Versatile Video Coding: Coding tools for 360-degree video

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Outline

- Introduction
  - Standardization development and process

- Versatile Video Coding Development
  - Joint Call for Proposals Outcome

- Coding Tools
  - Versatile Video Coding Test Model
Video coding standardization organizations

- ISO/IEC MPEG = Moving Picture Experts Group
- ITU-T VCEG = Video Coding Experts Group
- JVT = “Joint Video Team” collaborative team of MPEG & VCEG, responsible for developing Advanced Video Coding (AVC), documents and software publicly available
- JCT-VC = “Joint Collaborative Team on Video Coding” team of MPEG & VCEG, responsible for developing High Efficiency Video Coding (HEVC), documents and software publicly available
- JVET = “Joint Video Experts Team” responsible for developing Versatile Video Coding (VVC), documents and software publicly available
The scope of video standardization

- Only Specifications of the Bitstream and Decoder are standardized:
  - Permits optimization beyond the obvious
  - Permits complexity reduction for implementability
Video coding concept

Input Frame 1 | DCT | Quantized | Reconstructed Frame 1 (Inverse DCT and Inverse Q)

Input → DCT → Quantizer → EntropyCoder → Bitstream

Motion Estimation → Frame Buffer → Motion Compensation

Inverse DCT, Q → + → EntropyCoder → Bitstream

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Video coding concept

Input Frame 2

Reconstructed Frame 1 (in buffer)

Comparison
Video coding concept
Performance history of standard generations

Bit-rate Reduction: 50%
HEVC spatial coding structures

- Coding Tree Unit (CTU)
  - Corresponds to macroblocks in earlier coding standards.
  - Maximum CTU size: 64×64 pixels
  - Split into Coding Units (CU)

- Coding Unit (CU)
  - CU size 64x64, 32x32, 16x16, 8x8
  - For Intra or inter coding mode decision
  - Split into Prediction Units (PUs) and Transform Units (TUs)

- Prediction Unit (PU), the elementary unit for predication

- Transform Unit (TU), the units for transform and quantization
  - TU size 4x4, 8x8, 16x16, 32x32 DCT, and 4x4 DST
Motivation for improved video compression: “Spatial Resolution”

- **SD (PAL)**
  - 720 x 576
  - 0.414MPs
- **HDTV 720p**
  - 1280 x 720
  - 0.922MPs
- **HDTV 1080i**
  - 1920 x 1080
  - 2.027MPs
- **Digital Cinema 2K**
  - 2048 x 1080
  - 2.21MPs
- **UHDTV 1**
  - 3840 x 2160
  - 9.3MPs
- **4K**
  - 4096 x 2160
  - 11.64MPs
- **UHDTV 2**
  - 7680 x 4320
  - 33.18MPs
- **8K**
  - 8192 x 4320
  - 55.39MPs

- **Wider Viewing Angle**
- **More Immersive**
Motivation for improved video compression: "HFR (High Frame Rate)"

Increased perceived motion artifacts

Higher frame rates is needed
50fps minimum
Motivation for improved video compression: “WCG (Wide Color Gamut)”

- Deeper Colors
- More Realistic Pictures
- More Colorful
Motivation for improved video compression: “HDR (High Dynamic Range)“
Motivation for improved video compression: multi-view, 360° video
Versatile Video Coding (VVC)

- Necessary video data rate grows faster than feasible network transport capacities
- Better video compression (50% rate of current HEVC) needed, even after availability of 5G
Block partitioning

- Root Size $128 \times 128$ (64x64 in HEVC)

- 1st Tree
  - Quad Split

- 2nd Tree
  - Binary Split
  - Ternary Split

Quad/binary/ternary partitioning
360° video

- New omnidirectional cameras allow acquiring panoramic video (by mosaic stitching)
- Appropriate rendering to a head mounted display allows adapting the viewpoint according to head movements in real-time
- With appropriate projection, the panorama can be packed into a 2D frame
Multidirectional Camera
360° video

**Step 1:** multi-camera array captures video, then image stitching is applied to obtain spherical video

**Step 2:** spherical video is "unfolded" to 2D plane, e.g. using the equirectangular projection

**Step 3:** 2D video coding, packaging and delivery
360° video: panorama stitching

- Stitching requires registration
  - Identification of matching key points

- To mask artifacts
  - Some filtering/hole filling may be necessary
  - In video: avoid temporal variation of stitching path
360° video: projection formats

- Cubemap projection with 3x2 packing
  - 6 Faces can be treated as rectangular video
360° video: projection formats

- Equirectangular projection
  - The whole sphere is projected into a rectangular picture
360° video specific coding tools

- Projection formats from the family of cubemaps show best compression performance
  - They however suffer from visibility of face boundaries, which grow larger with decreased compression quality

- Two problems and proposed solutions:
  - Packed/projected neighbors which are no physical/spherical neighbors:
    - Solution: disable coding tools over face boundaries, such as prediction, filtering,...
  - Physical/spherical neighbors which are no packed/projected neighbors:
    - Solution: connect samples from disparate positions in the frame for better prediction, performing filtering,...
The proposed VVC Coding Tools

- **360-video specific**
  - Motivation: Special characteristics of 360 content
  - 360° symmetry not exploited by current codecs
    - Motion across face boundaries possible
360° video coding tool: face extension

- Compression of 360° video is dependent on projection, which with translational block-wise motion compensation can cause geometrical errors
  - Solution: Face extension
360° video coding tools – Second proposal
Corrected deblocking filter

- Reference samples of blocks at face boundaries changed.
  - Solution: Samples are chosen according to 3D cube geometry not just from top or left.
Research Area

- Various parts of VVC Standard
  - Intra-Picture Prediction
  - Intra-Picture Prediction by neural networks (NN)
  - Inter-Picture Prediction:
    - Non rectangular partitioning
    - Geometric (GEO) partitioning

- 360 Video
  - Projection
  - Quality Assessment
JVET AHG

- Test model software development
- Test material and visual assessment
- Coding of HDR material
- Neural Network in video coding
- Encoding algorithm optimization
- Quantization control

http://phenix.it-sudparis.eu/jvet/
Reference


- http://phenix.it-sudparis.eu/jvet/