Adaptive Boundary Exension for Inter Prediction

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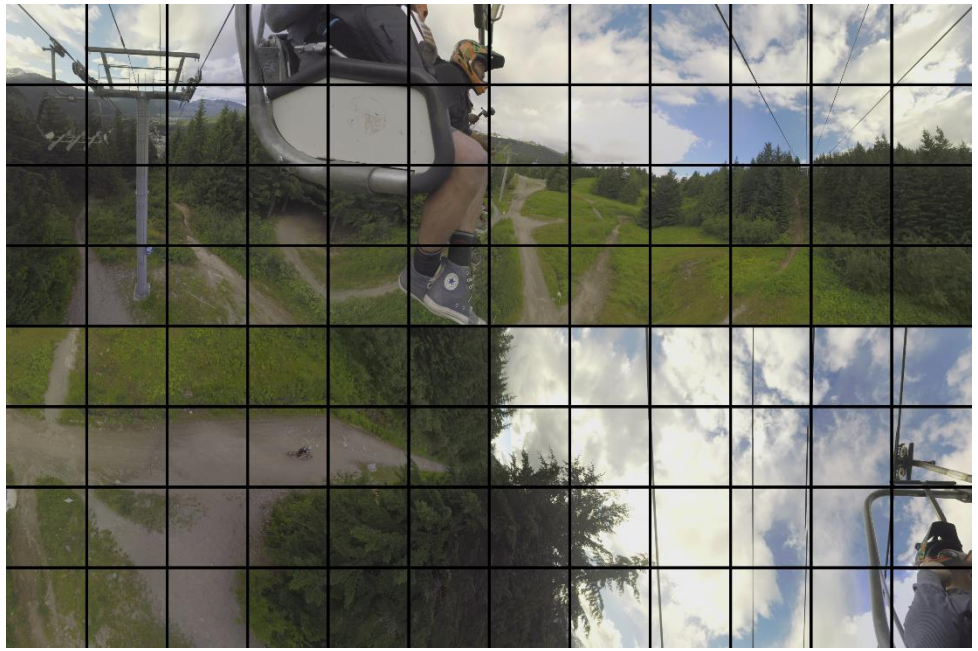
Motivation

- Omnidirectional videos typically displayed as viewport steered by the user
- Parts of video are coded in different quality options to reduce bandwidth
- Independently decodable subpictures introduced in Versatile Video Coding (VVC)

- Introduction of „picture boundaries“ inside the picture
- Picture boundary effects are highly increased

→ Improved boundary extension mechanism useful



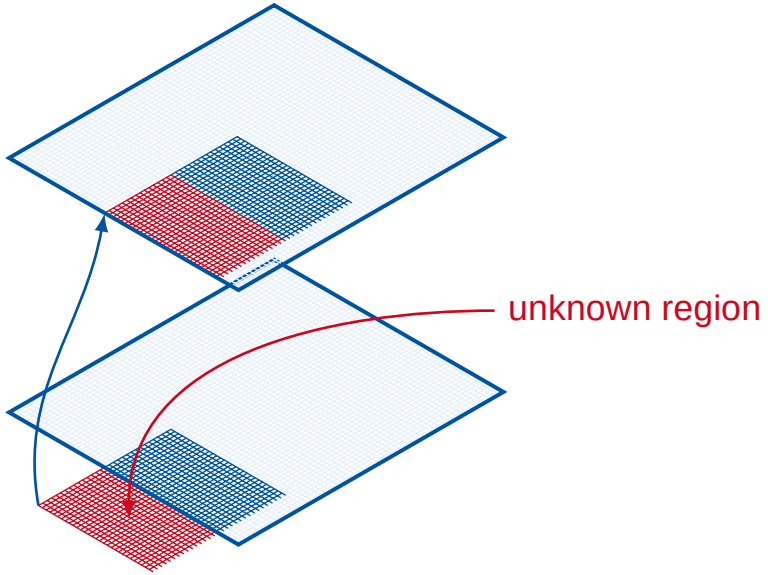
[1] JVET-M1032 „Description of Core Experiment 12 (CE12): Tile Set Boundary Handling“

Outline

- Boundary Extension Problem
- Adaptive Boundary Extension
  - Derived Approach
  - Signaled Approach
- Details of the Developed Signaled Method
- Results
- Conclusion and Outlook

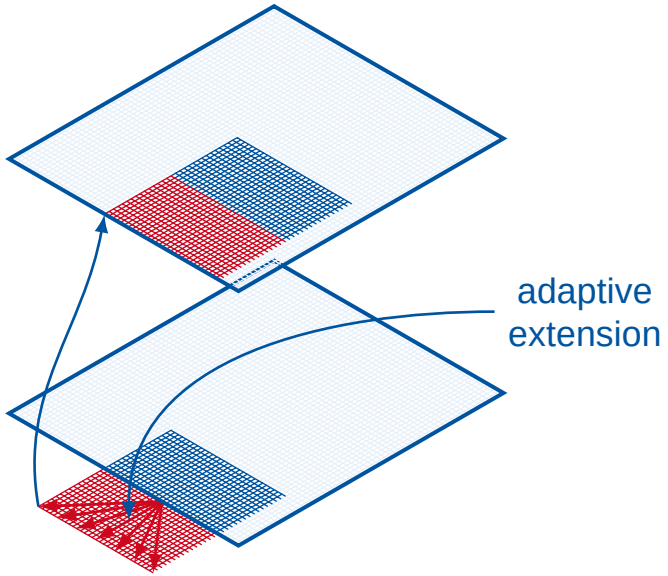
Boundary Extension

- Inter prediction at picture boundary areas
- Suspend restriction of motion vectors by boundary extension
- Method used in VVC and previous standards
  - Global extension of a subpicture
  - Nearest neighbor padding



Adaptive Boundary Extension

- Using an adaptive extension on a block basis
- Several prediction algorithms possible
- This work focuses on linear prediction
- Multiple prediction algorithms need either
  - a selection process on decoder side
  - or explicit signaling

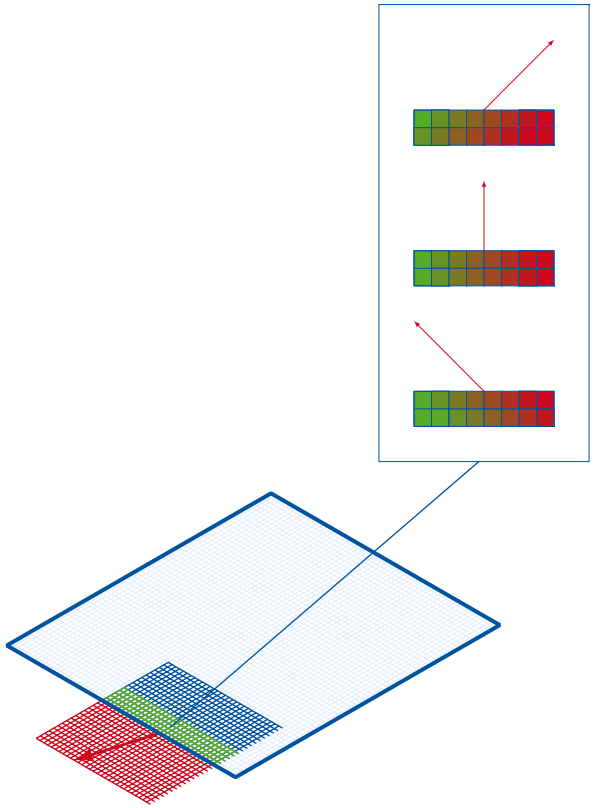


Derived Approach

- Approach presented in Call for Proposals for VVC [1]:
  - Use intra angular prediction algorithms
  - Derive prediction angle from block content

- No extra signaling needed

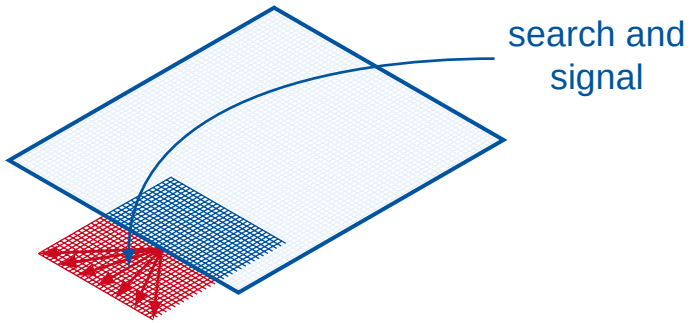
- Derived angle not always optimal in terms of
  - prediction error
  - continuity across subpicture boundary



- [2] JVET-J0014 „Description of SDR, HDR, and 360° video coding technology proposal by Fraunhofer HHI“

Signaled Approach

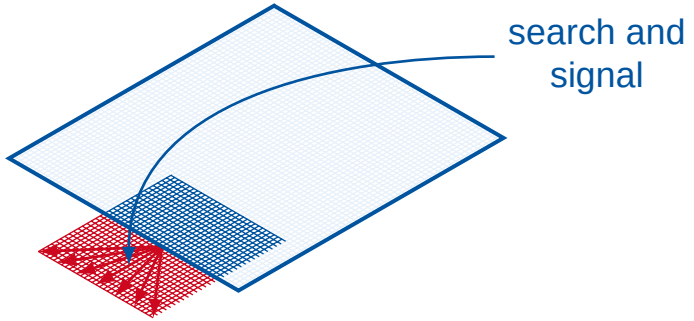
- Signaled approach allows to have optimal angle for prediction
- Our Approach:
  - Extension search is performed for every block
  - Signaling done at end of Coding Tree Unit (CTU)
  - number of blocks that need signaling is derived at decoder from motion vectors (parsing dependency)



Signaled Approach

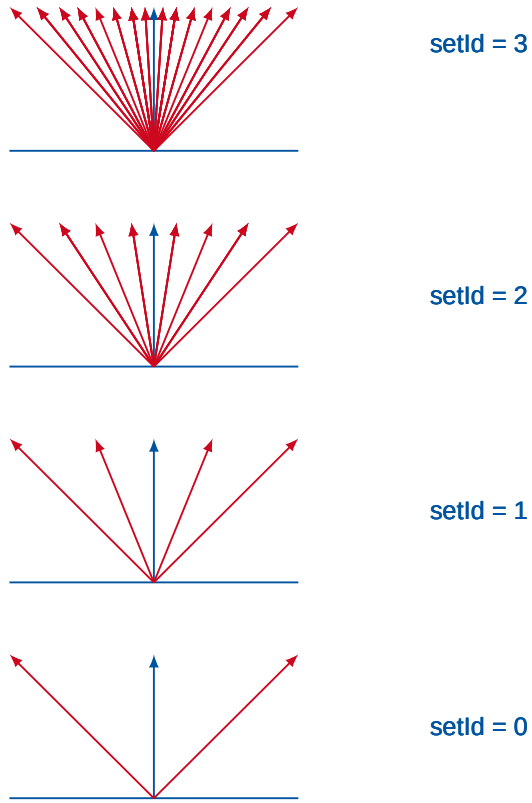
- Signaling of one extension mode:
  - Enabled flag
  - Sign flag that signals sign of angle
  - Index of used angles is signaled by using fixed-length binarization

- First simple signaling scheme to demonstrate method



Used Angles

- Signaling causes an increase in rate
- Signaling gets more expensive with more angle options
- We choose 4 sets of angles for the experiments
- Non-zero angles can be signaled with 0, 1, 2 or 3 bits for setId 0, 1, 2, 3 respectively
- SetId 3 equals intra angles used in High Efficiency Video Coding



Simulation Setup

- VTM-8.0 (VVC Test Model) anchor with low delay P configuration
- Disable some advanced inter prediction tools of VVC to avoid interaction
  - geometric partitioning mode (GEO), decoder-side motion vector refinement (DMVR), merge mode with motion vector difference (MMVD), adaptive motion vector resolution (AMVR)
  - Subblock-based prediction methods

- Sequences
  - ChairliftRide, SkateboardInLot, HarborBiking2, KiteFliteWalking2 (all with camera motion)

- Subpicture setup
  - Taken from CE on tile set boundary handling [1]
  - Projection format: CMP in 4608×3072 resolution
  - 384×384 subpicture partitioning → 96 subpictures 4608×3072

[1] JVET-M1032 „Description of Core Experiment 12 (CE12): Tile Set Boundary Handling“

Results

- BD-rate numbers for different approaches
  - Only small area affected by the methods
  - simple signaling scheme used

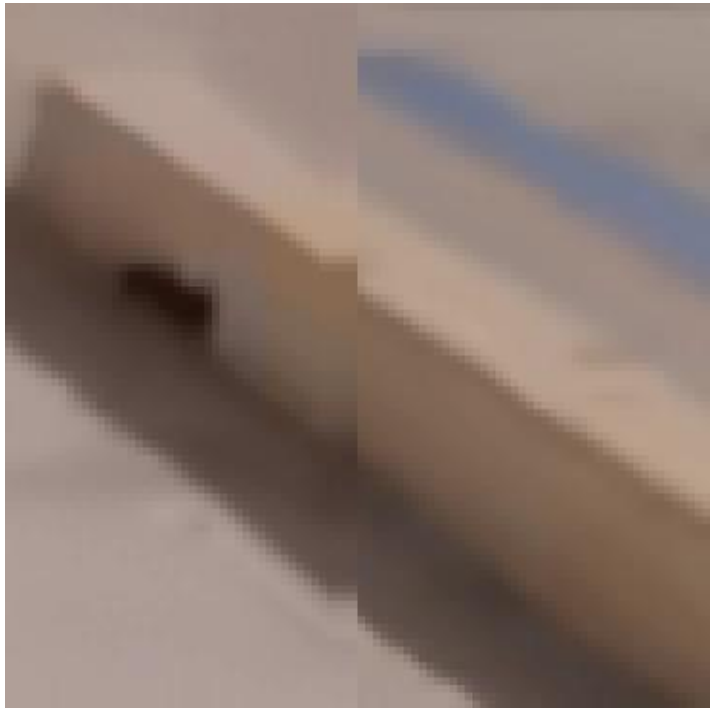
- For signaled approach smaller setIds yield better results because of reduced signaling cost
- Upper limit is theoretical number for what is reachable without signaling factored in
- Selection process chooses between method and anchor based on BD-rate number

sequence	setId	derived	der. sel.	signaled	sign. sel.	combined	upper limit
ChairliftRide	0	-0.10	-0.15	**0.03**	**-0.09**	-0.19	-0.71
	1	-0.23	-0.25	0.07	-0.09	-0.26	-0.98
	2	**-0.25**	**-0.27**	0.15	-0.05	**-0.27**	-1.07
	3	-0.22	-0.26	0.26	-0.03	-0.26	**-1.11**
SkateboardInLot	0	-0.03	-0.16	0.08	-0.12	-0.22	-0.63
	1	-0.05	-0.20	0.11	-0.13	-0.25	-0.75
	2	-0.20	**-0.32**	**0.07**	**-0.15**	**-0.40**	-1.04
	3	**-0.21**	-0.32	0.13	-0.12	-0.37	**-1.18**
HarborBiking2	0	-0.10	-0.16	**0.05**	-0.10	-0.19	-0.61
	1	-0.26	-0.29	0.06	-0.11	-0.31	-0.99
	2	**-0.30**	**-0.35**	0.07	**-0.13**	**-0.38**	-1.24
	3	-0.29	-0.35	0.17	-0.09	-0.36	**-1.42**
KiteFliteWalking2	0	-0.10	-0.15	0.02	-0.10	-0.18	-0.41
	1	-0.16	-0.20	**-0.01**	**-0.11**	-0.22	-0.67
	2	**-0.24**	**-0.27**	0.04	-0.07	**-0.28**	-0.89
	3	-0.22	-0.25	0.11	-0.06	-0.27	**-1.02**
average	0	-0.08	-0.16	**0.05**	-0.10	-0.20	-0.59
	1	-0.18	-0.23	0.06	**-0.11**	-0.26	-0.85
	2	**-0.25**	**-0.30**	0.08	-0.10	**-0.33**	-1.06
	3	-0.23	-0.29	0.17	-0.08	-0.32	**-1.18**

BD-rate numbers in % with (signaled) and without (derived) explicit signaling of the boundary extension mode averaged over all subpictures, the setId with the best BD-rate is marked bold

Visual Comparison

- Example taken from HarborBiking2
- Better continuation of edges across subpicture borders



anchor

ours

Conclusion and Outlook

- Possibility to match boundary regions of neighbouring subpictures in the encoding process due to signaling

- Upper limit numbers show promising rate savings when angular prediction is used as prediction method
- Signaled approach gives improvement on some subpictures
- Signaled method currently does not outperform the derived approach in general
  - Signaling cost to high
  - More elaborated signaling is needed
    - MPM, Grouping of modes etc. possible

- Region-based activation of method could improve results

Thanks for your attention