Non-uniform Partitioning for Graph-based Point Cloud Attribute Coding

Thibaut Meyer, Christian Rohlfing

Institut für Nachrichtentechnik, RWTH Aachen University

Introduction

Point clouds

- 3D collection of points representing objects
- Geometry: points in space $V_i = (x, y, z) \in \mathbb{R}^3$
- Attributes: colors $A_i = (r, g, b) \in [0, 255]^3$

Coding process

- Geometry and attributes encoded separately
- Geometry usually encoded first
- Full knowledge of geometry assumed at the decoder

Classic approaches (e.g. G-PCC, [1])
Point clouds split into blocks of fixed size b using octree partitioning

- Only uses geometry information
- Trivial to reproduce at decoder

Attribute Compression using Block-based Graph Fourier Transform

Reference method [1]: Graph Fourier Transform (GFT) applied on graph representations of point cloud blocks to decorrelate attributes

New approach: Blocks obtained using Cluster-based partitioning

⇒ Smooth geometry and attributes within blocks enhance compression

- Partitioning attribute-aware at encoder
- Side information necessary for decoder to reproduce partitioning

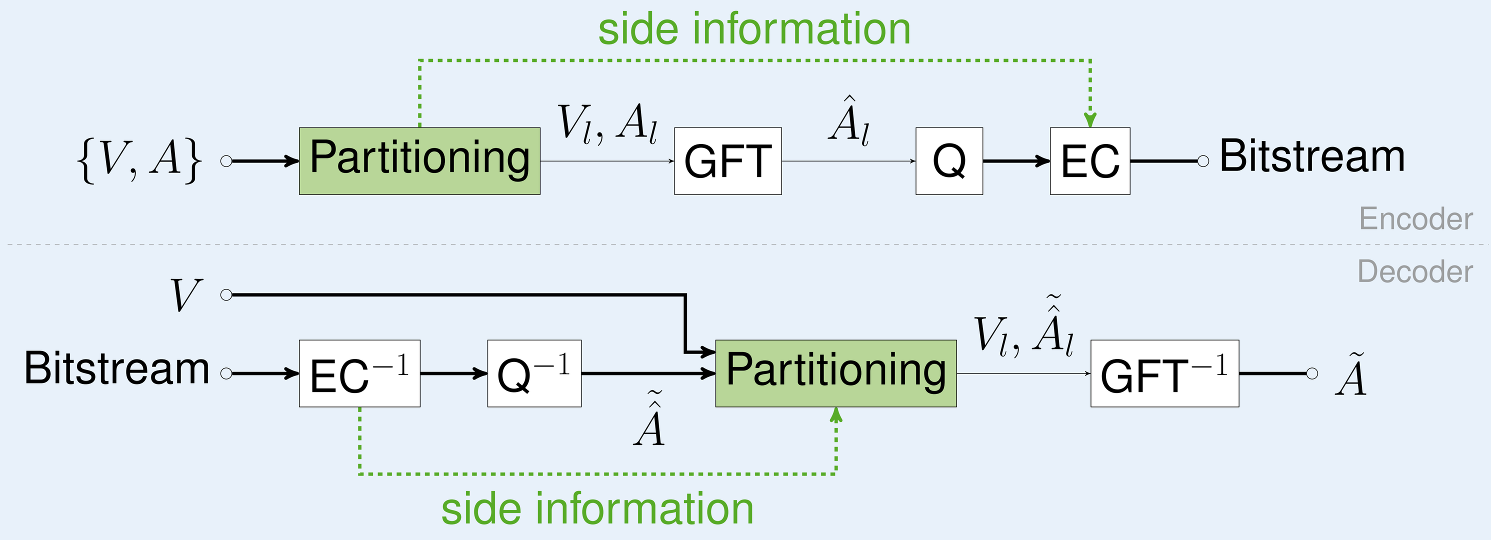


Fig. 1: Point cloud attribute compression scheme [1] with modified blocks

Clustering-based Partitioning

Batch k-means [2] on both geometry and attributes to partition points into k blocks

$$X_i = \begin{pmatrix} \bar{V}_i \\ \lambda \bar{A}_i \end{pmatrix} \in \mathbb{R}^6$$

V_i, A_i scaled to zero mean and unit variance

λ controls importance of attributes

Partition labels update rule

$$L_{VAi} = \arg\min_j \|\bar{V}_i - C_{Vj}\|_2 + \lambda \|\bar{A}_i - C_{Aj}\|_2$$

Side information
Quantization and transmission of k geometry centers $C_{Vj} \in \mathbb{R}^3$

Decoder
Partition labels L_V obtained using C_V

$$L_{Vi} = \arg\min_j \|\bar{V}_i - C_{Vj}\|_2$$

⇒ Encoder simulates decoder to keep partitions consistent

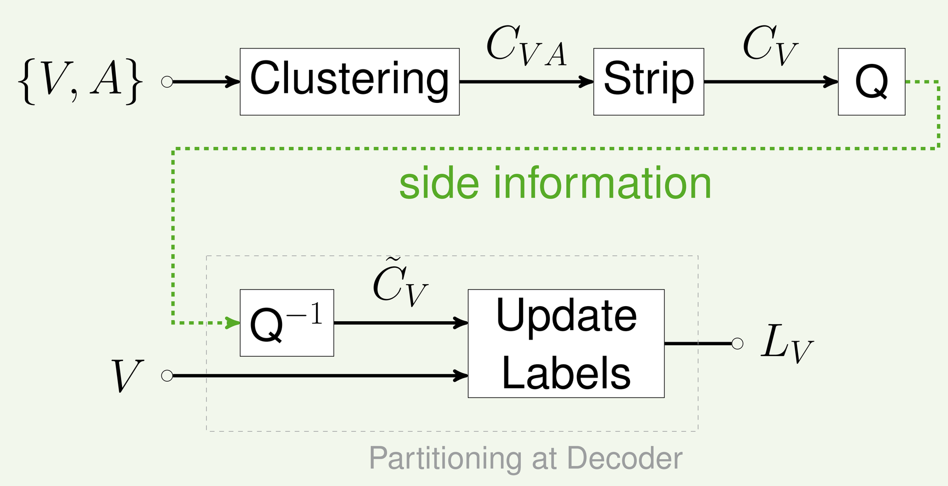
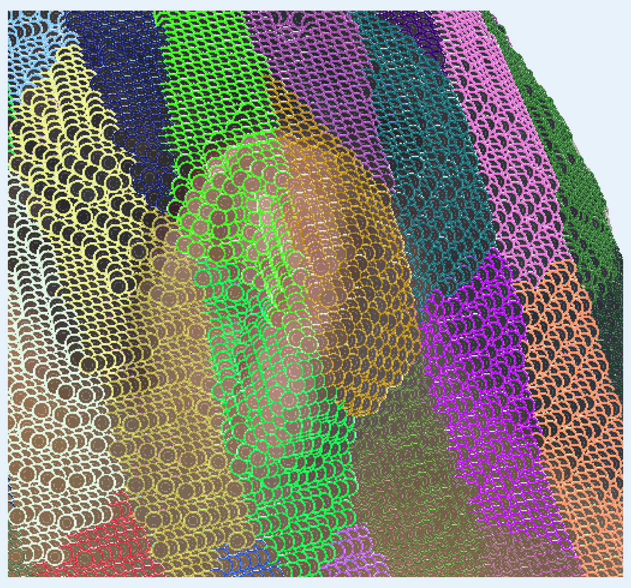


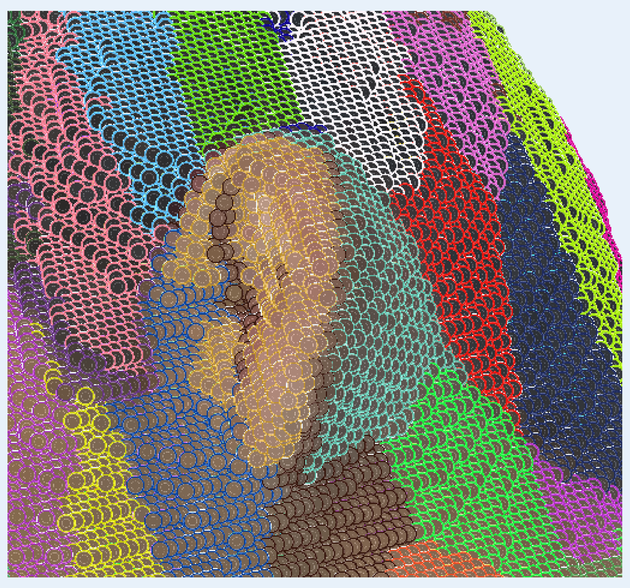
Fig. 2: Partitioning method block diagram

Visual Results

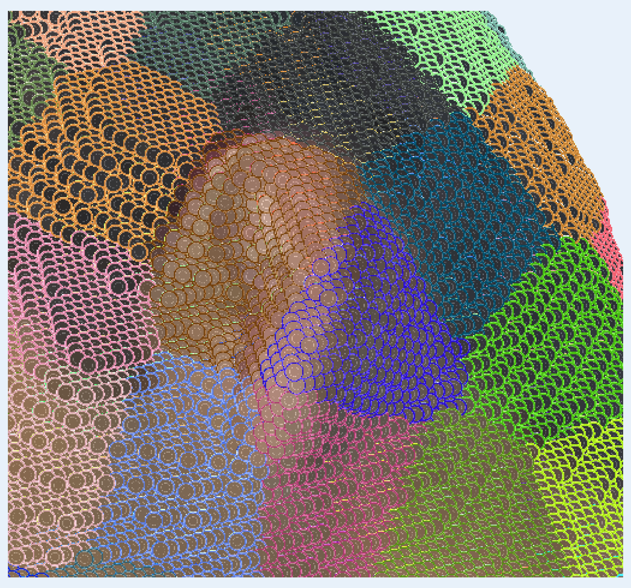
(a) Original colors



(b) Partitioning using $\lambda = 0$



(c) Partitioning using $\lambda = 0.2$



(d) Decoder partitioning using $\lambda = 0.2$

Experiments

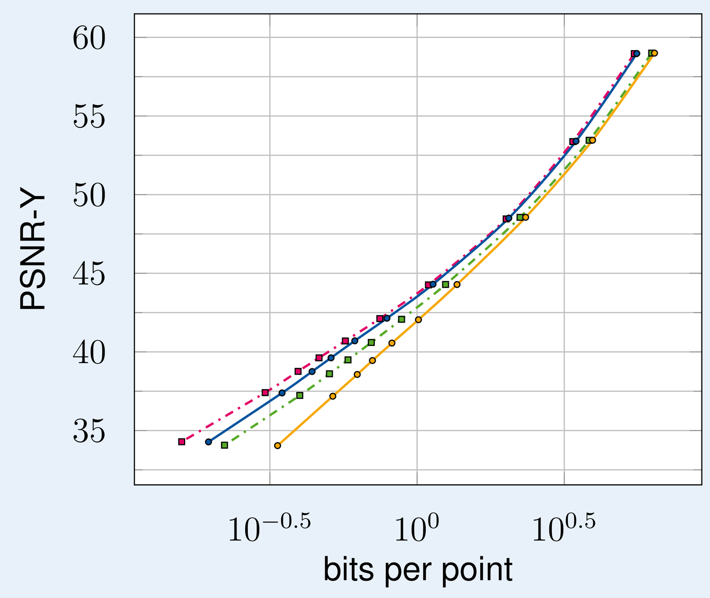


Fig. 3: loot

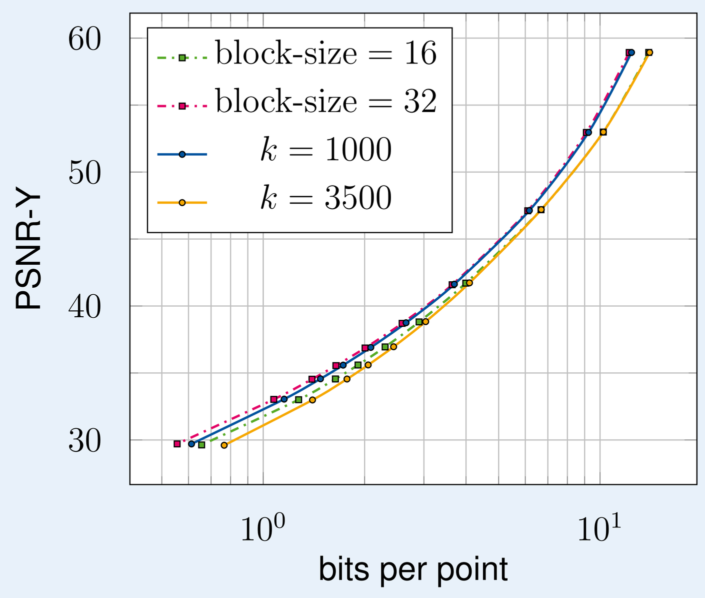


Fig. 4: longdress

- For sake of comparability, k chosen similar to number of octree blocks
- Mid-high bitrates: comparable performance
- Low bitrates: performance slightly worse due to side information overhead

⇒ However, influence on GFT performance needs further investigation

[1] Zhang, Cha, Dinei Florencio, and Charles Loop. “Point cloud attribute compression with graph transform.” In 2014 IEEE International Conference on Image Processing (ICIP), pp. 2066–2070. IEEE, 2014.

[2] Sculley, David. “Web-scale k-means clustering.” In Proceedings of the 19th international conference on World wide web, pp. 1177–1178. 2010.

thibaut.meyer@ient.rwth-aachen.de

www.ient.rwth-aachen.de

Institut für Nachrichtentechnik, Melatener Str. 23, 52074 Aachen

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