Viewport-adaptive 6DoF 360-degree Video Tiled Streaming for Immersive Media

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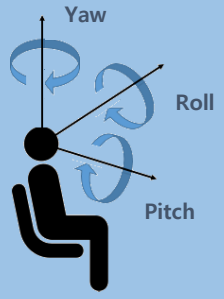
Virtual Reality in MPEG-I

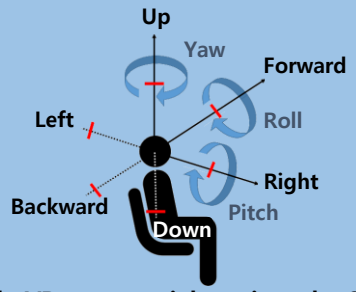
- Three phases of ISO/IEC MPEG-Immersive VR standardization
  - To support the entire movement in VR, 6DoF is required
  - 6DoF media support will be completed by 2022
  - 3DoF+ standard will be established by 2020 to support the limited 6DoF

Step 1



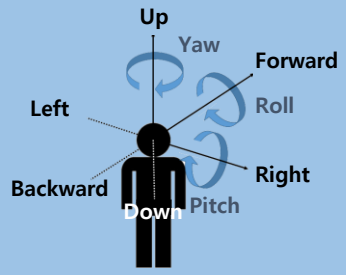
- Complete 3DoF standard by 2017
- Rotate head in a fixed state
- 360 video full streaming by default
- Tiled streaming if possible

Step 2



- Enable VR commercial servicers by 2020
- Allow head rotation and movement within a restricted area
- User-to-user conversations and projection optimization

Step 3

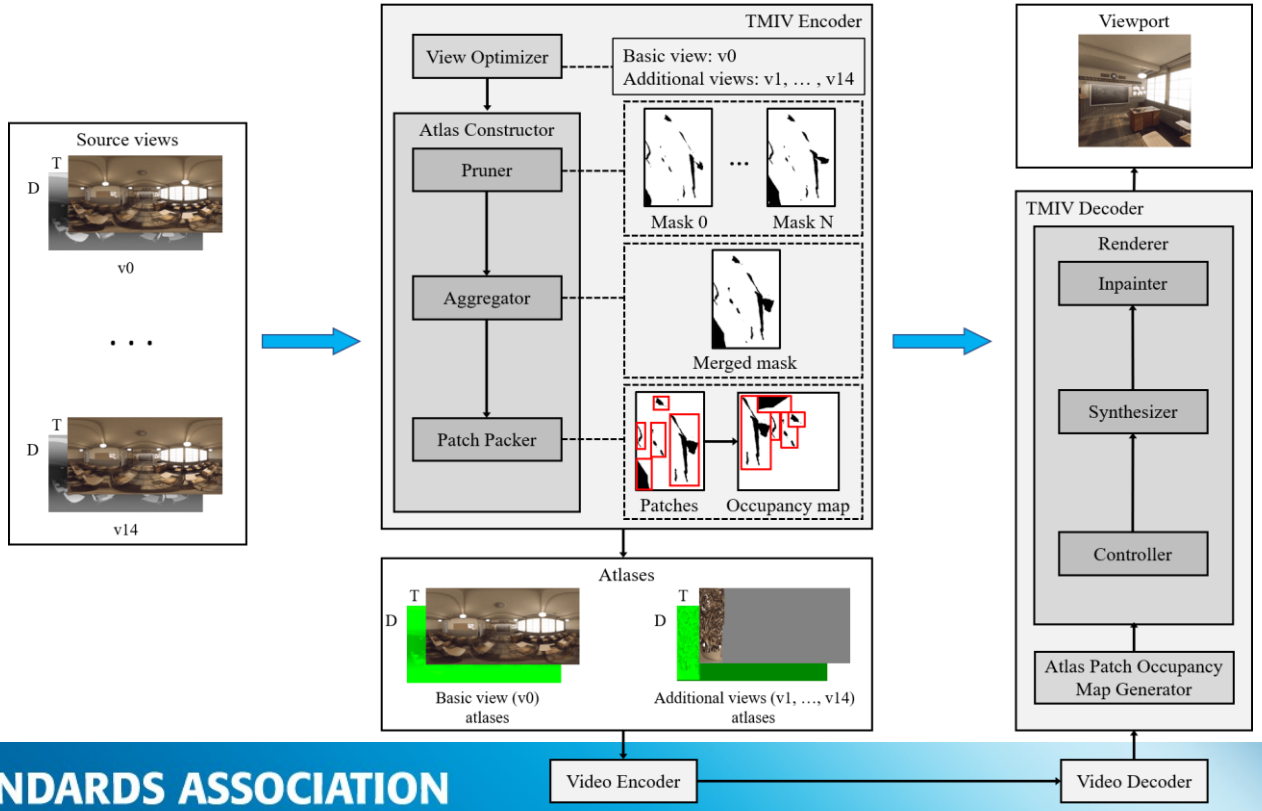


- Support 6DoF by 2022
- 6DoF video will reflect user's walking motion
- Support interaction with virtual environments

Virtual Reality in MPEG-I (Cont'd)

- 3DoF+ and 6DoF
  - MPEG-I requested call for proposals (CfP) on 3DoF+
  - Philips, Intel & Technicolor, Nokia, PUT & ETRI, ZJU submitted responses

    -> based on them, test model for immersive video (TMIV) was established
  - TMIV will be improved to compress 6DoF videos

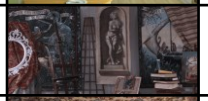


Block diagram of TMIV architecture

Virtual Reality in MPEG-I (Cont'd)

IEEE 3079

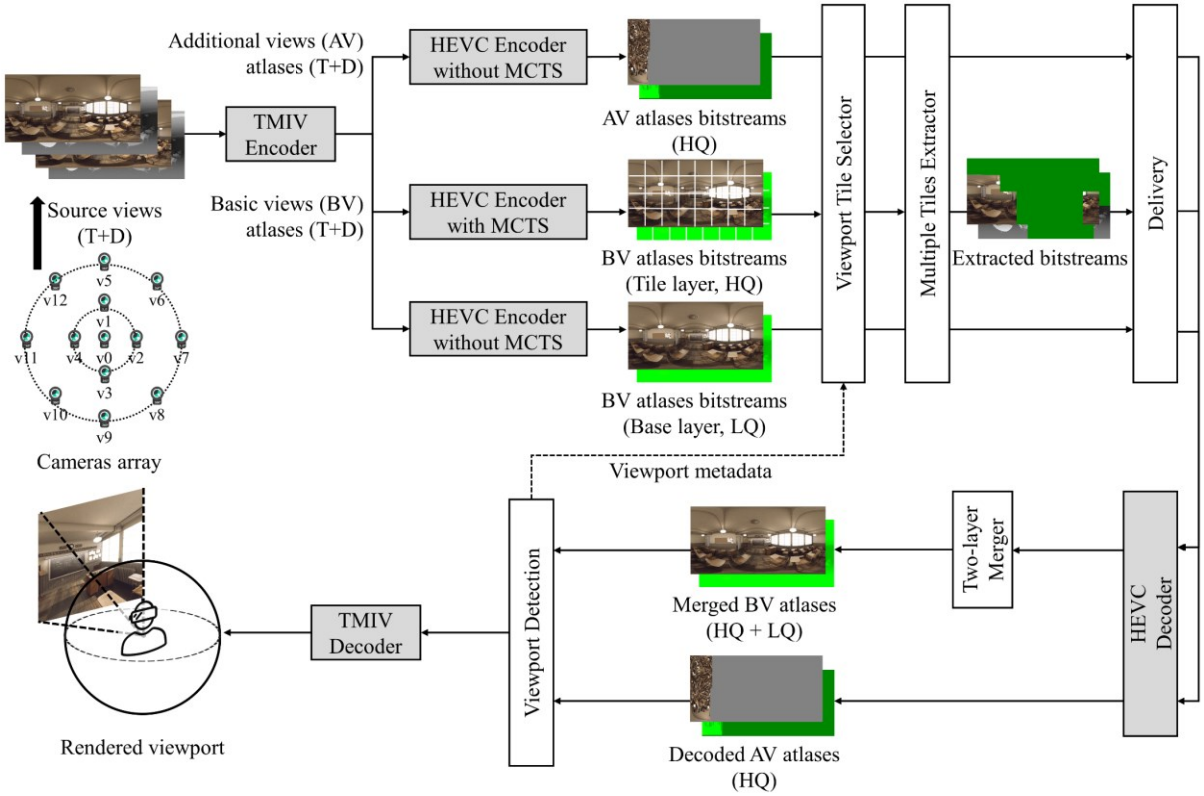
- Test sequences of immersive video
  - 11 test sequences are provided (5 computer graphics, 6 natural contents)
  - Among them, 4 sequences are 360 videos

Class (M/O)	Sequence name Resolution	Thumbnail	Type	No. of views	Depth range	Frame count	Frame rate	Bit depth
CG1-A (M)	**ClassroomVideo 4096x2048**		**ERP**	**15**	**[0.8m, inf]**	**120**	**30fps**	**Texture: 10, Geometry: 16**
CG1-B (M)	**TechnicolorMuseum 2048x2048**		**ERP**	**24**	**[0.5m, 25m]**	**300**	**30fps**	**Texture: 10, Geometry: 16**
CG1-C (M)	**InterdigitalHijack 4096x4096**		**ERP**	**10**	**[0.5m, 25m]**	**300**	**30fps**	**Texture: 10, Geometry: 16**
CG1-N (O)	**NokiaChess 2048x2048**		**ERP**	**10**	**[0.1m, 500m]**	**300**	**30fps**	**Texture: 10, Geometry: 16**
CG2-J (M)	OrangeKitchen 1920x1080		Perspective	25 (5x5)	[2.2, 7.2]	97	30fps	Texture: 10, Geometry: 10
NC1-D (M)	TechnicolorPainter 2048x1088		Perspective	16 (4x4)	-	300	30fps	Texture: 10, Geometry: 16
NC1-E (M)	IntelFrog 1920x1080		Perspective	13 (13x1)	[0.3, 1.62]	300	30fps	Texture: 10, Geometry: 16
NC2-L (M)	PoznanFencing 1920x1080		Perspective	10	[3.5, 7.0]	250	25fps	Texture: 10, Geometry: 16

MPEG-I immersive video test sequences

Tiled Streaming on 6DoF 360-degree Video

- Developed viewport tile selector (VTS) on 6DoF
- Compatible with TMIV and HEVC (or any other codecs, e.g. VVC)
- User's viewport tiles (HQ) + entire videos (LQ) simulcast streaming
  -> low delay and bandwidth adaptive streaming



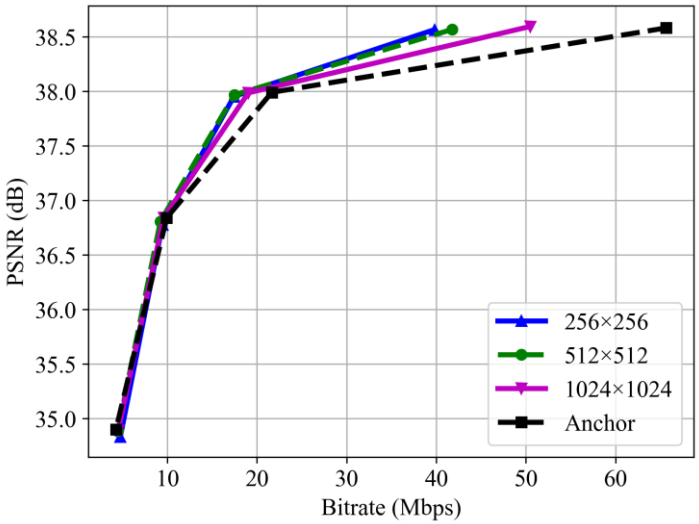
Viewport tile selector based tiled streaming

Tiled Streaming on 6DoF 360-degree Video (Cont'd)

- Tiled streaming shows BD-rate gain compared to the non-tiled streaming
- 512 × 512 tile shows the best result
- 5.69% of BD-rate saving for Y-PSNR was shown
  -> For realistic sequence, ClassroomVideo, 19.40% gain was shown
- Better results on VMAF and IV-PSNR
  -> Efficient on subjective quality

Sequence	Y-PSNR	VMAF	VIF	MS-SSIM	IV-PSNR
ClassroomVideo	-19.40%	-27.78%	-29.10%	-21.82%	-29.95%
TechnicolorMuseum	-4.65%	-4.31%	-6.30%	-2.05%	-3.40%
InterdigitalHijack	5.40%	6.10%	5.30%	6.80%	5.40%
NokiaChess	-4.14%	-7.94%	-9.20%	-3.88%	-6.23%
Average	**-5.69%**	**-8.47%**	**-9.82%**	**-5.23%**	**-8.55%**

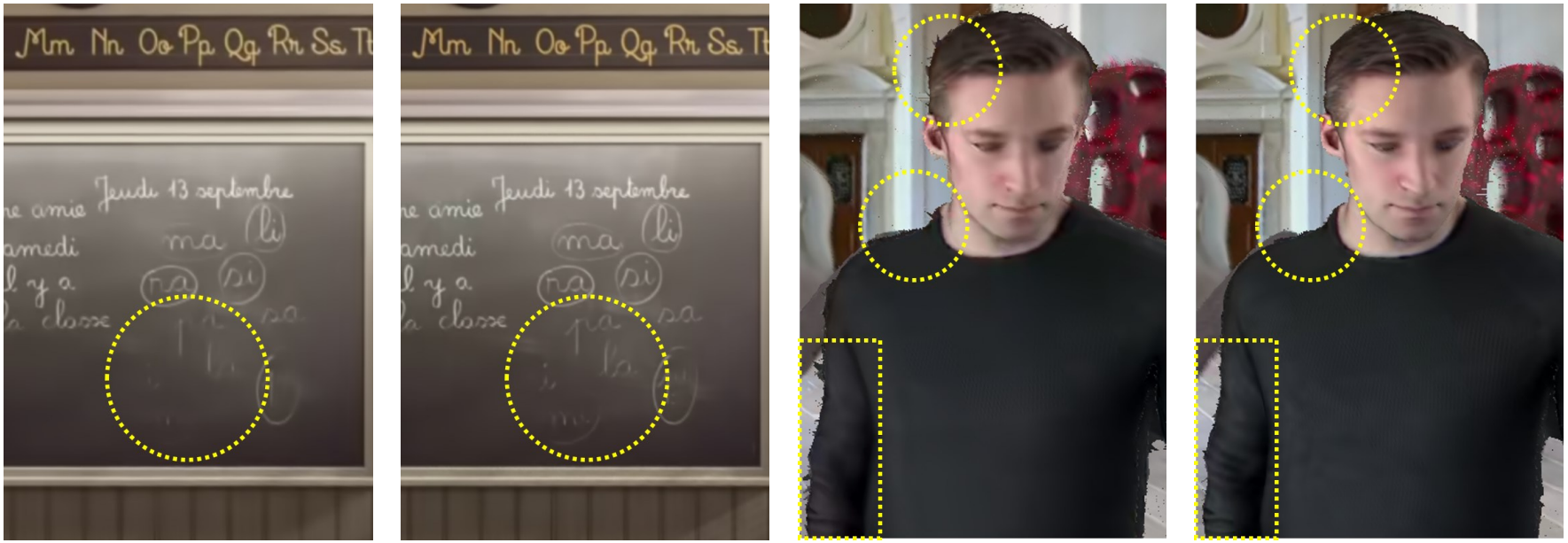
BD-rate savings of the VTS based tiled streaming method



RD-curve of the tiled streaming

Tiled Streaming on 6DoF 360-degree Video (Cont'd)

- At the same bandwidth, tiled streaming preserves more details
  (Traditional video artifacts)
- Especially on edge, there are less artifacts when using tiled streaming
  (6DoF view synthesis artifacts)



(a) (b) (c) (d)

Quality difference of tiled streaming and the TMIV anchor
(a, c: TMIV anchor; b, d: tiled streaming)

Conclusion

- Motivation
  - 6DoF 360-degree video streaming requires high bandwidth
  - Reducing the bitrate can reduce the latency, which influences quality of experience (QoE)
- Proposed Methods and Insights
  - Viewport-adaptive tiled streaming for 6DoF 360-degree video
  - Showed BD-rate gain compared to the non-tiled streaming
- Future Work
  - Experiment of mixed quality tiled streaming will be conducted