Overview of Video-based Dynamic Mesh Coding Standard

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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
Dynamic Mesh in Immersive Content

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

<table>
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<tr>
<th>Institution</th>
<th>Geometry_PSNR</th>
<th>Y-PSNR</th>
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<tbody>
<tr>
<td>Apple</td>
<td>-15.6%</td>
<td>-55.5%</td>
</tr>
<tr>
<td>InterDigital</td>
<td>-26.3%</td>
<td>-18.9%</td>
</tr>
<tr>
<td>Nokia</td>
<td>78.5%</td>
<td>101.6%</td>
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<tr>
<td>Tencent</td>
<td>61.0%</td>
<td>-8.3%</td>
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<tr>
<td>Sony</td>
<td>135.6%</td>
<td>93.7%</td>
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</table>

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

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

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

## Test material Datasets

### Encoding Procedure of Displacement Vectors

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

<table>
<thead>
<tr>
<th>Test Class</th>
<th>Test material dataset filename</th>
<th># Frames</th>
<th># Vertices</th>
<th># Faces</th>
<th>Geometry Precision</th>
<th>Texture Coord. Precision</th>
<th>Texture Map Size</th>
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<td>300</td>
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<td>40k</td>
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<td>12 bits</td>
<td>2k x 2k</td>
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<tr>
<td></td>
<td>soldier</td>
<td>300</td>
<td>22k</td>
<td>40k</td>
<td>10 bits</td>
<td>12 bits</td>
<td>2k x 2k</td>
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<tr>
<td>B</td>
<td>basketball_player</td>
<td>300</td>
<td>20k</td>
<td>40k</td>
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<td>12 bits</td>
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</tr>
<tr>
<td></td>
<td>dancer</td>
<td>300</td>
<td>20k</td>
<td>40k</td>
<td>12 bits</td>
<td>12 bits</td>
<td>2k x 2k</td>
</tr>
<tr>
<td>C</td>
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<td>300</td>
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<td></td>
<td>levi</td>
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<td>40k</td>
<td>12 bits</td>
<td>13 bits</td>
<td>4k x 4k</td>
</tr>
</tbody>
</table>

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

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

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

↑ Point cloud based metric

← Image based metric
Conclusion

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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