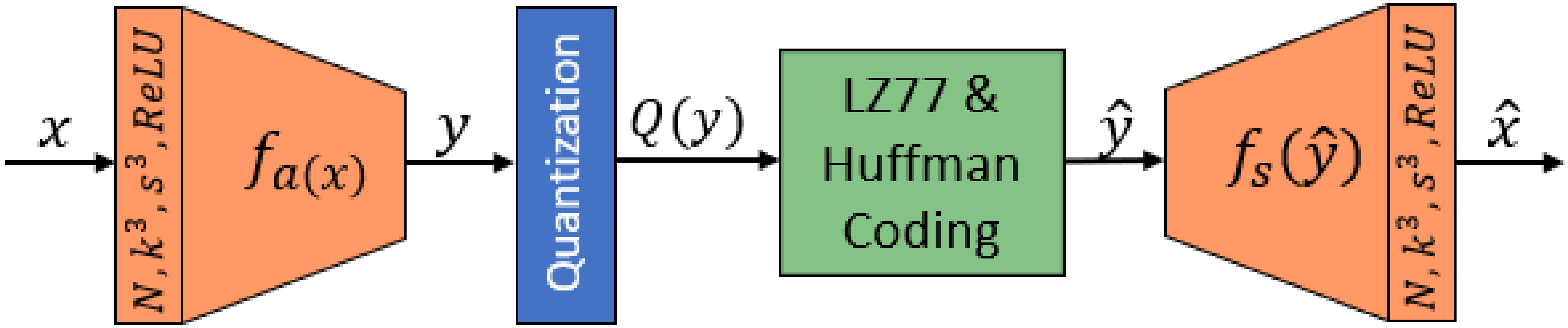
LEARNED CONVOLUTIONAL TRANSFORMS



- Directly operates on voxels and decoding-> Classification problem
- Analysis and synthesis transform.
- Number of filters, filter size and strides.
- Convolution and transpose convolution.
- Trained on ModelNet40, Tested on MVUB, MPEG anchor (51.5%).

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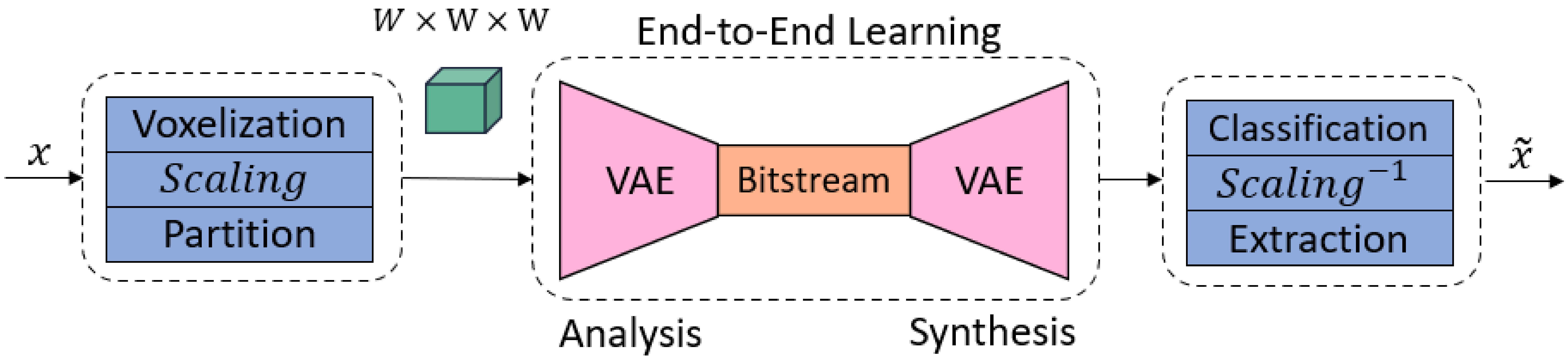
LEARNED PC GEOMETRY COMPRESSION



- Preprocessing: Voxelization is an optional step, Scaling ($\times\ s$) to reduce sparsity, Partition into non-overlapping blocks and metadata.
- VAE based encoder with Voxeption Resnet (VRN).
- Extraction: Volumetric to raw format.
- End-to-End training by changing λ.
- Training: ShapeNet, Testing: MPEG and JPEG Pleno.
- Outperforms GPCC and PCL (>50%).

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DEEP AE-BASED POINT CLOUD GEOMETRY COMPRESSION

- Advantages of CNNs: Retain spatial relations and weight sharing.
- FCNN: It works directly on the geometry coordinate.
- Filters in each layer: 64, 128, 128, 256 and k (no. of input points).
- ShapeNet with 90%, 10% split from a single class.
- MPEG-GPCC: 73.17% average gain.

$$z = D(Q(E(S(x))))$$

$$d_{CH}(S_1, S_2) = \sum_{x \in S_1} \min_{y \in S_2} ||x - y||_2^2 + \sum_{y \in S_2} \min_{x \in S_1} ||x - y||_2^2$$

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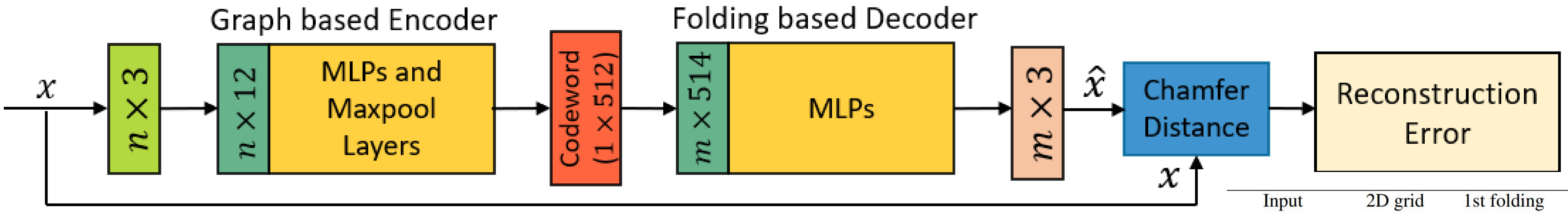
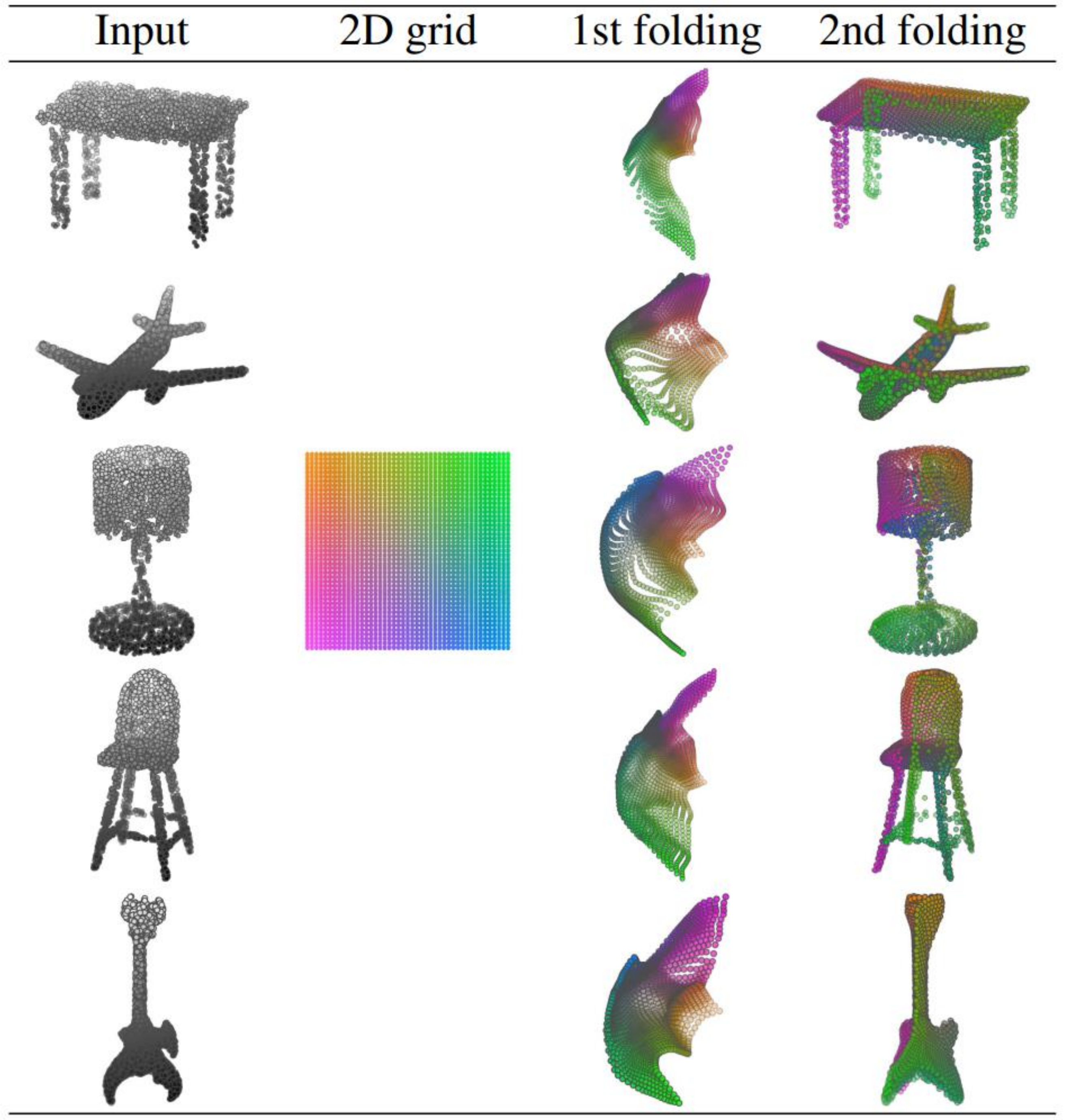
FOLDING NET: DEEP GRID FORMATION

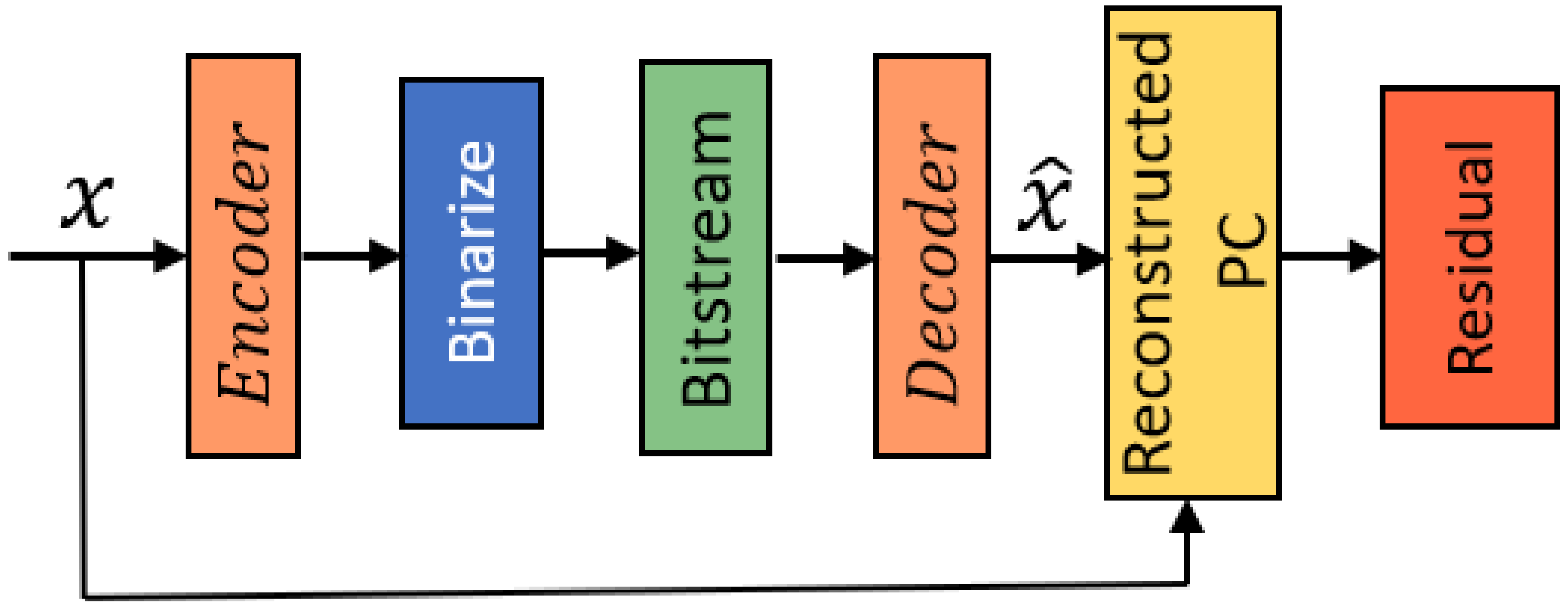




- Voxelization is performed to make CNN more meaningful.
- However, it sacrifices the original representation.
- Folding operation: 2D to 3D mapping.
- Starts with random folding.
- ShapeNet dataset and uses only 7% parameters of a FC decoder.

RECURRENT NEURAL NETWORK (RNN)

- Limited research on usage of RNN for PCC.
- Focused on data from 3D LiDAR sensors (Driving data from 11 areas of Japan)
- Challenging data to compress and hence works on raw packets.
- Raw packets to 2D matrices losslessly.
- Uses residual blocks for accurate decompression.



CONCLUSION

COMPARISON OF MACHINE LEARNING BASED METHODS FOR PCC.

	Feature	Technique	Dataset	Benchmark	Metrics	Loss Function	Optimizer
CNN	Geometry	CNN-based AE	MPEG	PCL	RD curve, D1	SGD (BCE)	Adam
CNN	Geometry	CNN-based AE	MPEG	MPEG GPCC	RD curve, D1	RD Loss	-
CNN	Geometry	3D CNN AE	Train: ModelNet40 Test: MVUB	MPEG GPCC	D1, D2	RD Loss	Adam
CNN	Geometry	3D Stacked CNN	Train: ShapeNet Test :MPEG, JPEG	MPEG GPCC, PCL MPEG VPCC	D1, D2	RD Loss WBCE	-
FCNN	Geometry	FCNN, MLPs	ShapeNet	MPEG GPCC	D1	RD Loss Chamfer Dist	Adam
FCNN	Geometry	Folding-based NN	ShapeNet ModelNet10	Fully connected decoder	-	Chamfer Dist	Adam
RNN	Geometry	RNN	TierIV	Octree, JPEG	SNNRMSE	-	-

- An emerging research area of PCC using ML/DL.
- Most existing work focuses on geometry compression.
- Most common choice is CNN-based AE with few FCNN and even fewer RNN.

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Thank You!

Questions?