Versatile Video Coding: Coding tools for 360-degree video

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Outline

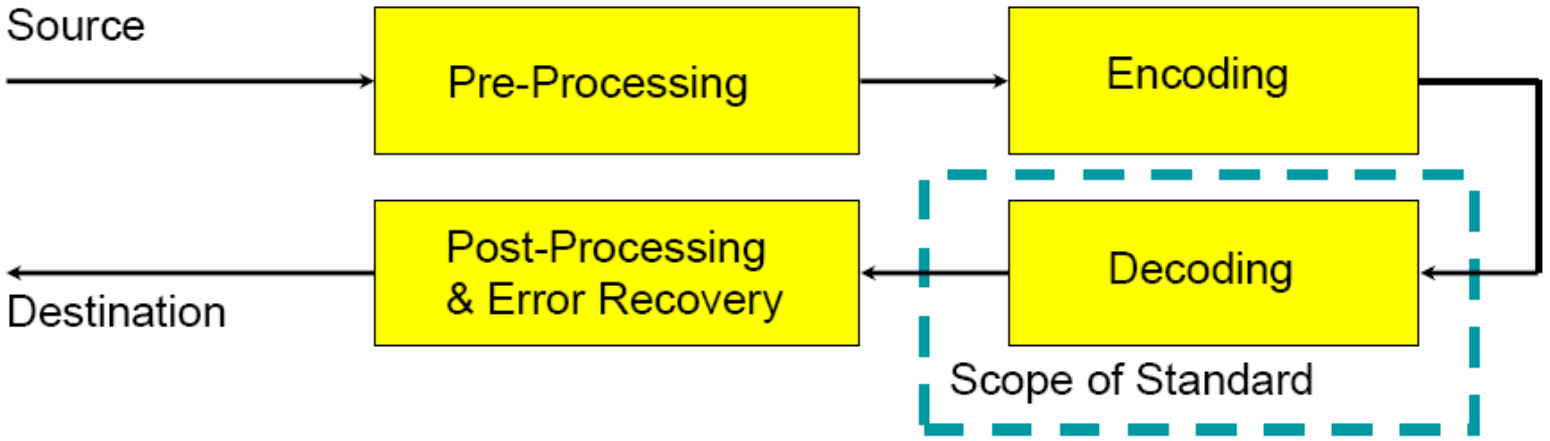
- Introduction
  - Standardization development and process
- Versatile Video Coding Development
  - Joint Call for Proposals Outcome
- Coding Tools
  - Versatile Video Coding Test Model

Video coding standardization organizations

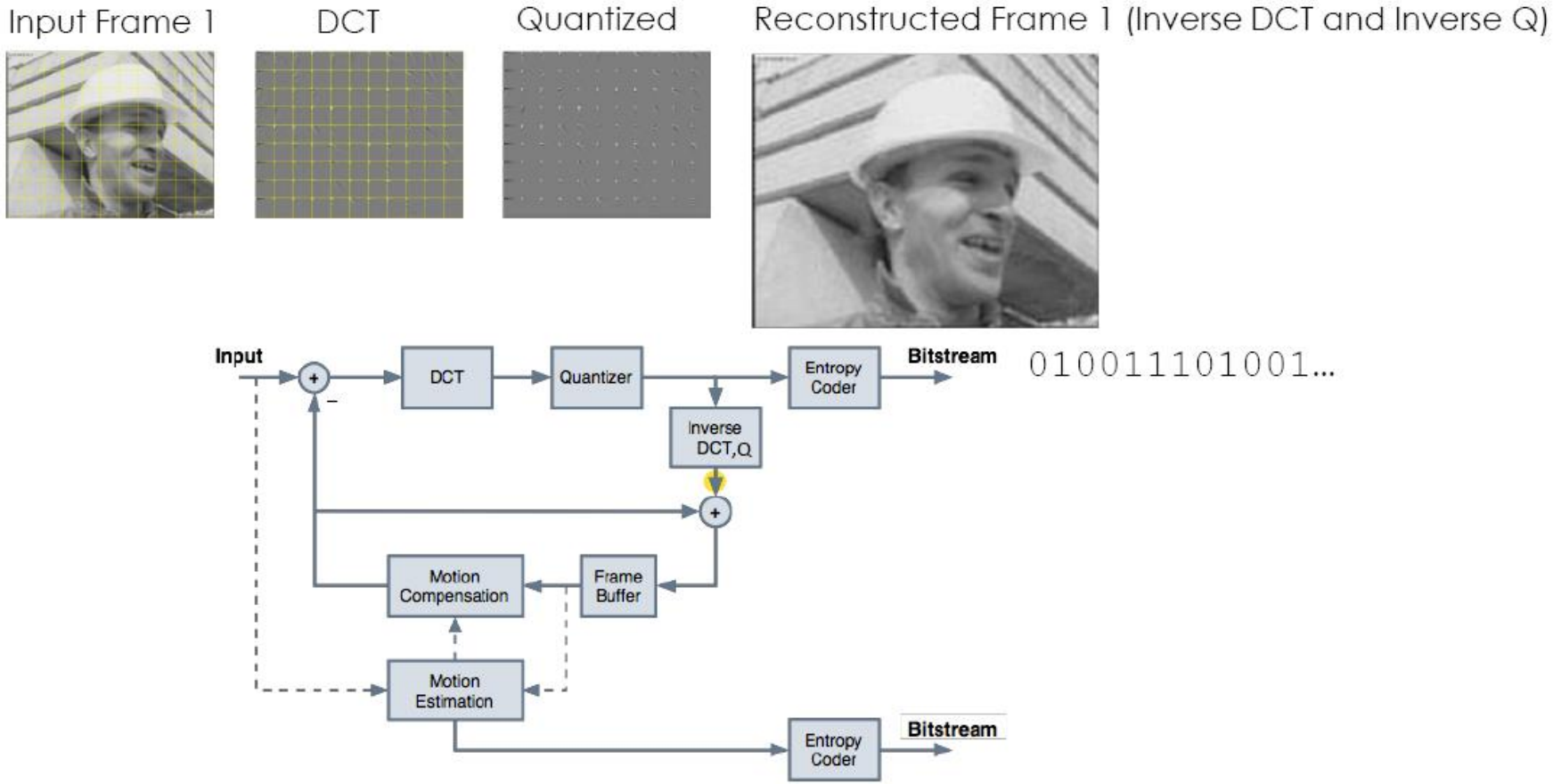
- **ISO/IEC MPEG= Moving Picture Experts Group**
- **ITU-T VCEG= Video Coding Experts Group**
- **JVT= "Joint Video Team"** collaborative team of MPEG & VCEG, responsible for developing Advanced Video Coding (AVC), *documents and software publicly available*
- **JCT-VC= "Joint Collaborative Team on Video 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



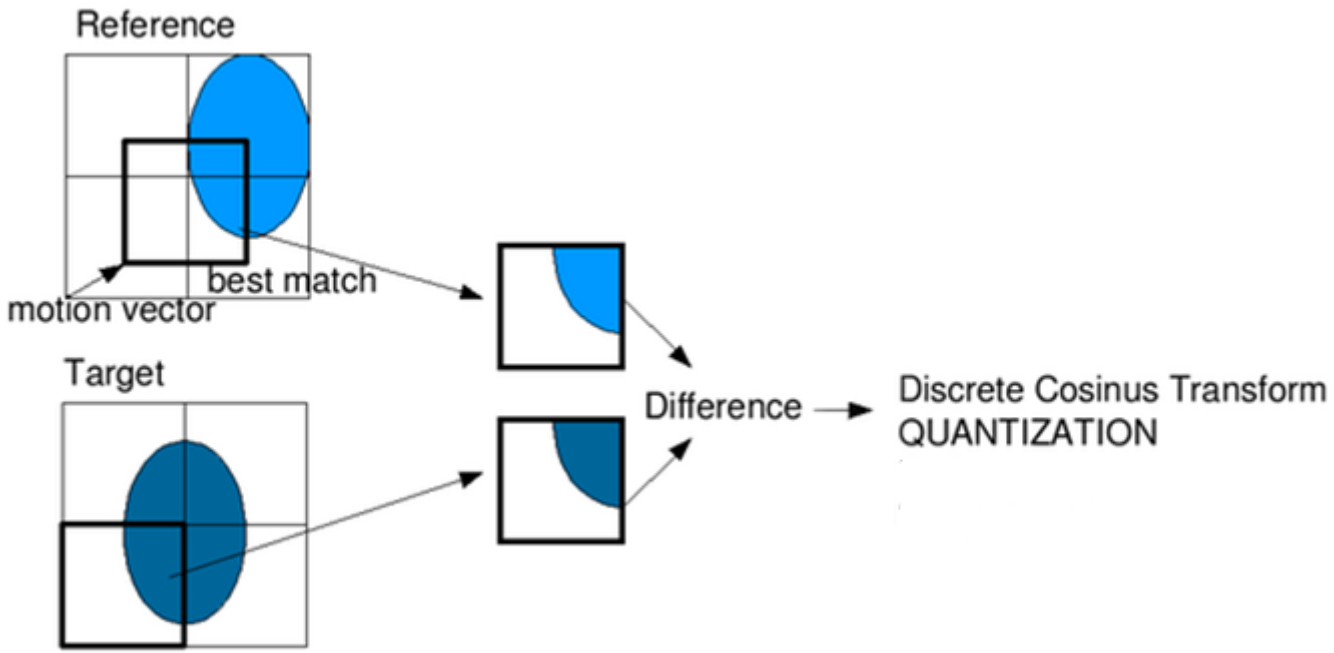
Video coding concept

Input Frame 2

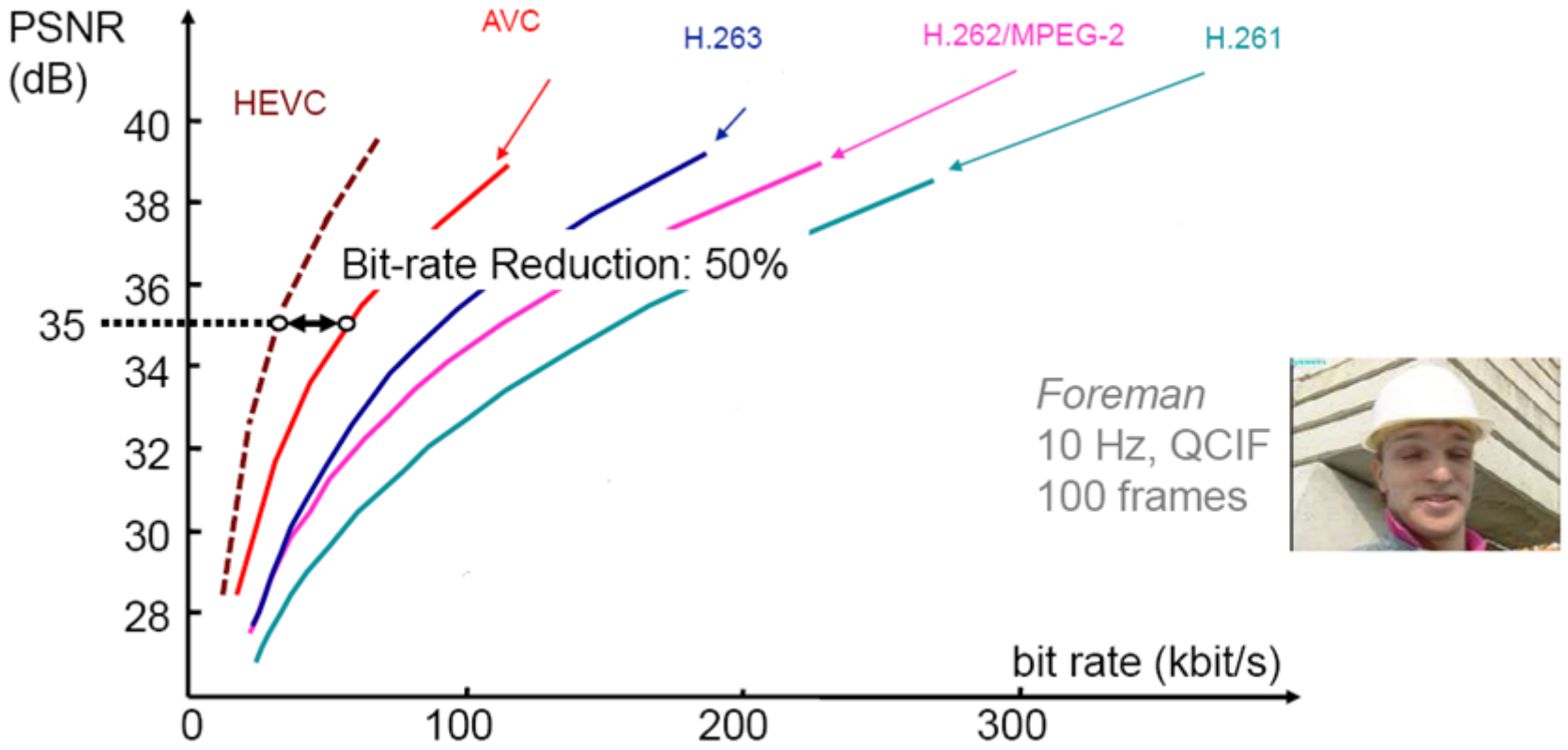
Comparison

Reconstructed Frame 1 (in buffer)

Video coding concept

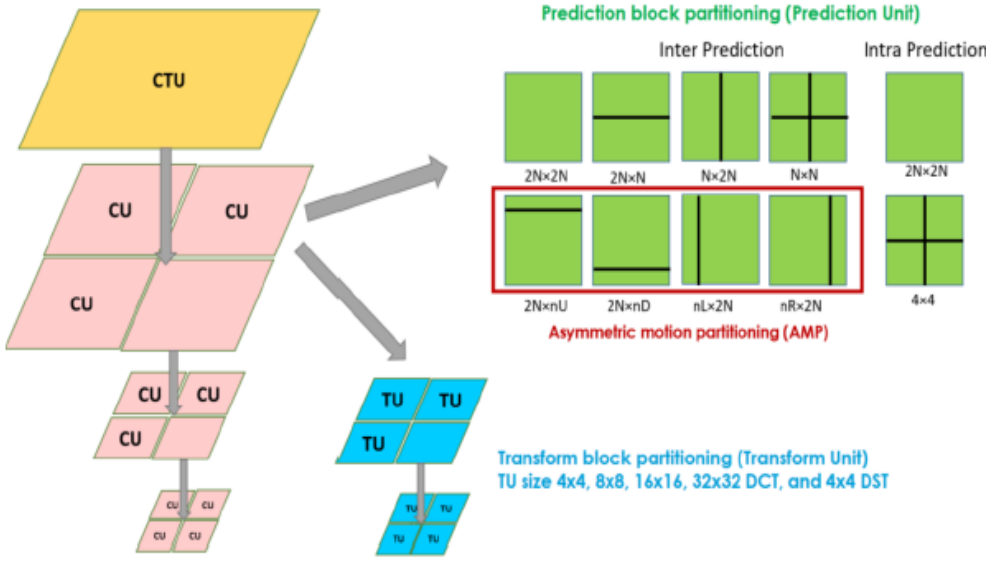


Performance history of standard generations

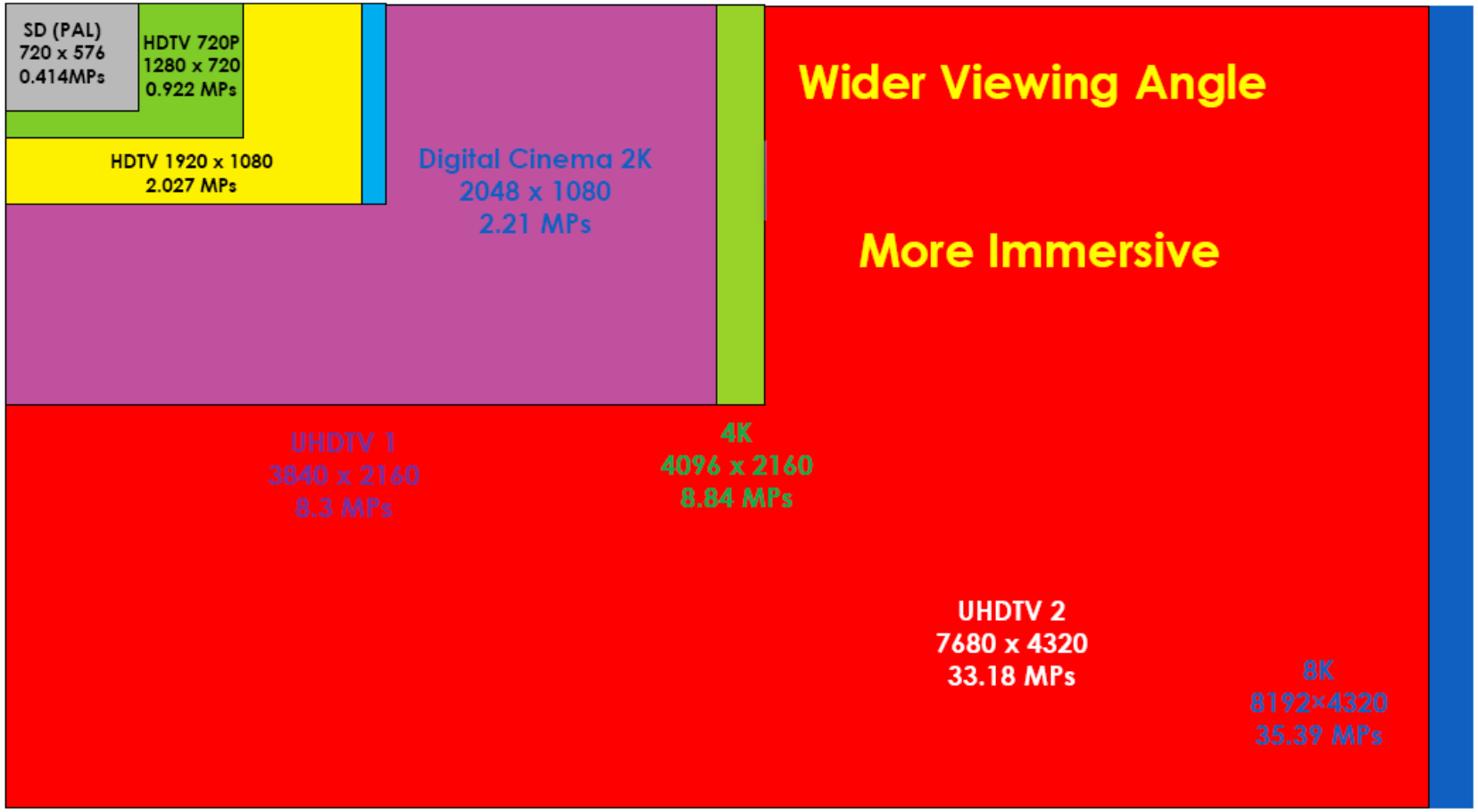


HEVC spatial coding structures

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



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)”

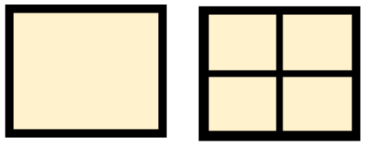
Motivation for improved video compression: multi-view, 360°video

Versatile Video Coding (VVC)

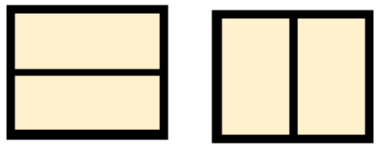
- **Necessary video data rate grows faster than feasible network transport capacities**
  - **Better video compression (50% rate of current HEVC) needed, even after availability of 5G**

Block partitioning

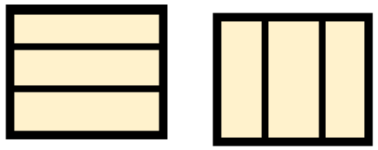
- Root Size 128×128 (64×64 in HEVC)
- 1st Tree
  - Quad Split

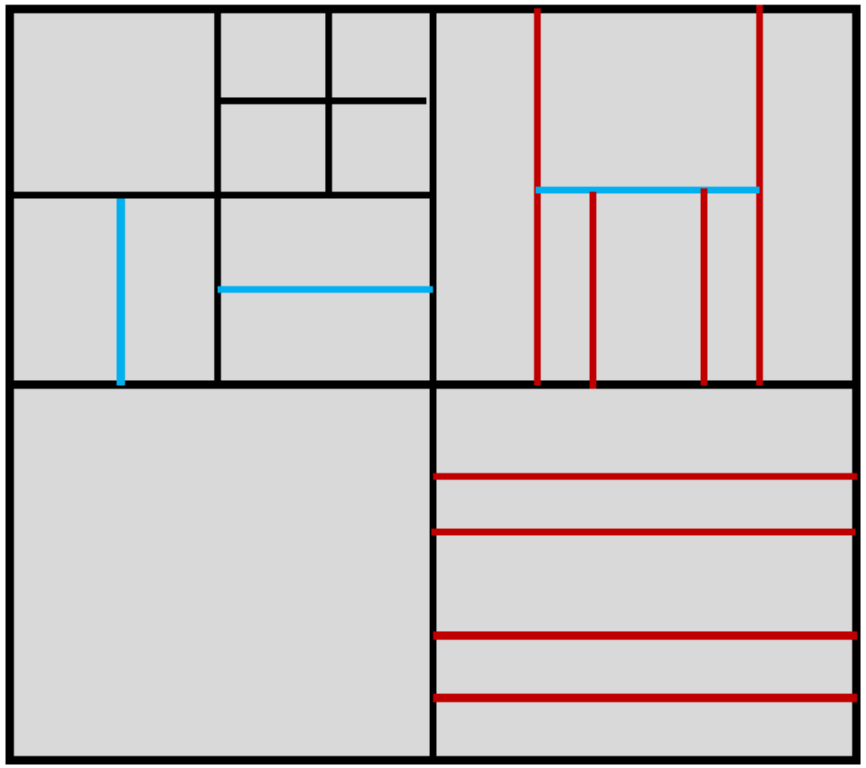


- 2nd Tree
  - Binary Split



  - Ternary Split





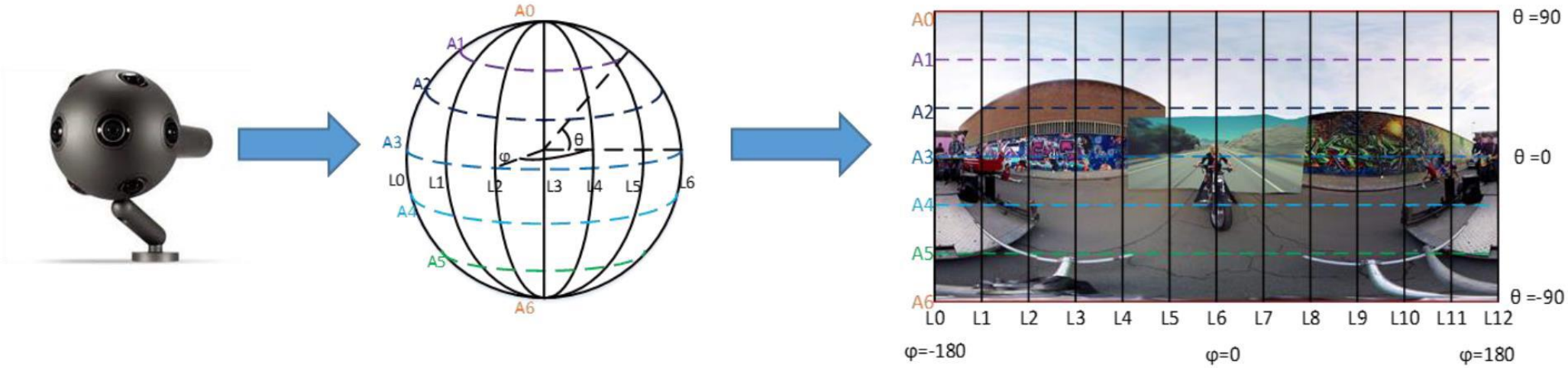
Quad/binary/ternary partitioning

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

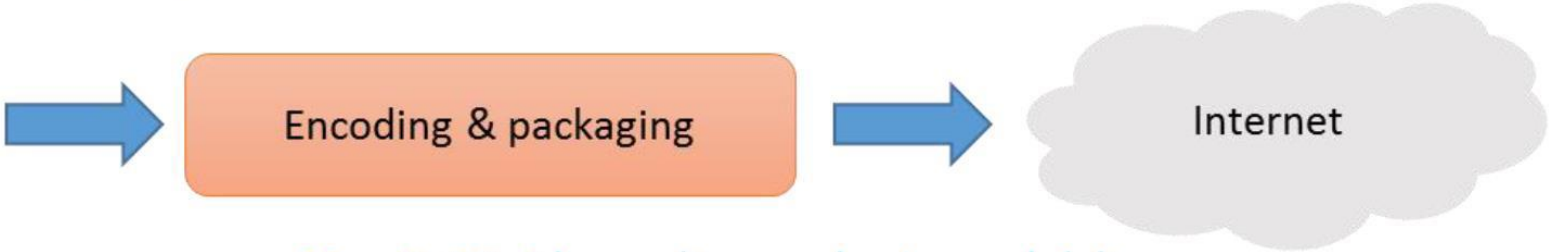
Multidirectional Camera

360°video



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

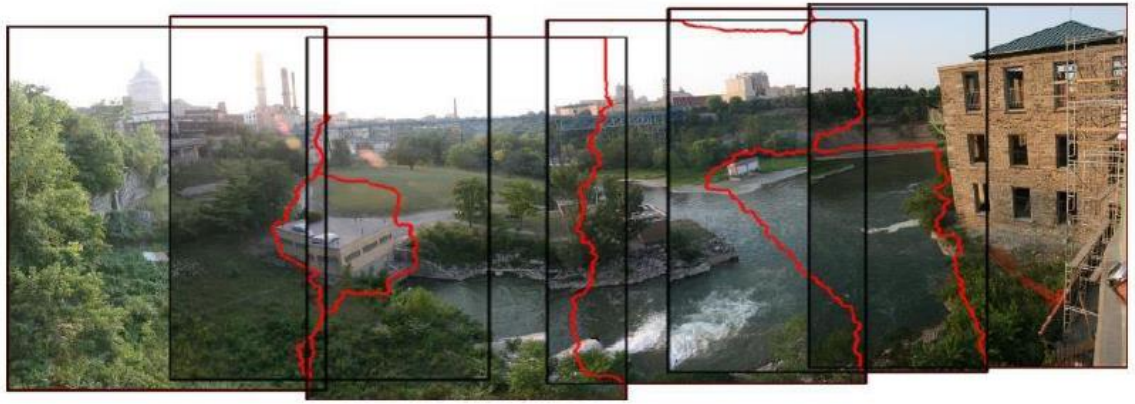
Step 2: spherical video is "unfolded" to 2D plane, e.g. using the equirectangular projection



Step 3: 2D video coding, packaging and delivery

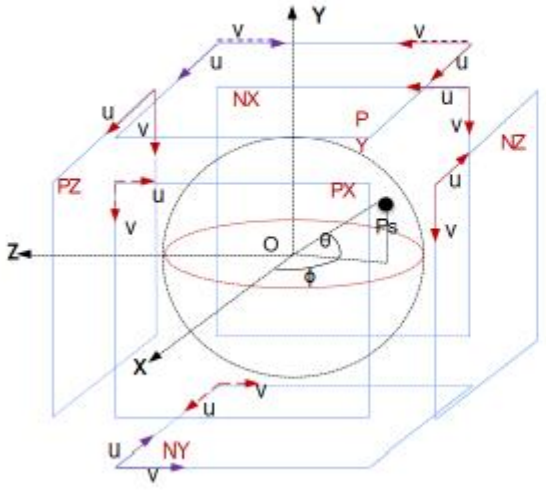
360°video: panorama stitching

- 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



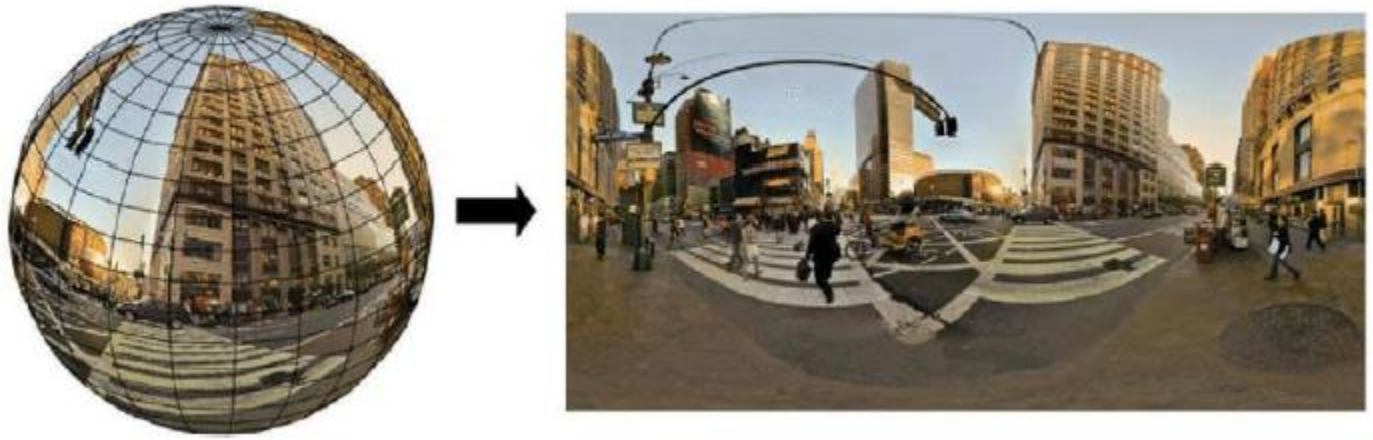
360°video: projection formats

- **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**

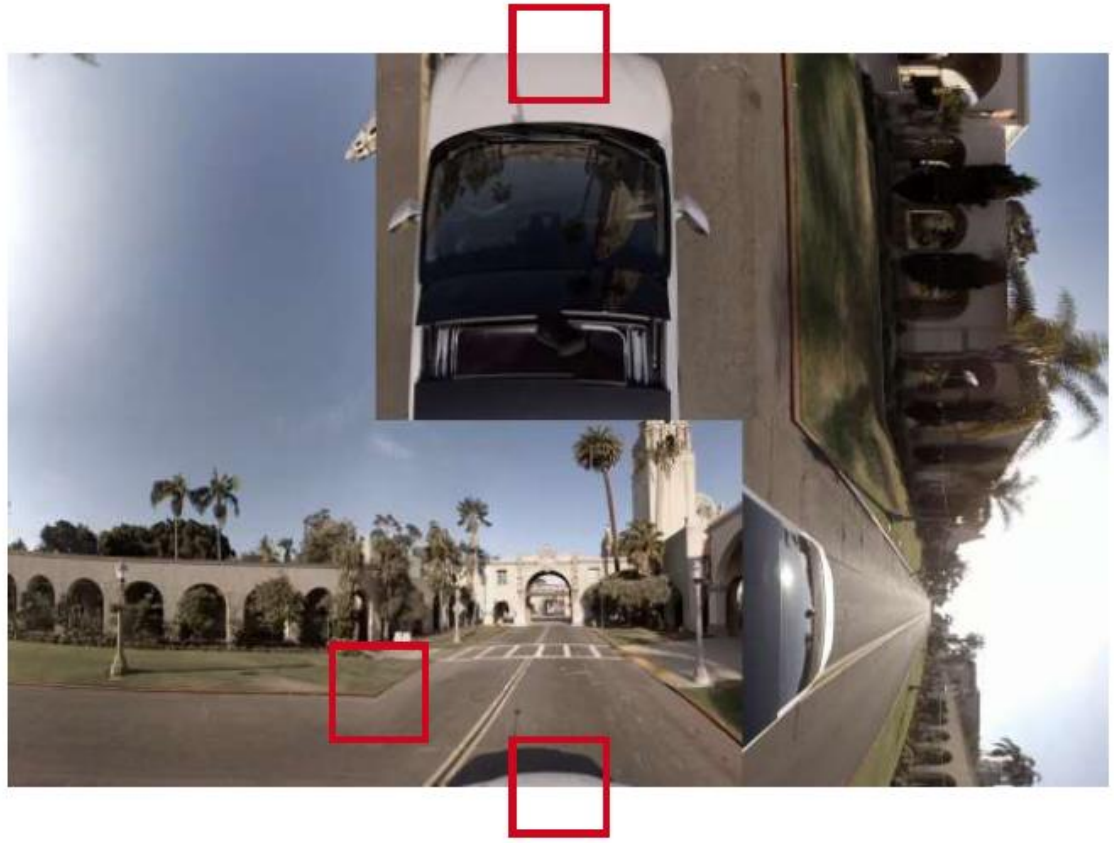


360°video specific coding tools

- 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,...

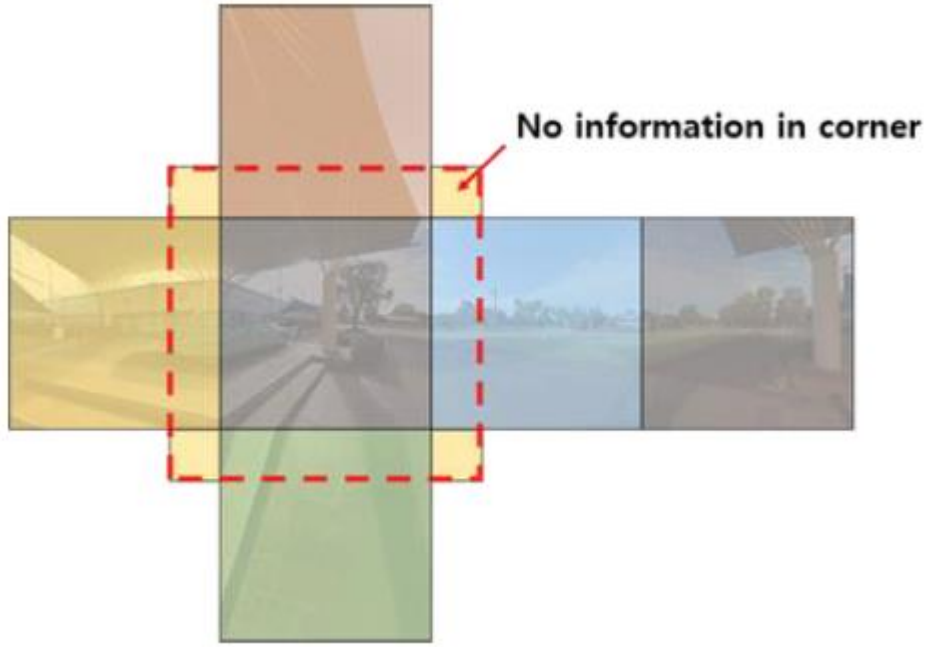
The proposed VVC Coding Tools

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



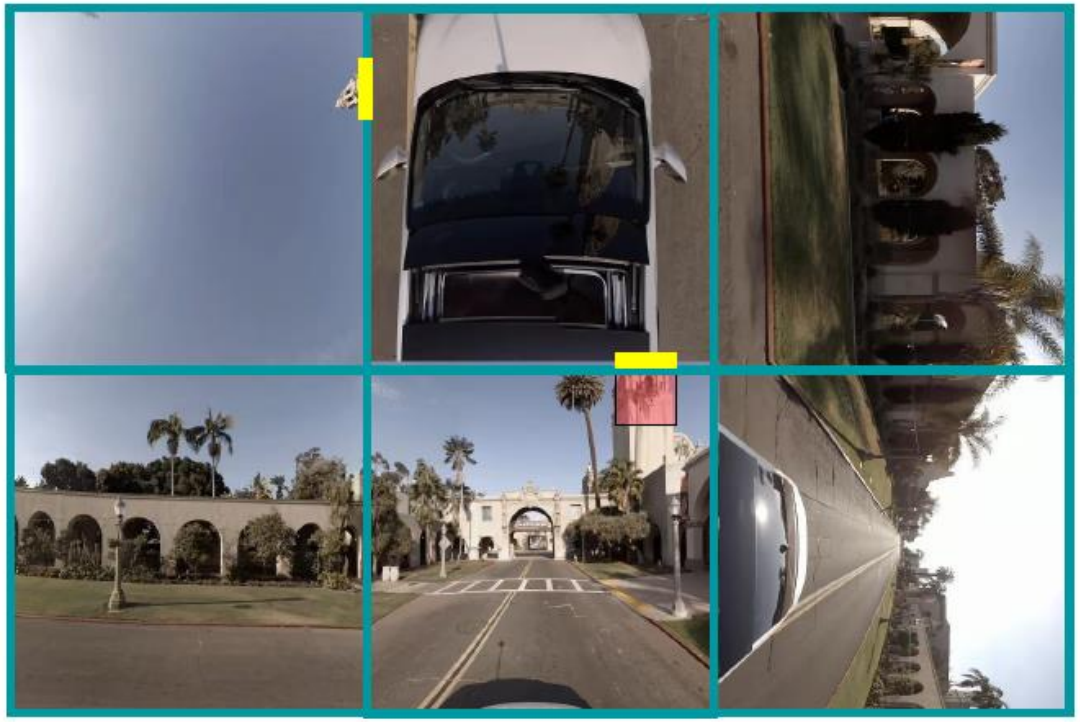
360°video coding tool: face extension

- **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

- M. Bläser, J. Sauer, and M. Wien, “Description of SDR and 360o video coding technology proposal by RWTH Aachen University,” Doc. JVET-J0023, Joint Video Experts Team of ITU-T VCEG and ISO/IEC MPEG, San Diego, USA, 10th meeting, Apr. 2018.

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