Overview of Video-based Dynamic Mesh Coding Standard

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Date: 2022-10-27

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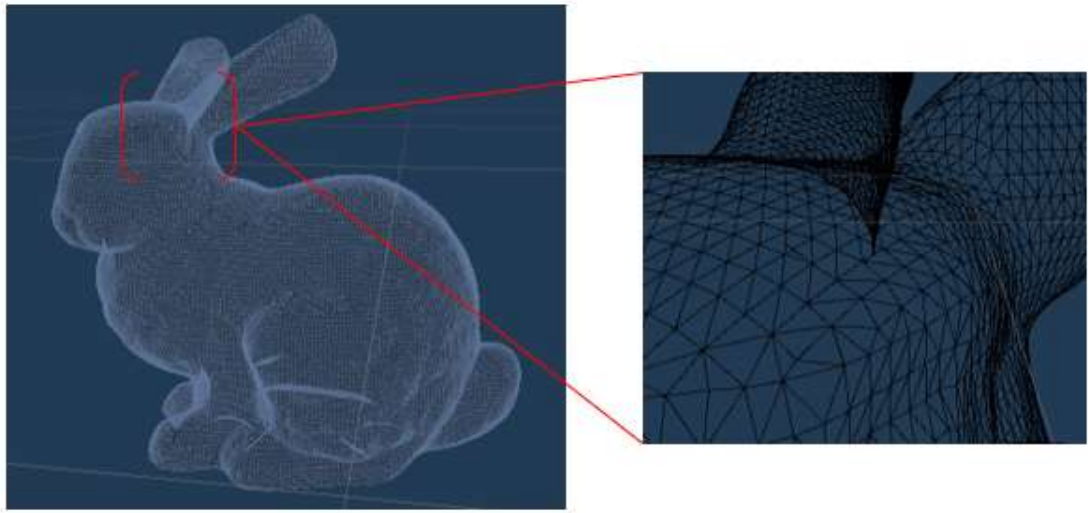
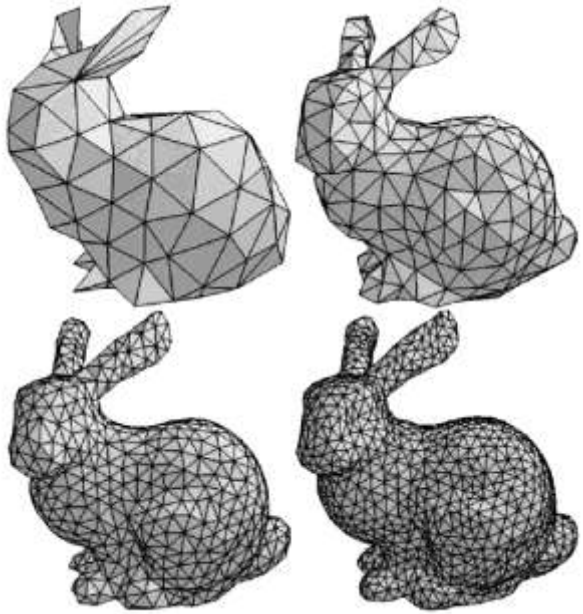
Mesh

- Polygon mesh consists of vertices, edges, and faces that defines the shape of a polyhedral object
- Connectivity information, Geometry information, Mapping information, Vertex attributes, Attribute maps to make the user more immersed
- Mesh that uses **more vertex** provides more realistic quality, but requires **more data**



Overview of Triangulation mesh



Difference in sophistication according to the number of vertex

Dynamic Mesh in Immersive Content

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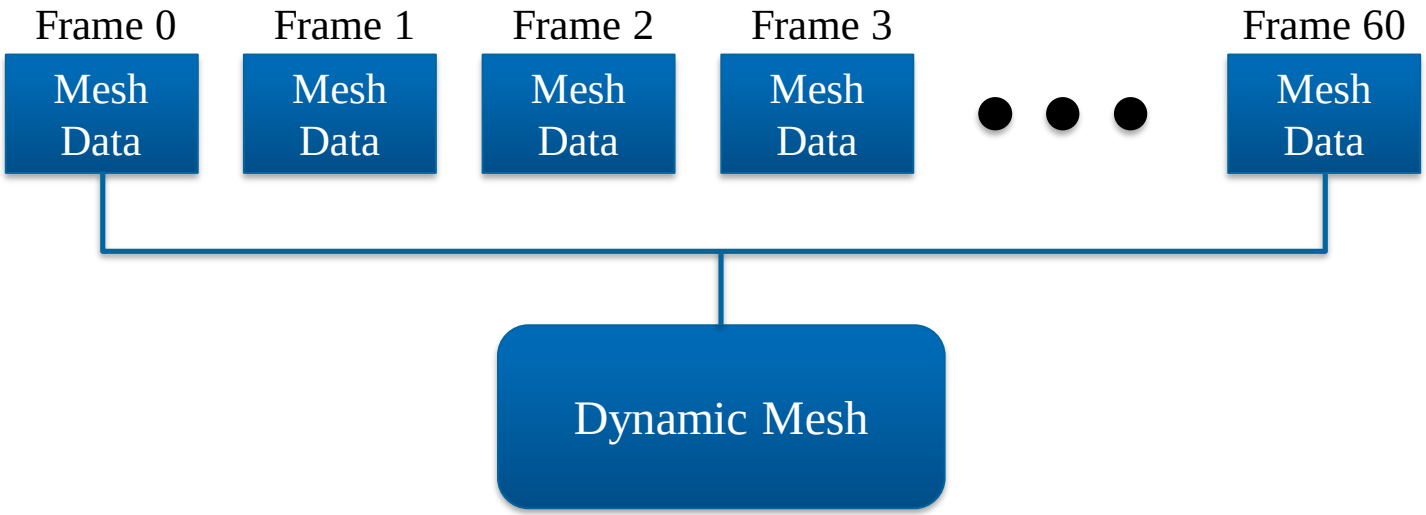
Dynamic Mesh

- The dynamic mesh must have all frame-specific mesh data
- As mesh data is increased, dynamic mesh data is also increased enormously

→ Increasing importance of technology to handle mesh data

Dynamic Mesh Standardization

- In Oct. 2021, ISO/IEC SC29/WG7 announced call for proposal (CfP) of new standard for dynamic mesh coding (DMC)
- **Multi-frame connectivity mesh**
- Apple, InterDigital, Nokia, Tencent, Sony responded



Responses of CfP

Compression Method of Anchor

- Mesh - Draco / scalable complexity 3D mesh coding (SC3DMC)
- Texture map – high efficiency video coding (HEVC) test model (HM) 16.21 + screen contents coding (SCC) extension

Result

- The proposals of Apple and Interdigital showed **high compression efficiency** compared to the anchor
- Bjontegaard-delta rate (BD-rate): performance evaluation on bitrate saving
- Proposal of Apple was adopted as a DMC test model (TM) in MPEG138

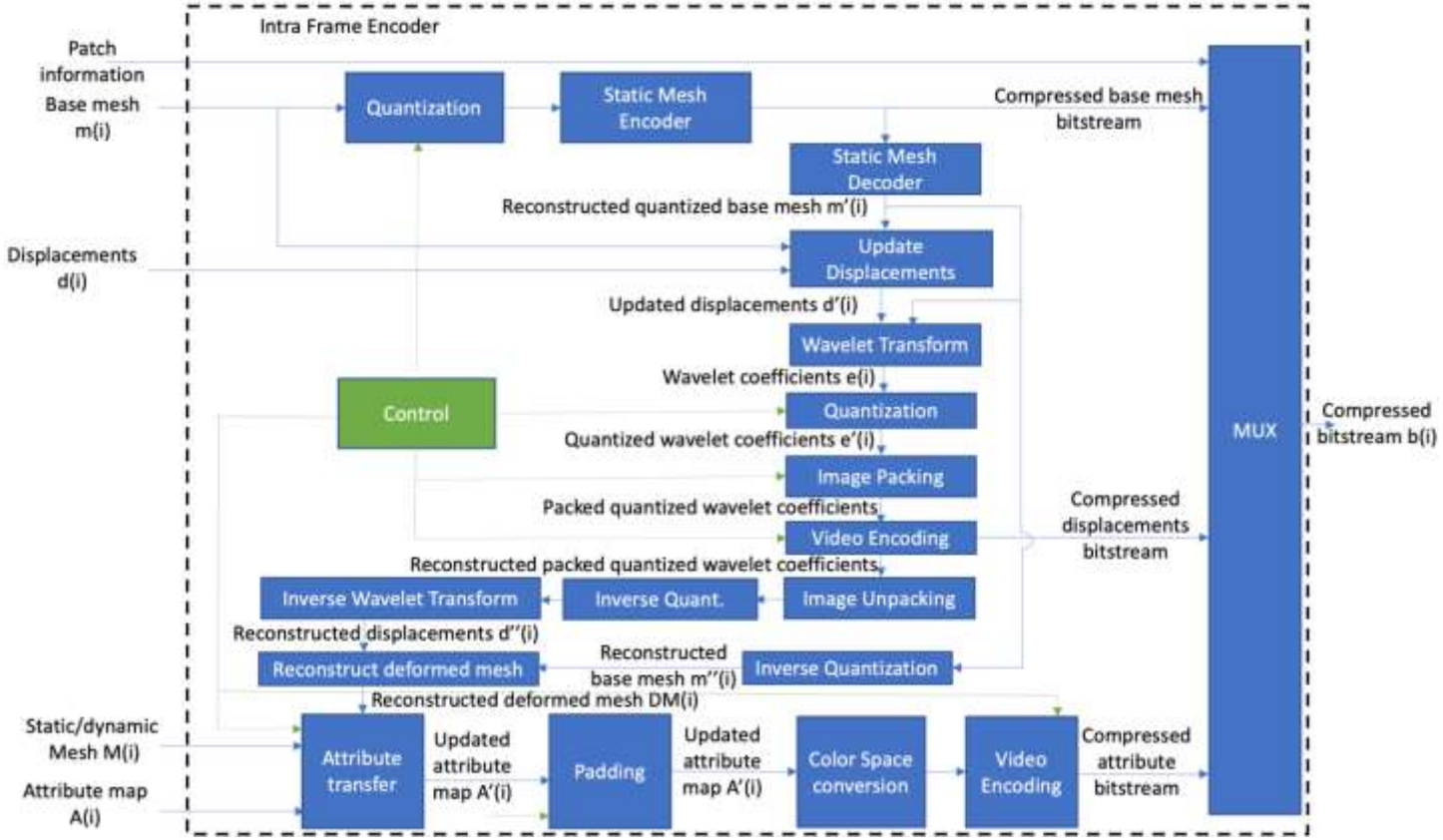
Institution	Geometry_PSNR	Y-PSNR
Apple	-15.6%	-55.5%
InterDigital	-26.3%	-18.9%
Nokia	78.5%	101.6%
Tencent	61.0%	-8.3%
Sony	135.6%	93.7%

BD-rate results of performance test for each proposal

Architecture of Encoding

Encoding Process

- Input data (base mesh, displacements) is created by **pre-processing**
- **Draco** is used to encode base mesh (decimated mesh)



Encoding process introduced in proposal of apple

Reference: ISO/IEC JTC 1/SC 29/WG 7 , Apple's Dynamic Mesh Coding CfP Response

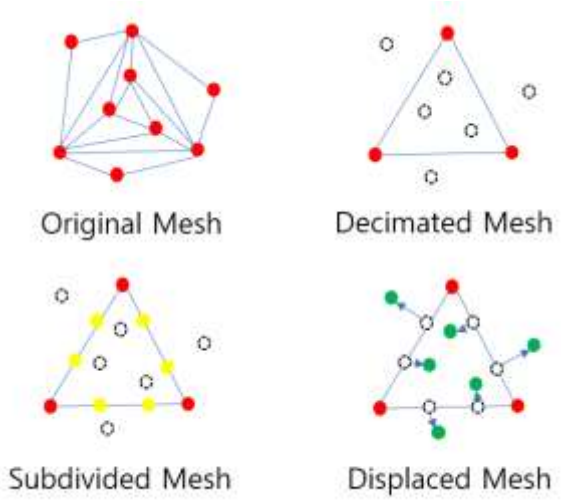
Pre-Processing

Generating Displacement Information

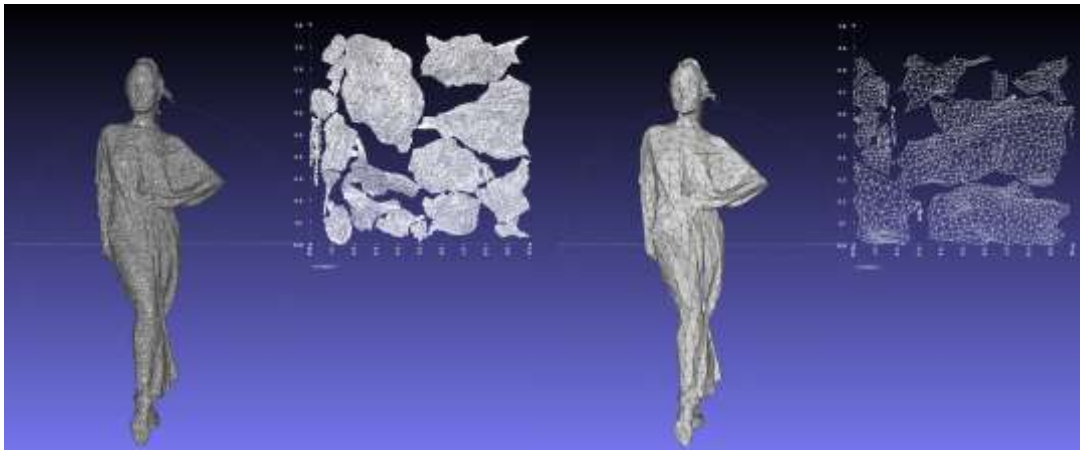
- Decimation – Down-sampling of original mesh data
- Subdivision – Creation of iterations between vertex (mid-point subdivision scheme)
- Displacement – Transform the generated iteration to resemble the original mesh

→ Get **decimated mesh data** and **displacement data** as a result of preprocessing

- Get **high compression efficiency** because the original mesh can be reconstructed using only **the decimated mesh data** and **displacement vector**



Mesh pre-processing procedure



Original mesh

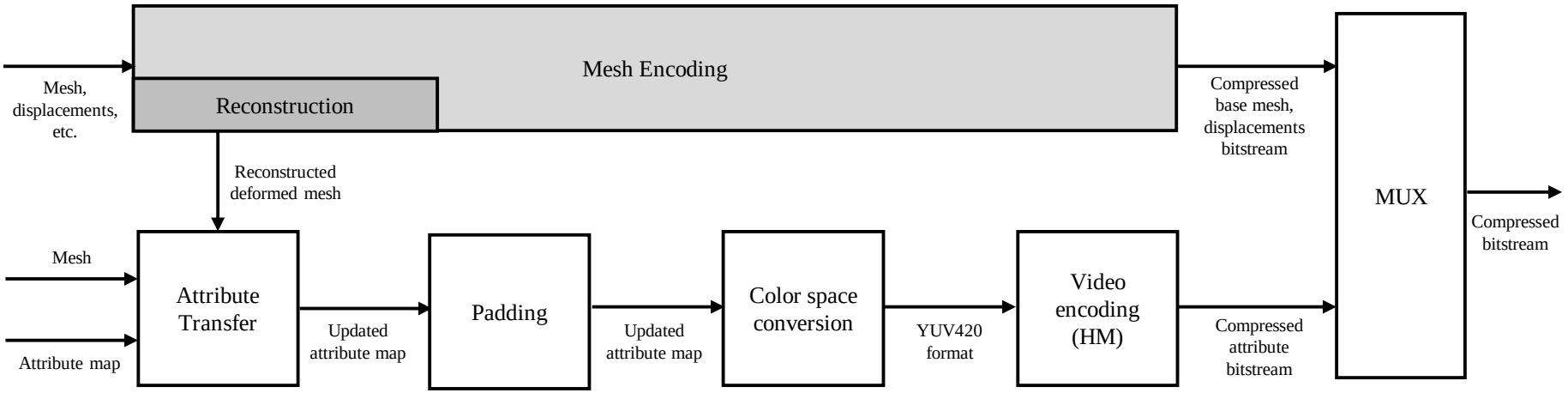
Decimated mesh

Reference: ISO/IEC JTC 1/SC 29/WG 7 , Apple's Dynamic Mesh Coding CfP Response

Attribute Encoding

Process of Attribute Map Encoding

- Attribute transfer – Computes a new attribute map which is suited for the reconstructed deformed mesh
- Padding – Replaces the empty part of attribute map generated in the previous process to the value of surrounding block
- Color space conversion – Optionally converts the picture format from RGB to YUV420
- HM encoding – Generates compressed bitstream using video encoder

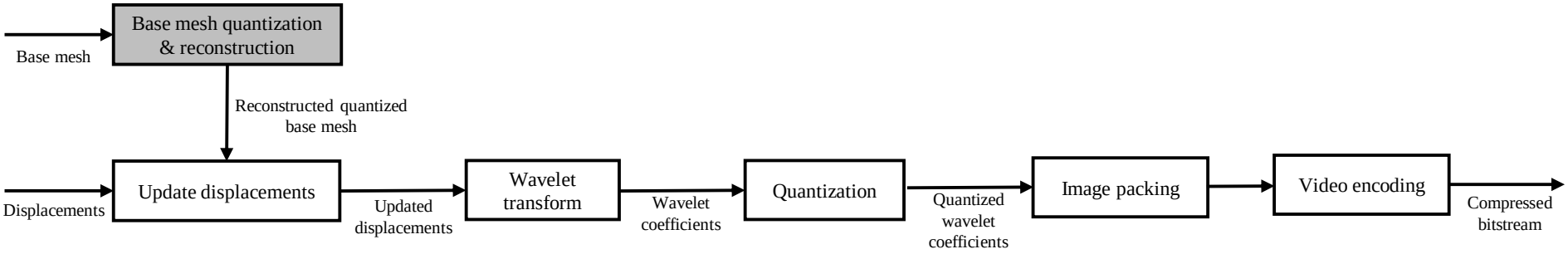


Intra encoding procedure of attribute data

Displacement Encoding

Encoding Procedure of Displacement Vectors

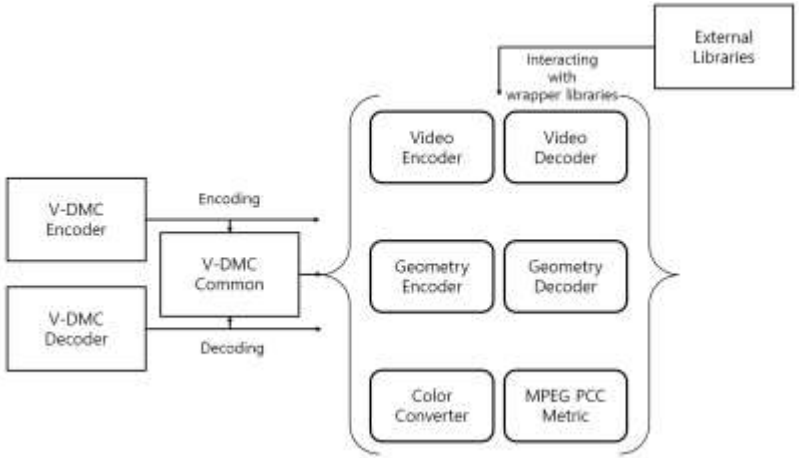
- Video encoding can be applied for displacement vectors which are generated at post-processing to reduce the size of mesh
- Update displacements based on reconstructed quantized base mesh
- Wavelet transform is applied to generate wavelet coefficient, which is then quantized
- Quantized wavelet coefficients are packed in 2D image/video, and then compressed through a traditional video encoder (such as HM)

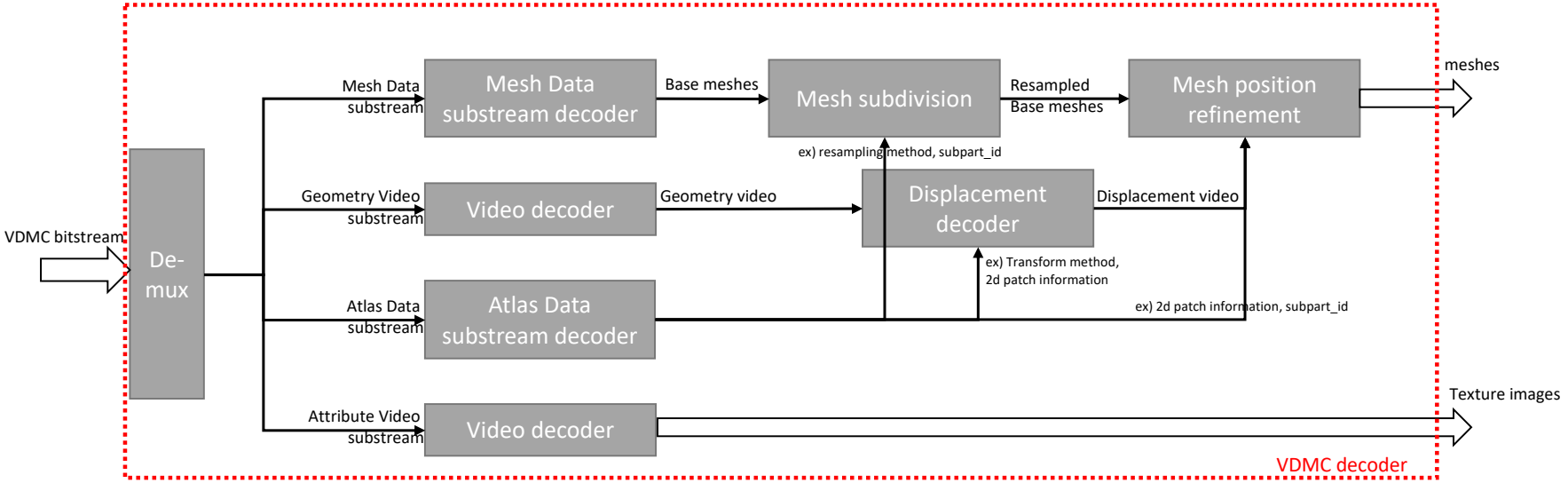


Intra encoding procedure of displacement vector

V-DMC Test Model (TM)

- **vmeshCommon** contains the util objects and the processes shared by V-Mesh encoding and decoding processes
- **vmeshEncoder** contains the V-Mesh encoding processes
- **vmeshDecoder** contains the V-Mesh decoding processes





Decoding procedure of V-DMC bitstream

Reference: ISO/IEC JTC 1/SC 29/WG 7 , Support of the V3C framework in VDMC-TM

Test material Datasets

Encoding Procedure of Displacement Vectors

- Below is a list of the mesh test material datasets to be use
- The test class is an indicator of how complex a mesh is to encode (A is the lowest and C is the highest)

Test Class	Test material dataset filename	# Frames	# Vertices	# Faces	Geometry Precision	Texture Coord. Precision	Texture Map Size
A	**longdress**	300	22k	40k	10 bits	12 bits	2k x 2k
	soldier	300	22k	40k	10 bits	12 bits	2k x 2k
B	**basketball_player**	300	20k	40k	12 bits	12 bits	2k x 2k
	dancer	300	20k	40k	12 bits	12 bits	2k x 2k
C	**mitch**	300	16k	30k	12 bits	13 bits	4k x 4k
	thomas	300	16k	30k	12 bits	13 bits	4k x 4k
	football	300	25k	40k	12 bits	13 bits	4k x 4k
	levi	150	20k	40k	12 bits	13 bits	4k x 4k

Test materials

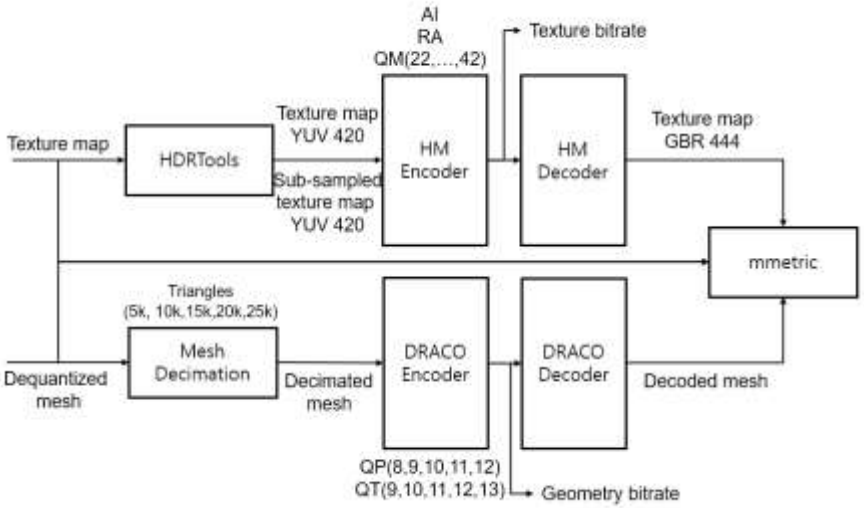
Examples of rendered images

Reference: ISO/IEC JTC 1/SC 29/WG 7 , CfP for Dynamic Mesh Coding

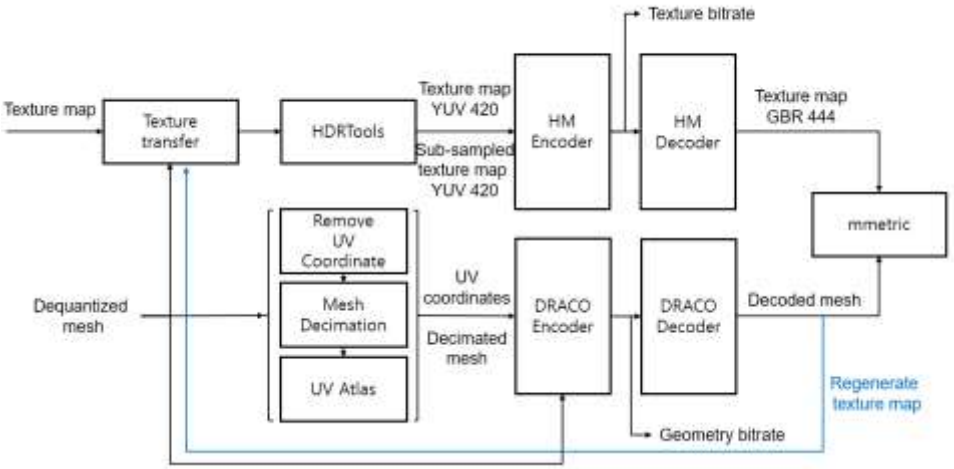
V-DMC Proposal (m60199)

New Anchor Proposal

- The anchor utilized geometry decimation and texture down-sampling to achieve lower bitrates
- Encoding of geometry and texture was performed **independently and in parallel**
- Proposed an anchor that generates a regenerated texture map in geometry encoding and uses it for texture encoding



Architecture of privious anchor



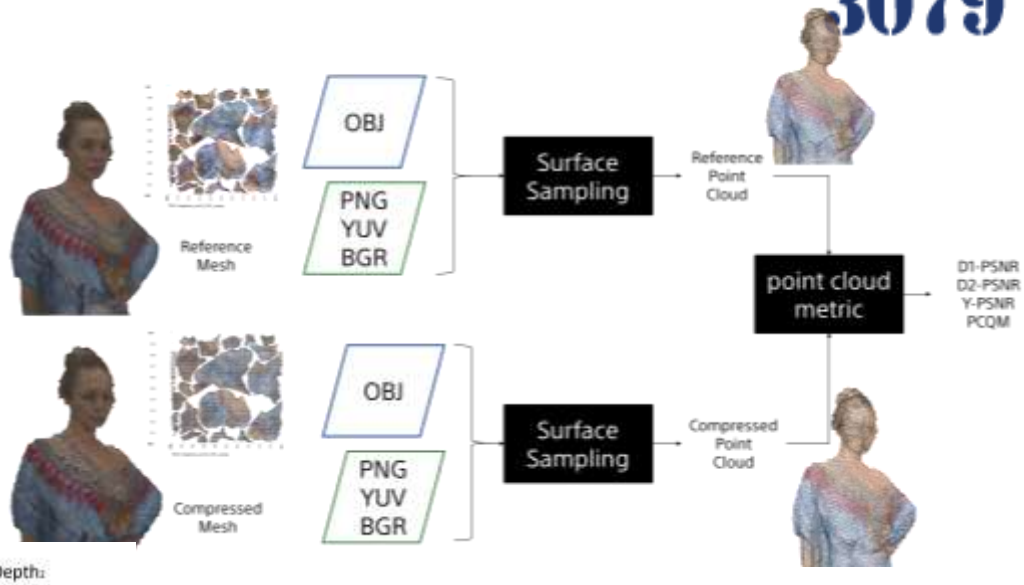
Architecture of proposed anchor

Reference: ISO/IEC JTC 1/SC 29/WG 7, On anchor improvement investigation, m60199

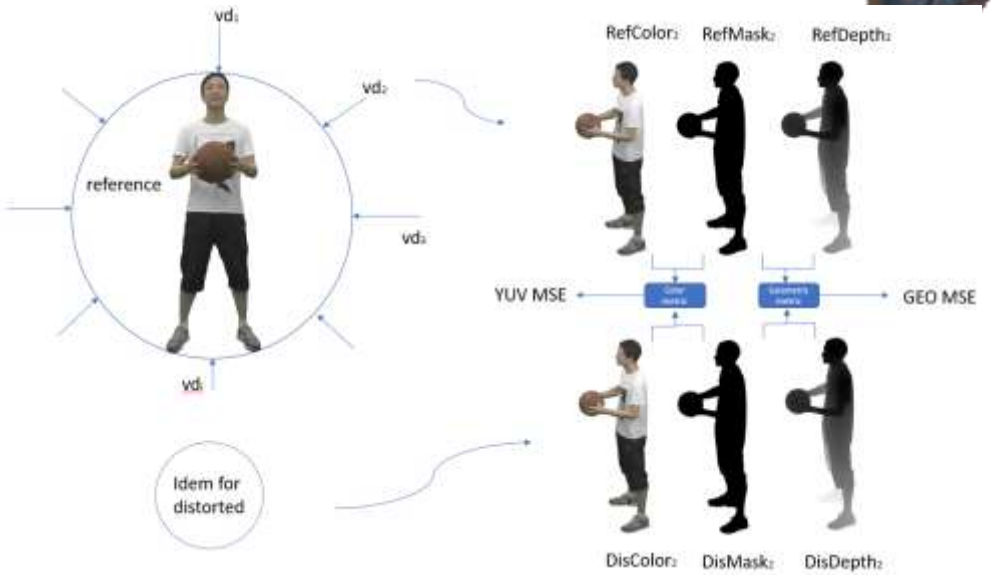
Metrics for V-DMC

Proposed Objective Metrics

- Point cloud based – converting to two point clouds, sampling, estimating point error of distance
- Image based – projects the reference and distorted mesh into several images, and then calculates the distortion for each view



↑ Point cloud based metric



← Image based metric

Reference: ISO/IEC JTC 1/SC 29/WG 7, Metrics for Dynamic Mesh Coding, N00225

Conclusion

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Previous Standards

- V-PCC – Compression of point cloud, which consists of geometry and attribute data of points

Importance of Dynamic Mesh Compression

- Needs for MPEG standard to access dynamic meshes (with time varying attributes and connectivity information) that has capability of the V3C standards
- Can be used at real-time 3D immersive telepresence, AR/VR viewing with interactive parallax, and 3D free viewpoint sport replays broadcasting

Conclusion and Future Work

- Efficient methods for mesh compression have been proposed, but there are additional areas to be researched
- E.g., Dividing method while coding mesh data for the purpose of high-efficiency mesh streaming service

Thank You !

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