Versatile Video Coding for Video-based Point Cloud Compression

Dominik Mehlem

Institut für Nachrichtentechnik, RWTH Aachen University

SVCP 202(0)1 Berlin

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Motivation

- Capturing and rendering point clouds becomes more and more popular
  - Compression of point cloud data inevitable [Tul+16]

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- Video-based Point Cloud Compression (V-PCC) designed to be video coder agnostic [3Dg16]

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  - Compression of point cloud data inevitable [Tul+16]
- Video-based Point Cloud Compression (V-PCC) designed to be video coder agnostic [3Dg16]
- Current testing only performed with HEVC (CTC) [3DG20]

⇒ Approach shall also be proven for other video coding standards

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Outline

Point Cloud Coding

- Point cloud
  - 3D collection of points representing objects, e.g. people, rooms or geographic maps
  - Typically captured at 30 fps
  - Approx. 700k to 2 million points per frame
  - Geometry with 10-11 bits and colour attributes with 8-10 bits

$\Rightarrow$ Raw data has high amount of bandwidth demand

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  ⇒ Raw data has high amount of bandwidth demand
- ISO/IEC WG7 currently developing two different point cloud compression standards [Sch+18]
  - Video-based Point Cloud Compression (VPCC)
    - mostly suitable for dynamic objects
  - Geometry-based Point Cloud Compression
    - mostly suitable for static scenes and dynamically acquired content

Contents

VPCC

- General idea:
  - Project 3D point cloud onto 2D video frames
  - Compress video data with conventional video coder

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    - List of all candidate patches and their positions
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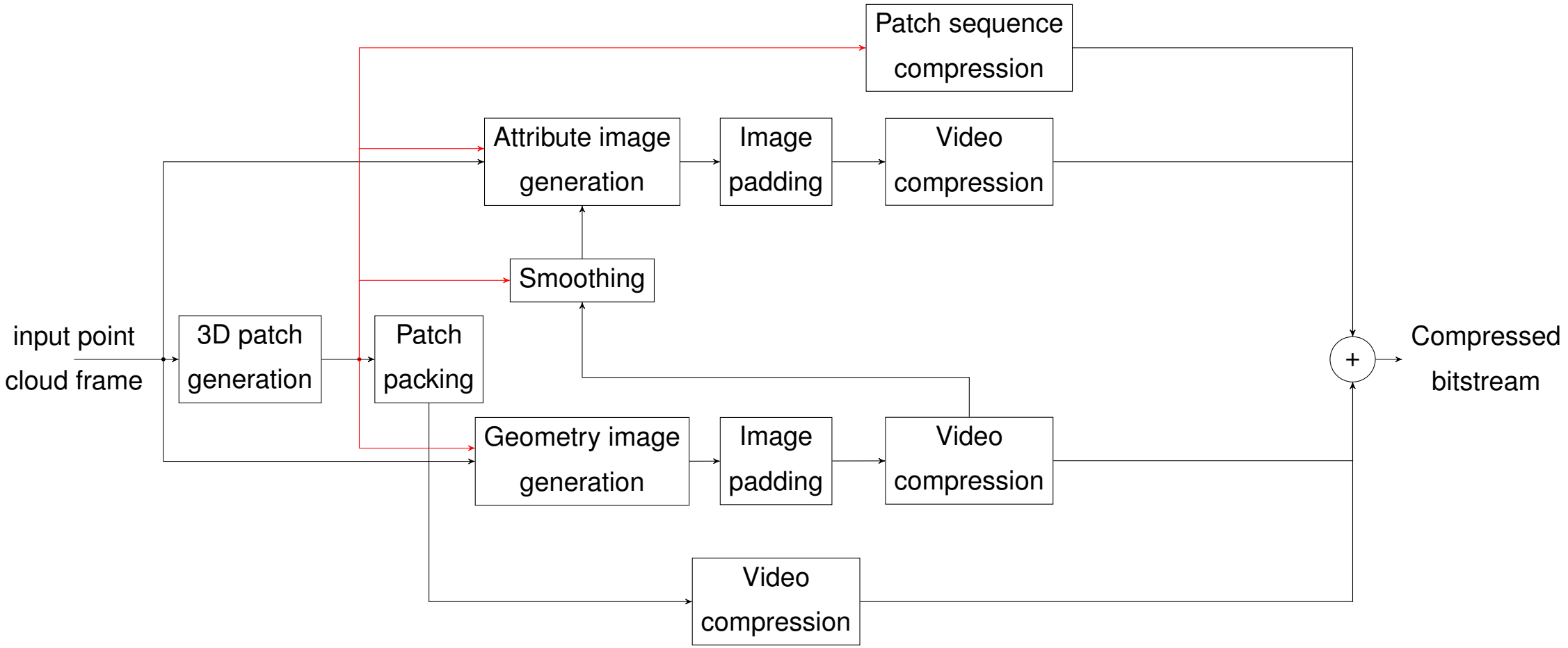
  - Geometry video
    - Greyscale video, specifying depth of patches
  - Attribute video
    - Attribute information (e.g. color) of patches

VPCC



VPCC TMC2 encoder [3DG19]

Patch generation and packing

- Patch generation
  - Project every point on closest surface of bounding cube
  - Separate into patches
  - Bounding box around patches

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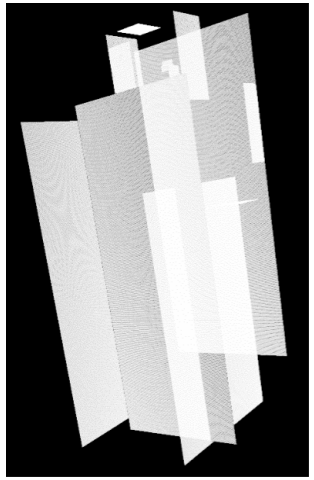
Patches in 3D



Atlas patches

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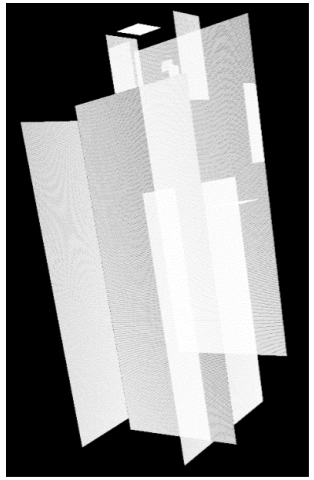
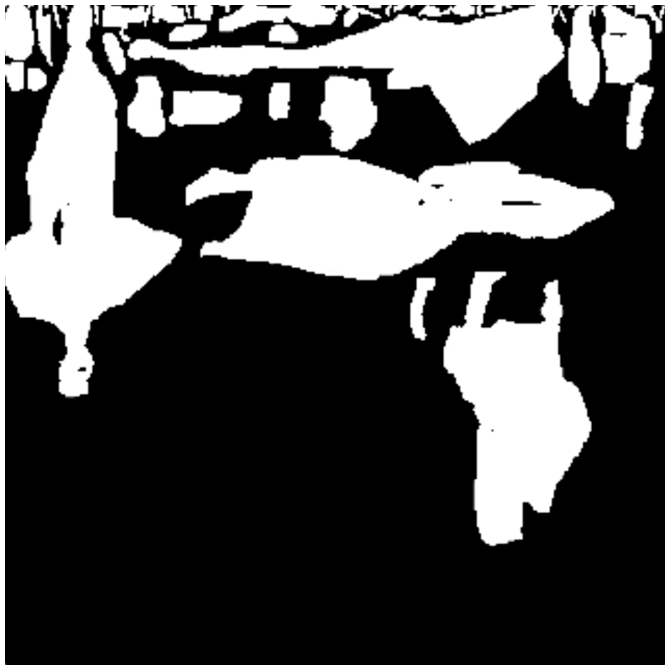


Atlas patches

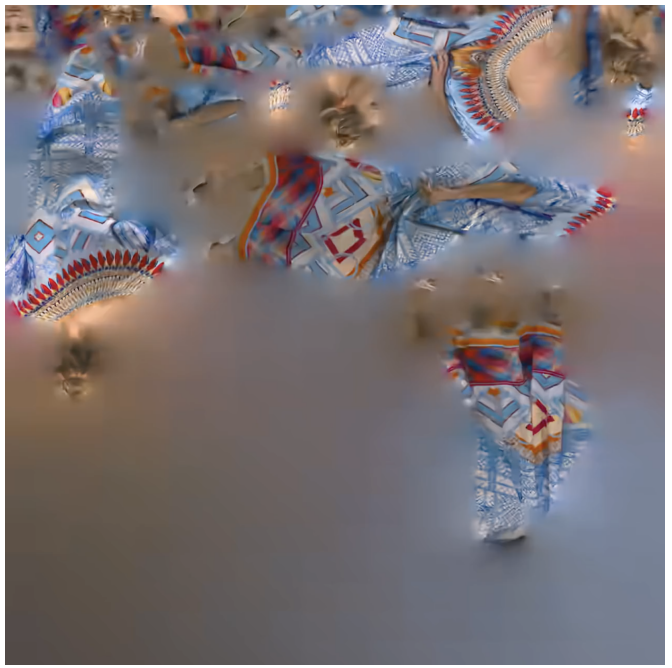
- Patch packing
  - Sort patches according to size
  - Pack from largest to smallest
  - Smaller patches fill "gaps"
  - 8 patch orientations possible
    - 4 rotations
    - 4 respective mirror images

VPCC video frame examples



Occupancy map

Geometry video



Attribute video

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- Implementation based on TMC2-14.1 [3DG] and VTM-13.0 [JVE] reference softwares
  - Coding of occupancy map, geometry video and attribute video with VVC
  - All-intra and random access lossy configurations
  - 7 sequences with 5 rate points each

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Cat2 test set description

Sequence	geometry bits	# of frames
loot	10	300
redandblack	10	300
soldier	10	300
queen	10	250
longdress	10	300
basketball_player	11	64
dancer	11	64

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- Anchor implementation based on TMC2-14.1 and HM16.20+SCM8.8 [Bos13] reference softwares

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Results - AI

BD-rate change for the lossy all-intra case for simulations performed on the full sequences in %.

Sequence	Geo		Att		
	D1	D2	Luma	Cb	Cr
loot	−17.3	−15.7	−19.8	−23.4	−15.9
redandblack	−23.5	−23.3	−25.0	−20.7	−5.0
soldier	−12.8	−13.2	−18.1	−27.3	−29.0
queen	−27.9	−27.7	−21.9	−27.0	−21.9
longdress	−20.3	−20.7	−22.5	−21.2	−11.5
basketball	−29.1	−27.1	−22.4	−23.5	−23.3
dancer	−27.7	−25.9	−22.3	−27.0	−23.2
AVG	−22.6	−22.0	−21.7	−24.3	−18.6

- Table shows BD-rate savings [Bjo01] for geometry and attributes
- Consistent performance gain for the sequences of the Cat2 test set is observed

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- Peak D1 performance gain for the “basketball” sequence

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- Peak D1 performance gain for the “basketball” sequence
- Generally higher performance gain for vox11 sequences

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Results - RA

BD-rate change for the lossy random access case for simulations performed on the full sequences in %.

Sequence	Geo		Att		
	D1	D2	Luma	Cb	Cr
loot	−24.7	−24.4	−26.0	−27.2	−21.2
redandblack	−25.6	−26.2	−24.8	−23.3	−16.7
soldier	−21.6	−21.6	−23.0	−27.9	−26.6
queen	−32.3	−32.1	−26.0	−33.7	−29.9
longdress	−25.8	−26.3	−27.1	−29.4	−21.0
basketball	−31.9	−31.0	−25.4	−24.6	−20.3
dancer	−30.7	−29.6	−25.8	−26.9	−17.4
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- Table shows BD-rate savings [Bjo01] for geometry and attributes
- Consistent performance gain for the sequences of the Cat2 test set is observed
- Peak D1 performance gain for the “queen” sequence
- Generally higher performance gain for vox11 sequences
- Gain for RA is larger than for AI

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  - Utilizing VVC instead of HEVC in the VPCC framework shows comparable gain to plain comparison of VVC and HEVC
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  ⇒ The video coder agnostic approach shows VPCC to be future-proof
- Outlook
  - Implementation of point cloud coding specific tools
    - E.g. Occupancy map based RDO
  - No consistent gain for the lossless approach
    - Further investigation in encoder configurations neccessary
    - Might just not be better

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Thank you for your attention

Any questions?

mehlem@ient.rwth-aachen.de