Tencent Cloud Tencent Media Lab

VCIP 2020 Tutorial: Screen Content Coding in Recently Developed Video Coding Standards

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2020/12

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Tutorial Outline

- Introduction of screen content coding and recently developed video coding standards
- Screen content coding tools (I)
  - IBC, PLT, ISC, TSRC, BDPCM, DBK
- Screen content coding tools (II)
  - IMVD, ISP, GPMBO, ACT, HashME
- Performance/complexity analysis
  - Performance and complexity of SCC tools in various standards
- Conclusion and discussion
  - Implementation hints, future directions, etc.

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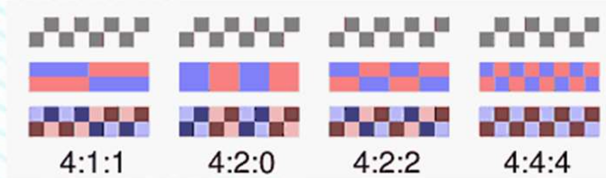
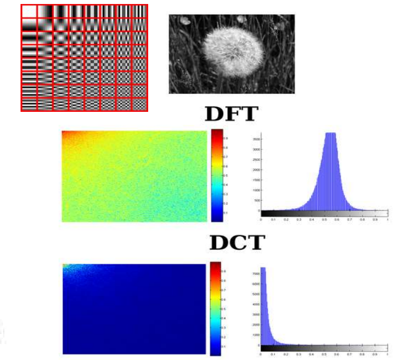
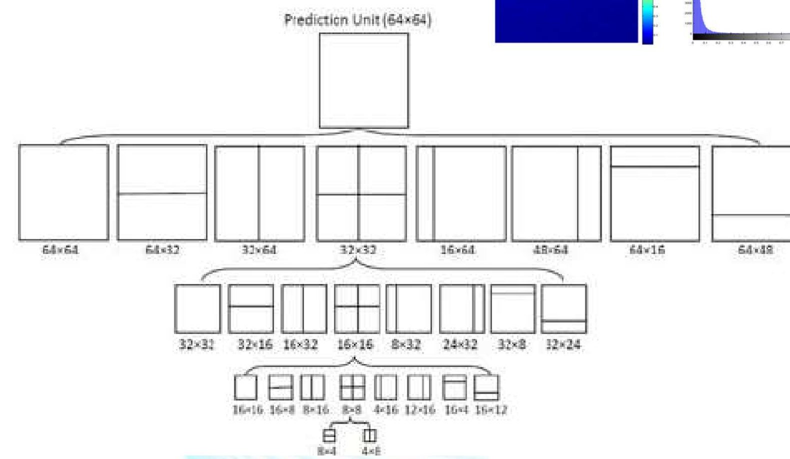
Video Compression







- Find correlations → Remove redundancies
    - Chroma sub-sampling
    - Spatial prediction
    - Temporal prediction
    - Transform
    - Quantization
    - Entropy coding

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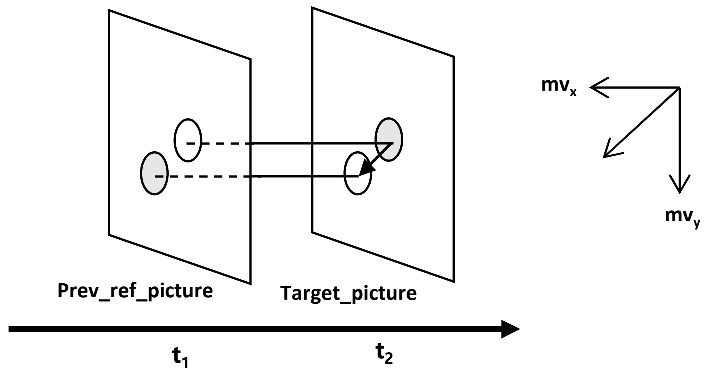
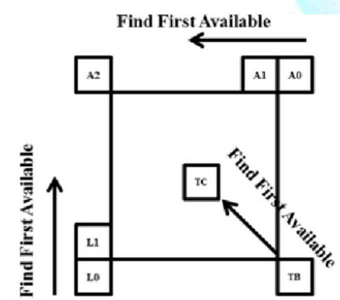
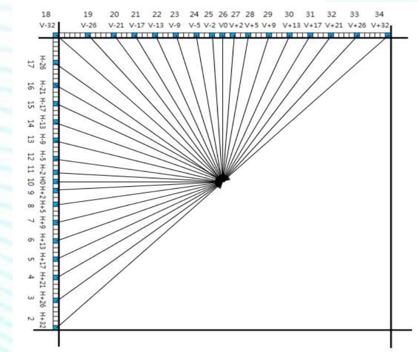
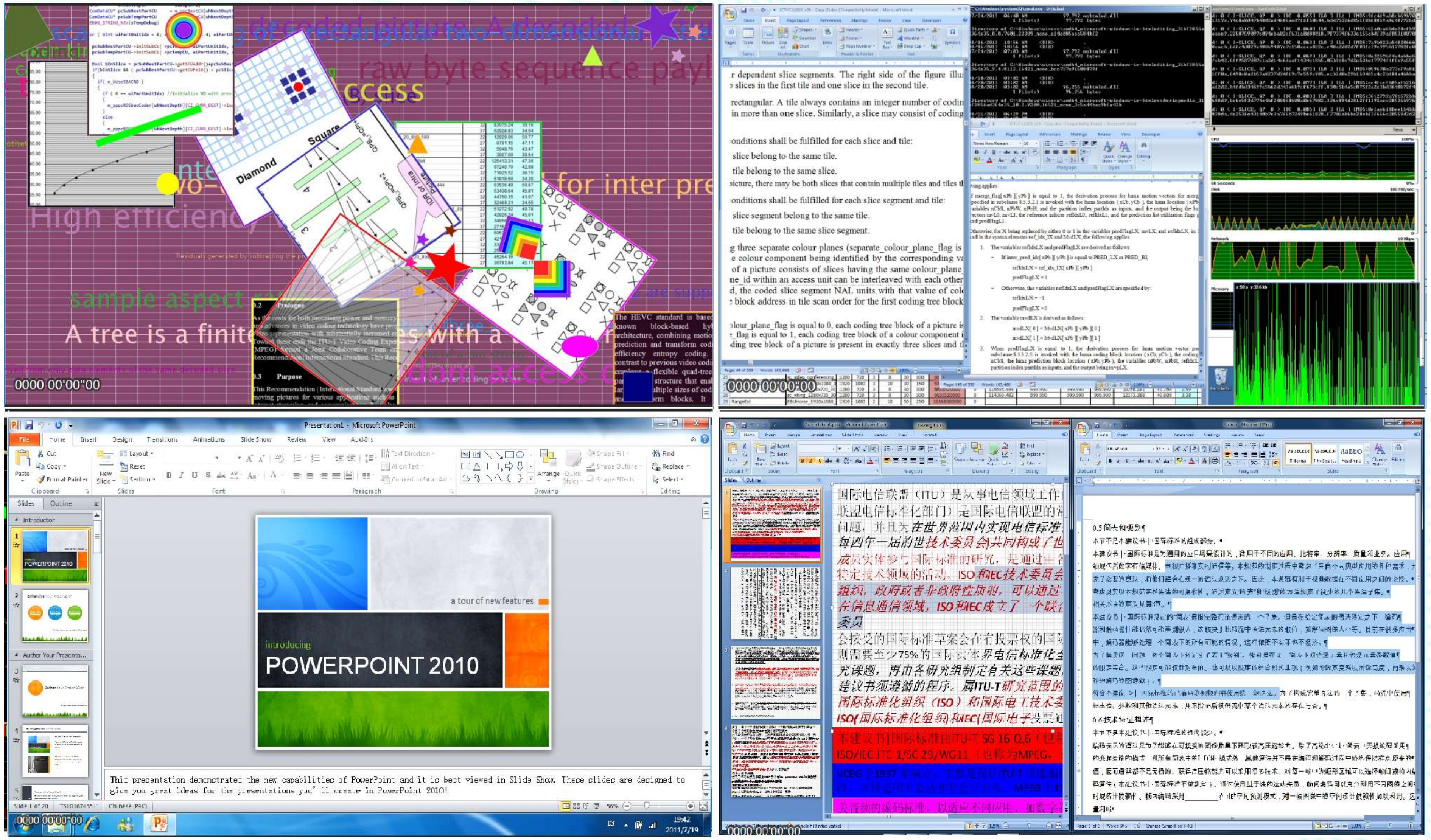






Typical Screen Content Video



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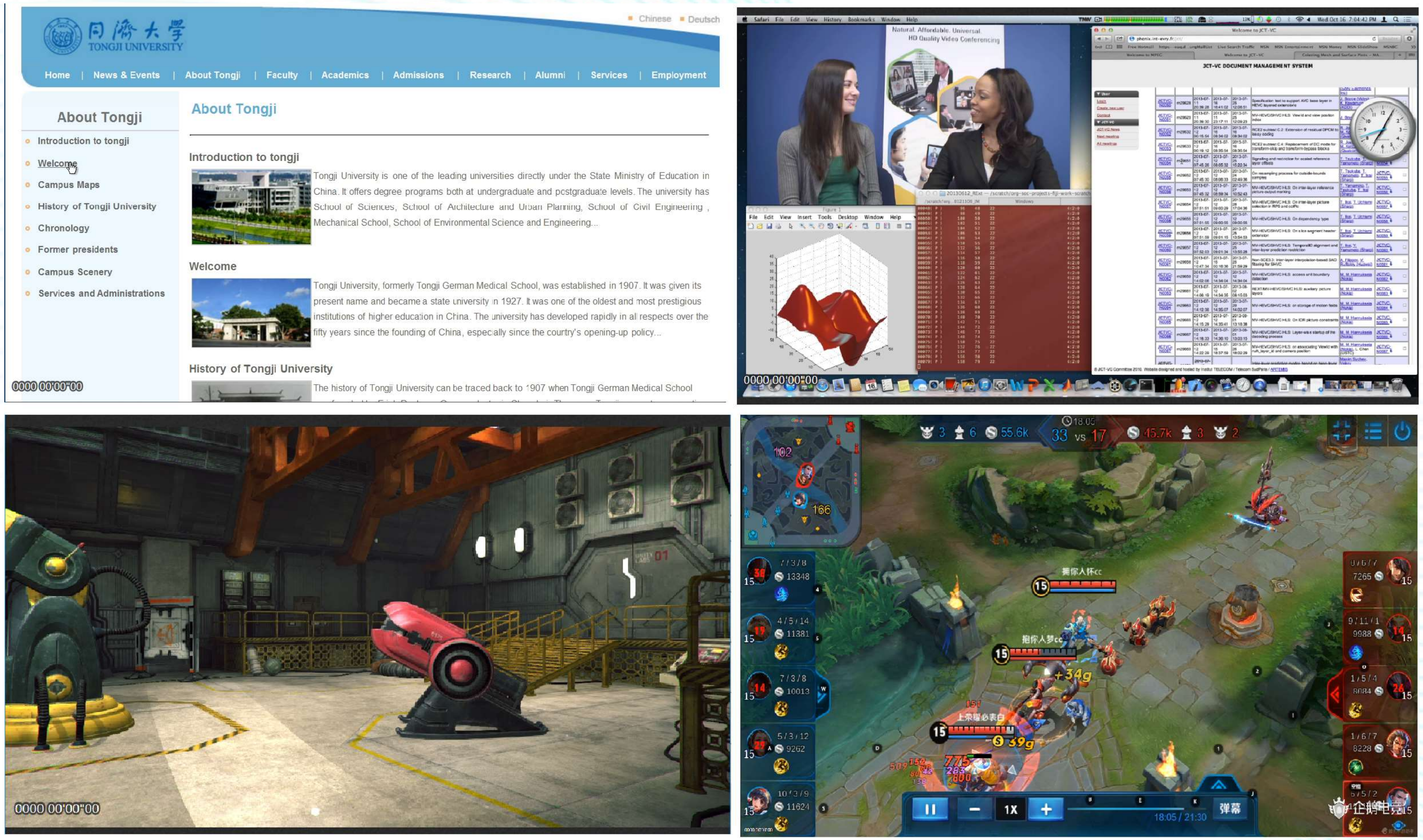

Screen Content Coding Technologies

Intra block copy (IBC)
Palette mode coding (PLT)
Transform Skip Residue Coding (TSRC)
Block based differential pulse code modulation (BDPCM)
Adaptive Colour Transform (ACT)
Adaptive motion vector resolution (AMVR)
Intra string copy (ISC)
Intra subblock partitioning (ISP)
Deblocking filter modifications (DBK)
Integer motion vector difference (IMVD)
Geometrical partition mode blending off (GPMBO)
Hash based motion estimation (HashME)
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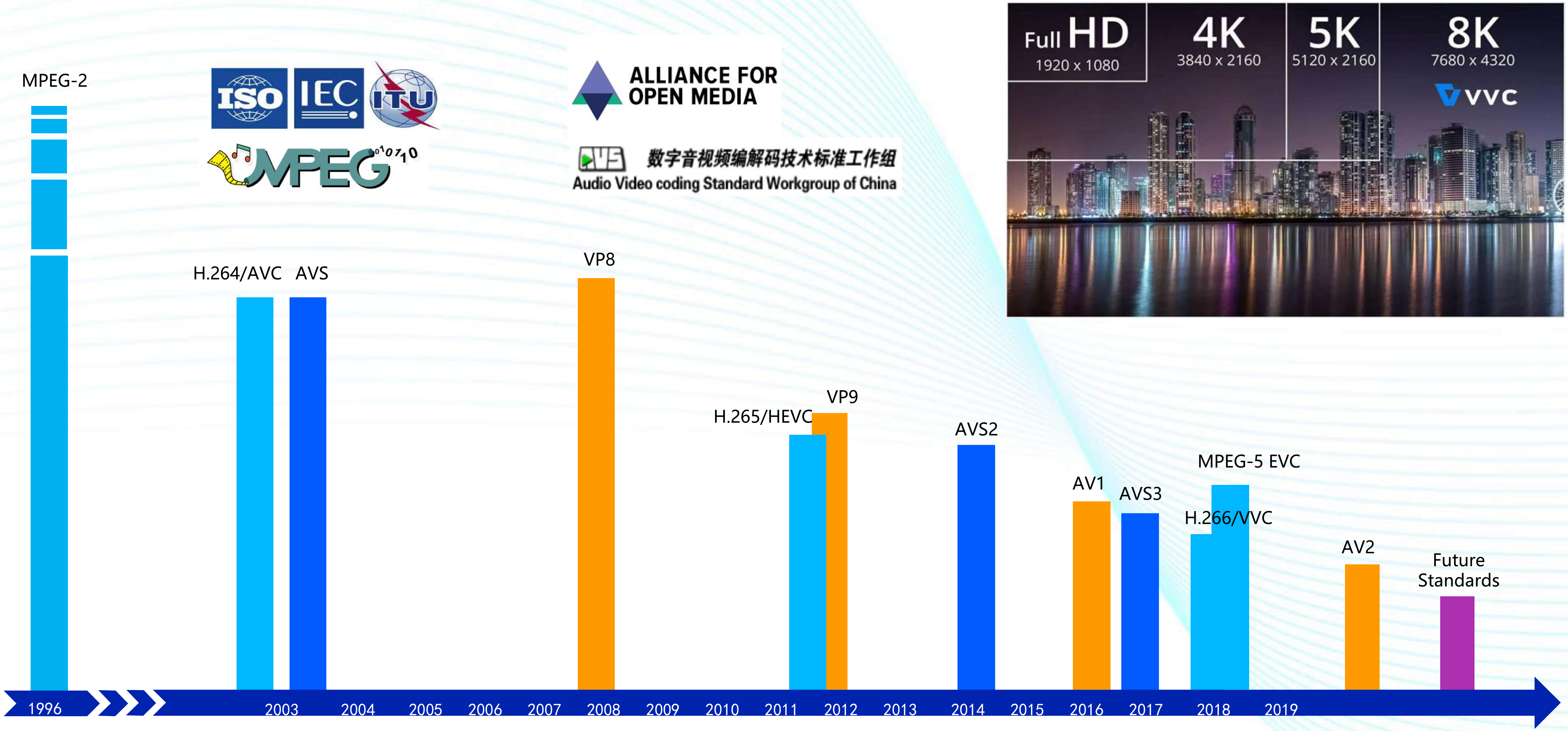
Video Coding Standards



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Background – H.265/HEVC SCC

- H.265/HEVC standard development
  - Developed jointly by ITU-T VCEG and ISO/IEC MEPG
  - Version 1 (v1) released in 2013; version 4 finished in 2016
  - v1 achieved ~50% BD-rate reduction over H.264/AVC
    - targeted generic applications include HD/UHD video
  - v2 included format range (4:4:4), scalable and multi-view extensions
  - v3 included 3D extensions
  - v4 included screen content coding (SCC) extension
  - v4 achieved ~50% BD-rate reduction on screen contents on top of v1

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Background – AV1

- Alliance for Open Media (AOM) Video 1 standard development
  - Driven by a royalty-free IPR policy
  - Developed by AOM members
    - 40+ companies including Google, Facebook, Netflix, Tencent*, etc.
  - Released in 2018
  - Achieved 20~25% BD-rate reduction over HEVC v1
  - Targeted applications include camera-captured HD/UHD video, screen content video, etc.
  - IBC and Palette mode are included in AV1.

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Background – H.266/VVC

- H.266/VVC standard development
  - Developed jointly by ITU-T VCEG and ISO/IEC MEPG
  - Started 2018.04
  - Version 1 (v1) finalized on 2020.07
  - v1 supports HD/UHD, HDR, 360, scalable and SCC applications
  - v1 with ~40% BD-rate reduction over HEVC v1 for UHD
  - Achieved 60+% BD-rate reduction on screen contents over HEVC v1
  - Achieved ~20% BD-rate reduction on screen contents over HEVC v4 (SCC)
  - Included various SCC tools.

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Background – MPEG-5 EVC

- Essential Video Coding (EVC) standard development
  - Driven by a controllable and clear licensing policy
  - Developed by ISO/IEC MEPG
    - Huawei/Samsung/Qualcomm/Tencent as patent holders
  - Baseline profile designed as royalty-free; main profile as royalty-baring but patent holders required to declare licensing policy within 18 months after the completion of standard, to facilitate the potential deployment
  - Targeted applications include 4K/8K video, screen content video, etc.
  - For UHD video, main profile ~30% BD-rate reduction vs HEVC v1; baseline profile ~38% BD-rate reduction vs AVC.
  - Features freeze (FDIS) as of 2020.08
  - IBC is included in EVC.

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Background – AVS3

- AVS3 (Audio Video Standard, series 3) development
  - Developed by AVS work group of China
    - Former successful standards include: AVS1 (AVC counterpart) and AVS2 (HEVC counterpart)
  - v1 completed in 2019, with ~26% BD-rate reduction compared to HEVC v1 for UHD
  - v2 under development, with ~30% BD-rate reduction compared to HEVC v1, expected to complete in late 2021
  - Targeted applications include 4K/8K video, surveillance, screen content, etc.
  - Included IBC, TSM, ISC and deblocking modifications.

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SCC Features in Various Standards

Tools	HEVC SCC	VVC	AV1	EVC	AVS3
IBC	✓	✓	✓	✓	✓
PLT	✓	✓	✓		
TSM	✓	✓			✓
ACT	✓	✓			
BDPCM		✓			
ISC	studied				✓
DBK					✓

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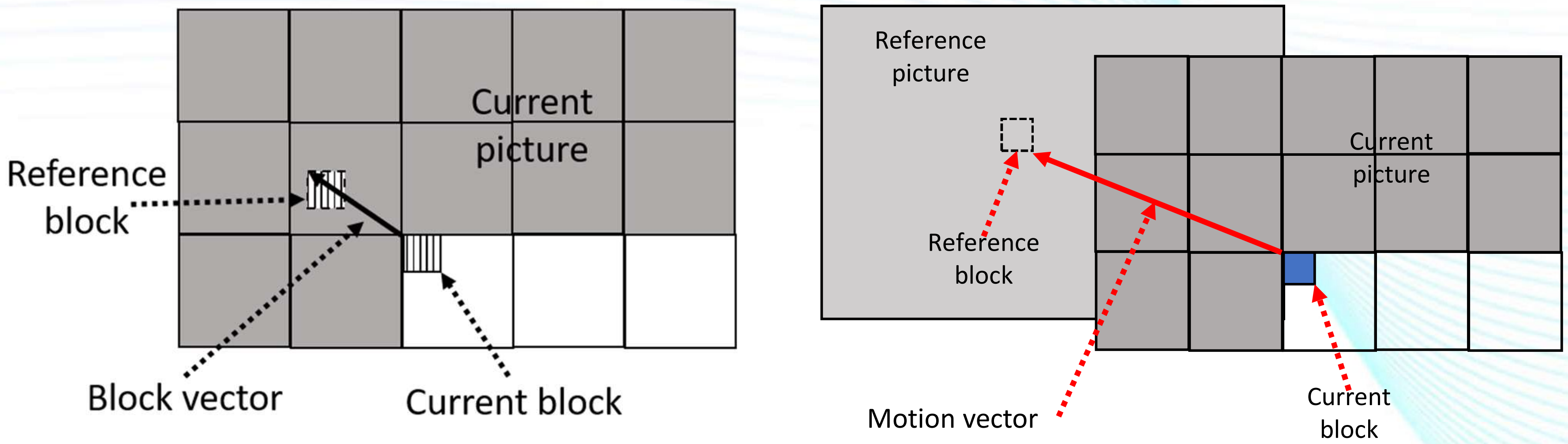
Intra Block Copy – Overview

- Block based prediction, similar as motion compensation
- Reference samples come from inside the current picture
- Also called current picture referencing (CPR)



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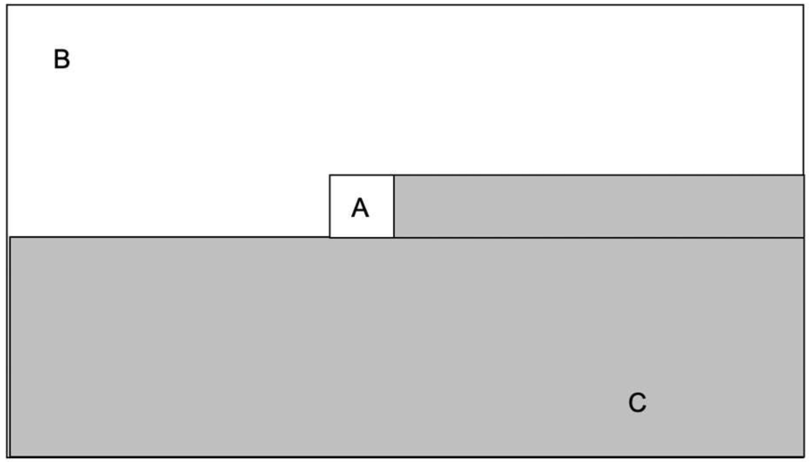
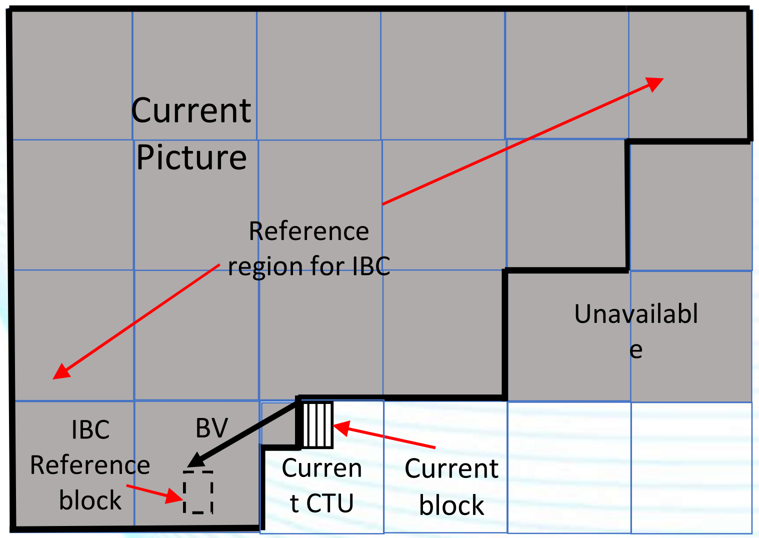
IBC in H.264/AVC Development

- JVT-C151: New Intra Prediction using Intra-Macroblock Motion Compensation, Siu-Leong Yu and Christos Chrysafis (Divio Inc.) 2002
  - Full frame based
  - Using inter MC to do intra-picture block compensation
    - Including interpolation and MV coding
  - Uncoded area is padded with 0 value
  - Signaled as a special MB mode



IBC in H.265/HEVC SCC

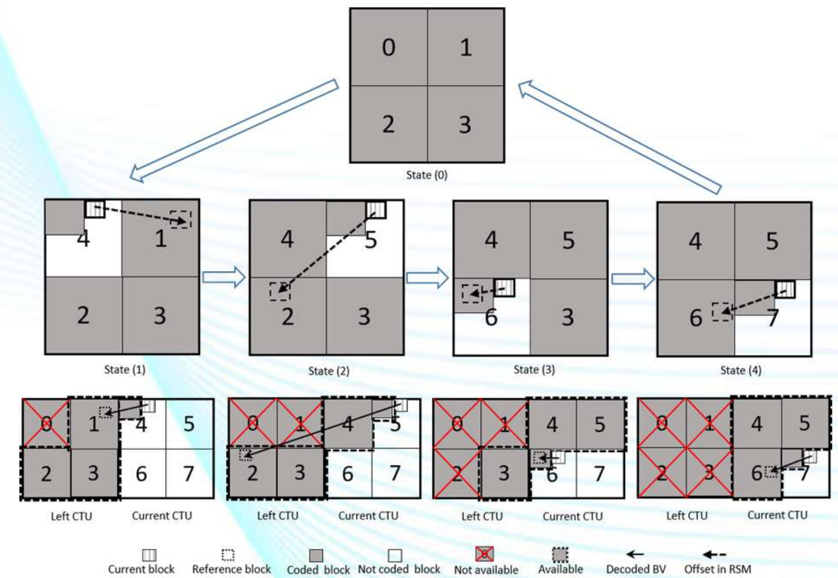
- Allowed search range (prediction region)
  - Full frame based, the reconstructed part of current decoded picture
  - Top-right part of the (coded) picture is excluded for WPP consideration
- Block vector prediction and merge mode same as inter
- Block vector difference coding
  - Aligned with inter MVD coding
  - Integer luma BV resolution
  - Chroma BV can be ½-pel when luma BV is an odd number
- IBC mode signaling
  - Current picture treated as one reference picture (long-term)
  - Reference index used to indicate current reference picture
  - Bi-prediction allowed (inter+IBC, IBC+IBC)
- Current reference picture is not filtered.



X. Xu et al., "Intra Block Copy in HEVC Screen Content Coding Extensions," in IEEE Journal on Emerging and Selected Topics in Circuits and Systems, vol. 6, no. 4, pp. 409-419, Dec. 2016.

IBC in H.266/VVC

- Allowed search range
  - Local CTUs, available samples stored in one fixed size (128x128) memory
- Block vector prediction and merge simplified from inter
- Block vector difference coding
  - Aligned with MVD coding
  - Luma BV resolution switch between 1 and 4 samples
  - Integer chroma BV (crop)
- IBC mode signaling
  - Signaled as a separate mode at CU level
  - Not combined with inter or intra
- In case of dual tree, chroma IBC not allowed
- IBC predictor is not filtered.



B. Bross, J. Chen, S. Liu, Y. Wang, "Versatile video coding (Draft 10)", JVET-S2001.

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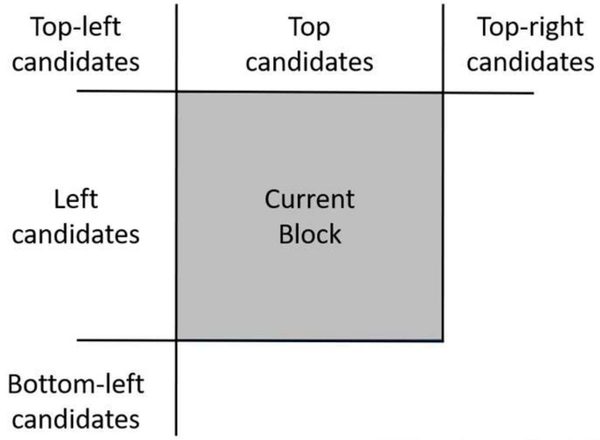
IBC in EVC and AVS3

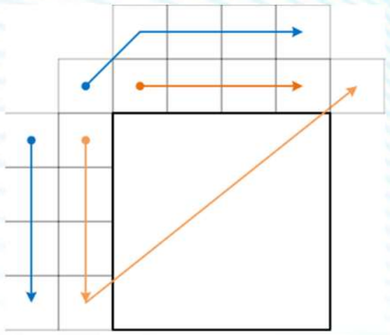
- IBC in MPEG-5 EVC development
  - Search range same as in VVC
  - No BVP; BV is coded directly
  - BVD coding aligned with MVD coding
  - Separate IBC mode at CU level
  - Not combined with inter or intra
  - IBC predictor is not filtered.

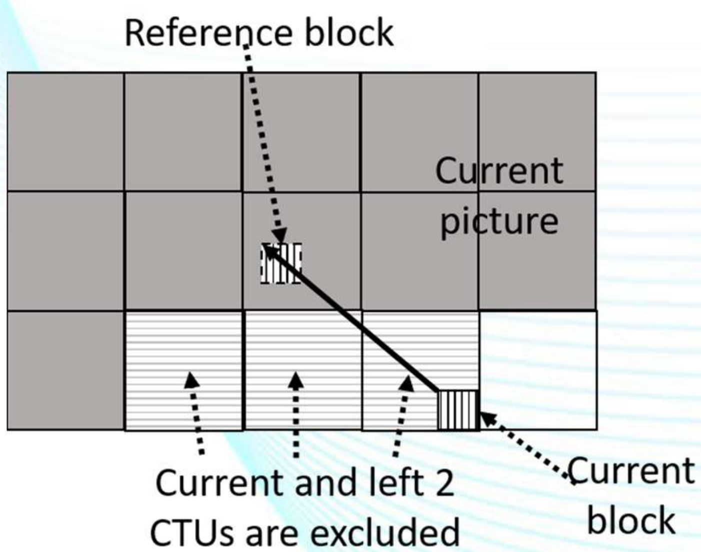


- IBC in AVS3 development
  - Search range same as in VVC
  - History-based BVP
  - BVD coding aligned with MVD coding
  - Luma BV resolution 1 and 4 samples
  - Chroma BV crop to integer
  - No merge/skip mode
  - Separate IBC mode at CU level
  - Not combined with inter or intra
  - IBC predictor is not filtered.

IBC in AV1

- Allowed search range
  - Full frame based, excluding local neighboring 2 CTUs (and unconstructed area)
- Block vector prediction
  - Spatial BVP
- Block vector diff coding
  - Same as MVD coding
  - Luma BV integer (1-pel)
  - Chroma BV can be ½-pel
- IBC mode signaling
  - Signaled as a separate mode at CU level
  - Not combined with inter or intra
- IBC only applied in intra pictures
- IBC predictor is not filtered.





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Remarks of Full Frame IBC

- Pros:
  - Aligned with inter prediction
  - Software friendly
  - Higher coding gain (search range)

- Cons:
  - Increased decoded picture buffer size
    - Two copies of the current reference picture (filtered and unfiltered) need to be stored for the use of MC inter prediction and IBC prediction, respectively.
  - Memory bandwidth
    - This extra (unfiltered) version of current decoded picture, if stored off-chip (external memory), causes memory bandwidth increase.
  - Processing timing
    - Neighboring reconstructed samples need time to dump off-chip and fetch on-chip.

Remarks of Local IBC

- Reference samples can be stored “on-chip”, in high-speed memory
  - Pre-filtered samples are stored; no extra storage needed
  - No extra memory bandwidth required
  - No extra processing time (dump and fetch)

- Trade-off between cost and compression performance
  - Limit the search range to accommodate on-chip memory cost
  - Coding gain is slightly less than full frame IBC (~10%)
  - One maximum CTU size of memory is considered an acceptable balance
  - With optimized reference sample management, the coding performance of using storage size up to one CTU (128x128) is close to allowing search in up to two CTUs.

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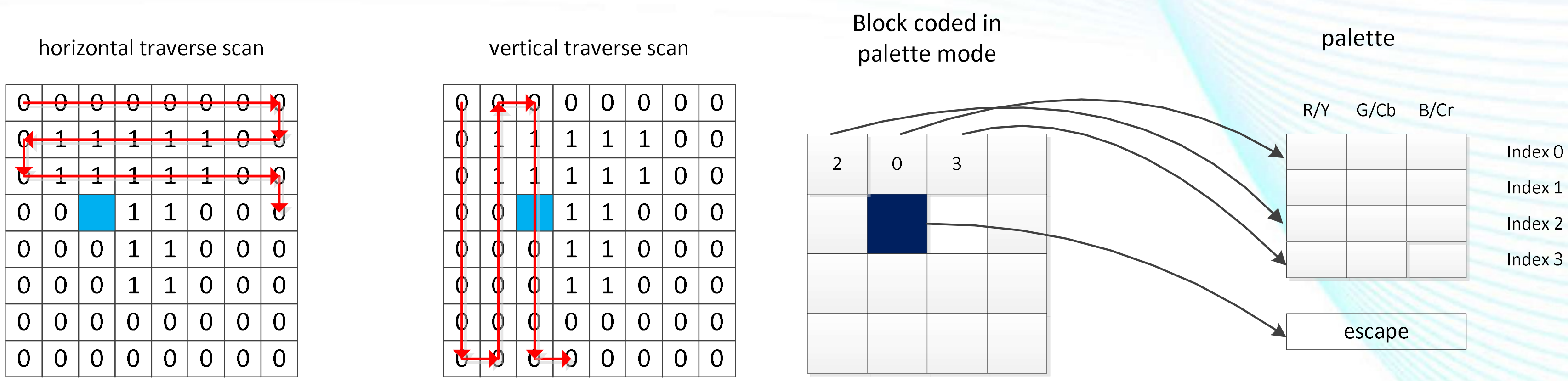
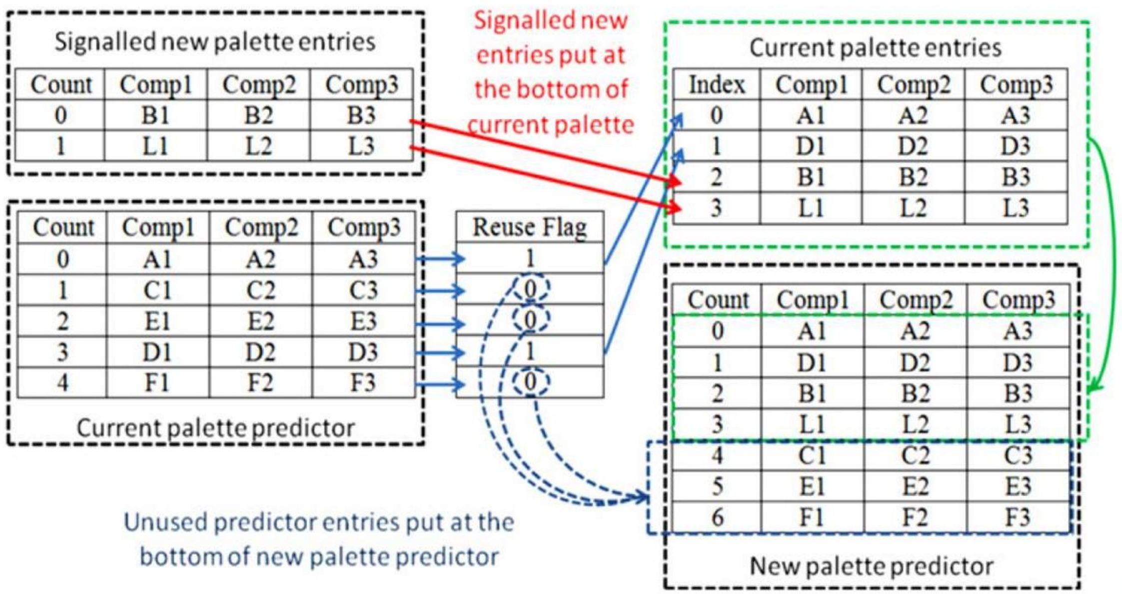
Palette Mode – Overview

- Pixels are predicted by a set of colors (i.e. palette)
- The indices of the predictors are signalled (index map)
  - The index map (indices throughout the CU) is coded
  - Residues from palette prediction may be coded (AV1) or not (in HEVC SCC and VVC)
- Escape pixel (the one cannot be found in palette) coding
  - Signal the absolute (quantized) values



Palette Mode in H.265/HEVC SCC

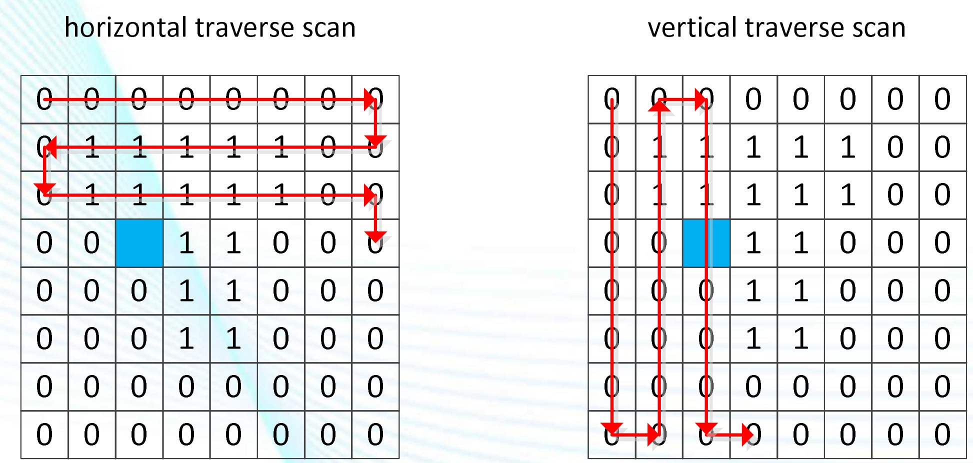
- Palette construction, prediction and update
  - YCbCr combined palette
  - Current palette consists of new entries and entries from PLT predictor
  - New entries (colors) outside the predictor are signaled
  - After the CU is coded with PLT mode, the PLT predictor is updated.
  - Each entry in PLT predictor is associated with a reuse flag
- Index coding in HEVC SCC
  - Current index is coded in one of two run modes
    - copy_from_above_index
    - copy_from_previous_index
  - All signaled indices are grouped together
  - All lengths of the runs are grouped together
- Horizontal and vertical scan with traverse
- Signaled as a separate intra mode at CU level



W. Pu et al., "Palette Mode Coding in HEVC Screen Content Coding Extension," in IEEE Journal on Emerging and Selected Topics in Circuits and Systems, vol. 6, no. 4, pp. 420-432, Dec. 2016,

Palette Mode in H.266/VVC

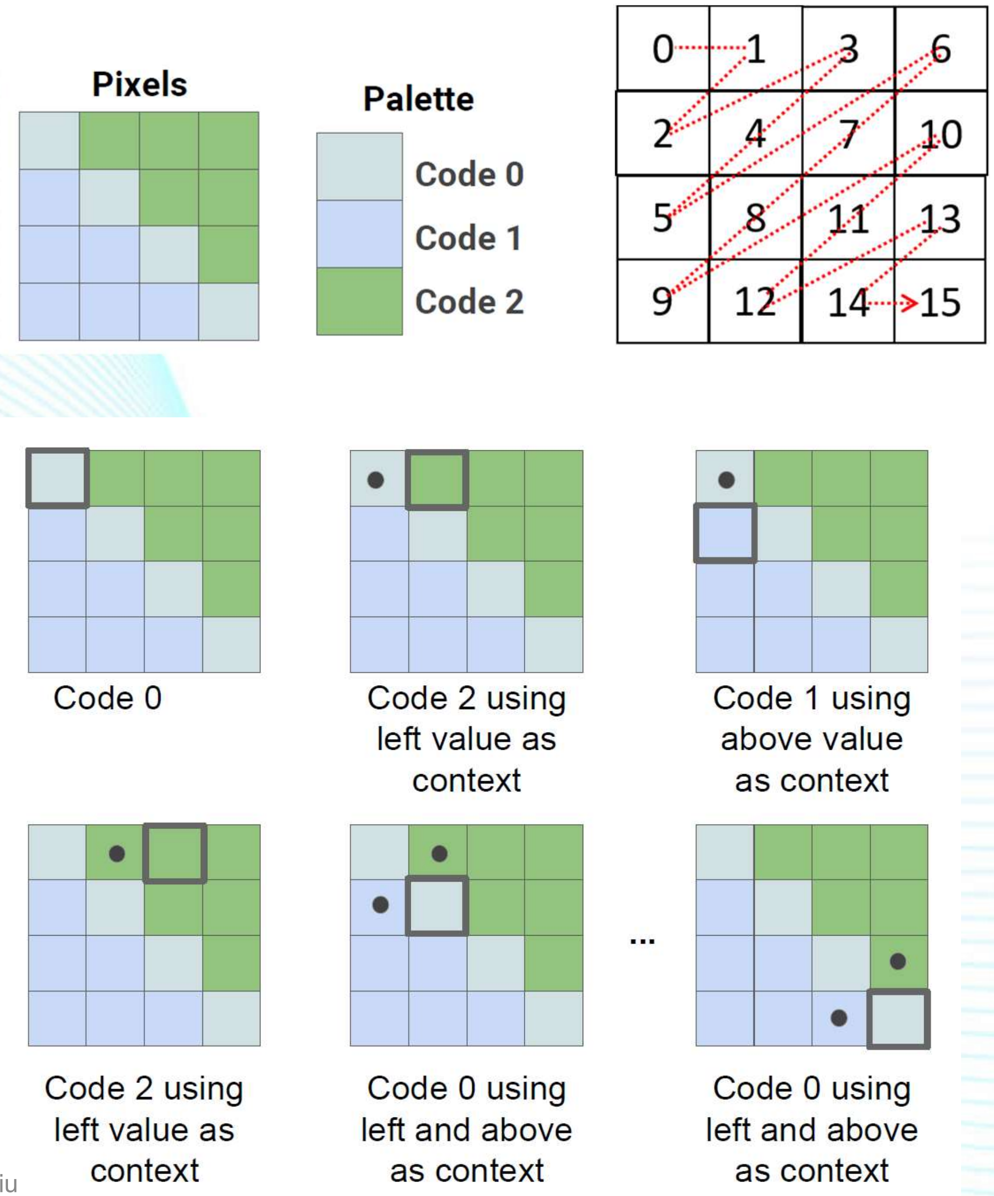
- Palette construction and prediction
  - YCbCr for single tree
  - Y, CbCr for dual tree
  - Palette prediction similar to HEVC SCC
    - Chroma PLT not applied for local dual tree
- Index coding
  - Concept similar to HEVC SCC
  - Each 16 indices are grouped together
    - To increase throughput
- Horizontal and vertical scan with traverse
- Signaled as a separate (intra) mode at CU level



B. Bross, J. Chen, S. Liu, Y. Wang, “Versatile video coding (Draft 10)”, JVET-S2001.

Palette Mode in AV1

- Palette construction and prediction
  - Separate palette (Y, Cb, Cr)
  - 2~8 colors (entries) per palette
  - Top and left neighboring block palettes as predictors
  - Signal delta (to palette predictor) when needed
- Index signaling
  - Diagonal scan for coding index map
  - Neighboring index values used as context
- Residue coding applied after palette prediction, like other intra modes
- Signaled as an intra (DC) mode



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Geometrical partition mode blending off (GPMBO)

Hash based motion estimation (HashME)

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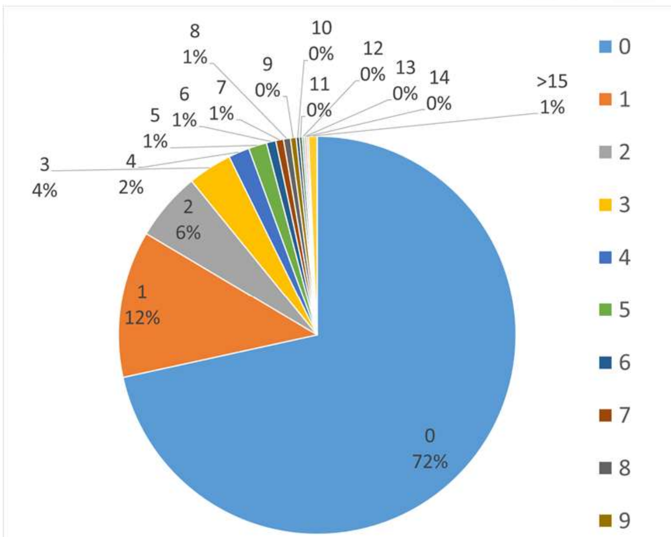
Transform Skip Mode (I)

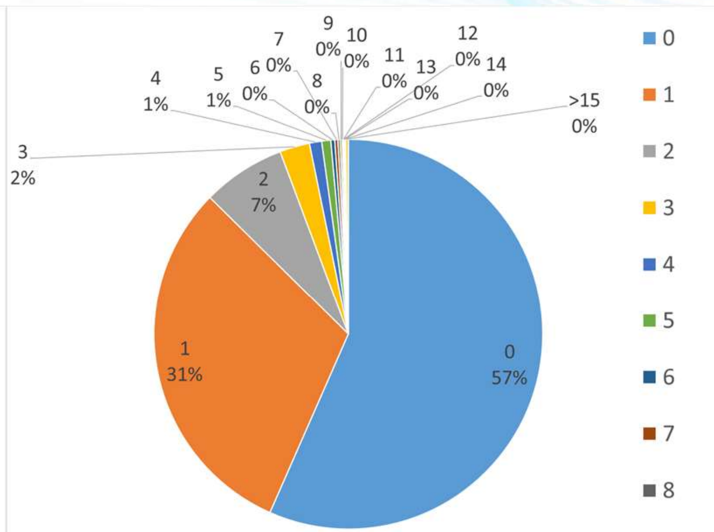
- Transform skip means prediction residues can by-pass the transform module and go directly to quantizer and coefficient entropy coding
- TSM block size
  - Was applied for 4x4 only in HEVC v1
  - Increased to 32x32 in syntax (not CTC) in HEVC RExt
  - Enlarged to 32x32 for VVC and AVS3
- TSM signaling
  - In VVC, a block level flag for each coding block
  - In AVS3, the use is inferred by the parity of even coefficients in the block
    - Odd number infers the use of TS mode
    - Even number infers regular transformed coefficients

Transform Skip Mode (II)

- TS Residue Coding (TSRC) remains the same as transformed blocks in HEVC/AVS3, but different in VVC
- The fact that the distribution of prediction residues are different from transformed coefficients enables the redesign of residue coding part of TSM. In VVC TSRC (coding gain of ~5%):
  - Block divided into 4x4 subblocks
  - coded_sub_block_flag to indicate if each subblock has non-zero coefficients
  - In each position along raster scan, sig_coeff_flag to tell if 0 residue
  - Additional abs_level_gtX_flag (X=1, 3, 5, 7, 9) and par_level_flag to signal the level
  - abs_remainder to signal the remaining part if greater than 9



TS Residue Distribution



Transform Coefficents Distribution

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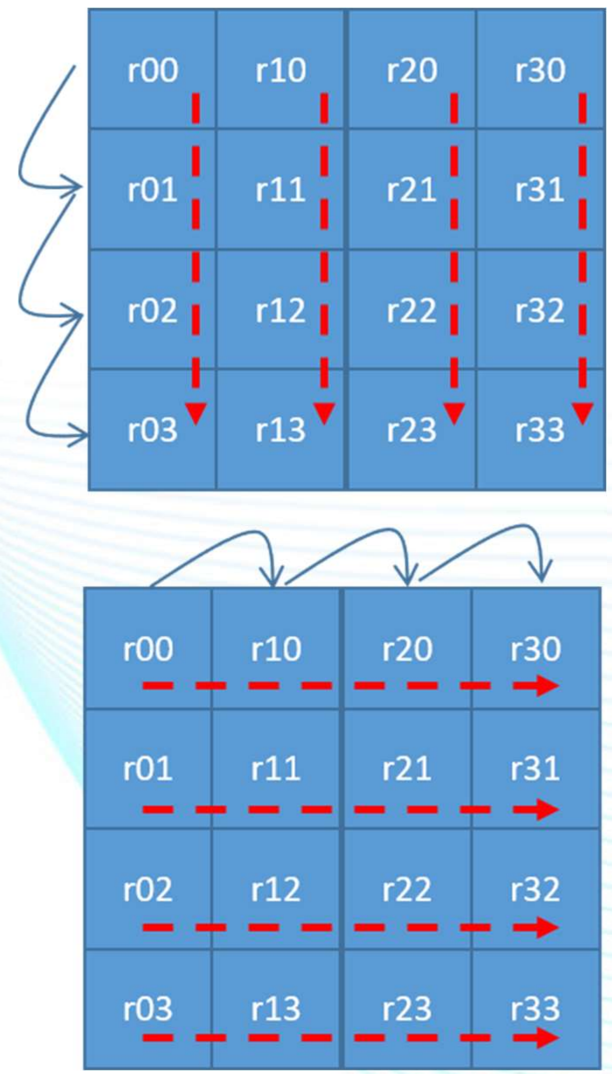
RDPCM/BDPCM

- RDPCM in HEVC RExt Extensions
  - Applied to both intra/inter block residues
  - For intra, only when IPM is either horizontal or vertical (implicit)
  - For inter, signal the processing direction (explicit)
- BDPCM on residue domain (only in VVC)
  - Applied to horizontal or vertical predicted intra prediction residues (after quantization)
  - Can be either horizontal or vertical processed, associated with the same intra prediction direction
  - Implied to be TSM coded

$$\tilde{r}_{i,j} = \begin{cases} Q(r_{i,j}), & j = 0 \\ Q(r_{i,j}) - Q(r_{i,(j-1)}), & 1 \le j \le (N-1) \end{cases}$$

$$\tilde{r}_{i,j} = \begin{cases} Q(r_{i,j}), & i = 0 \\ Q(r_{i,j}) - Q(r_{(i-1),j}), & 1 \le i \le (M-1) \end{cases}$$



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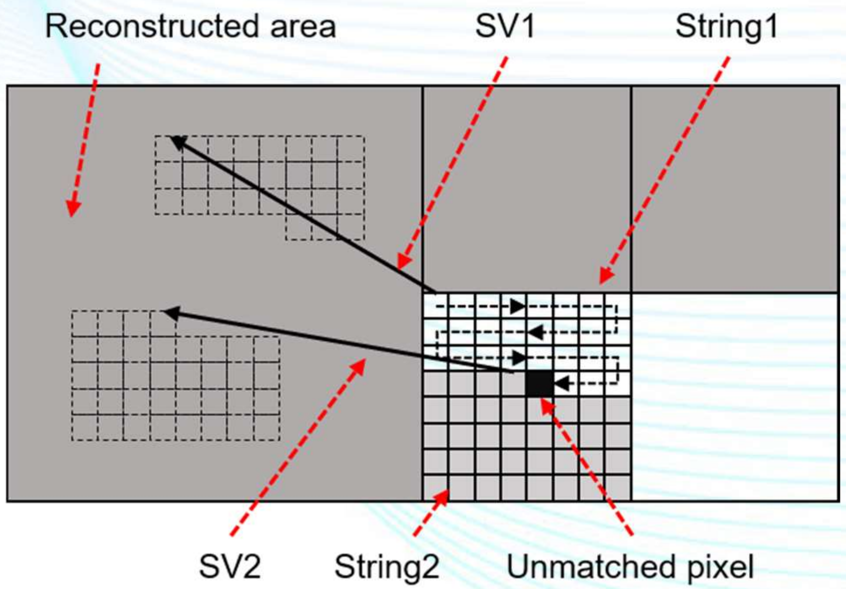
Intra String Copy

- Proposed in HEVC, adopted in AVS3
  - A coding block is divided into strings along the scan direction
  - The string vector (SV) and length of string to be coded
  - Only horizontal traverse scan is allowed*
  - Length of a string is fixed to be a multiple of 4*
  - SV is predicted from history-based predictor list*
  - Number of strings are capped
  - Unmatched pixels are signaled
  - Search region aligned with IBC*



* Different from HEVC proposal

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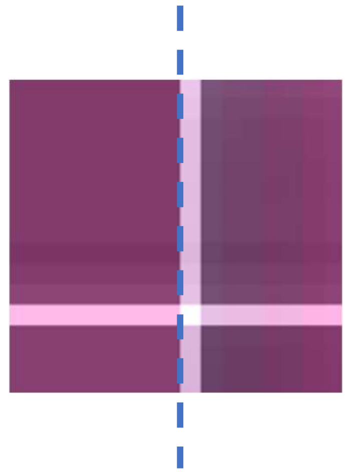
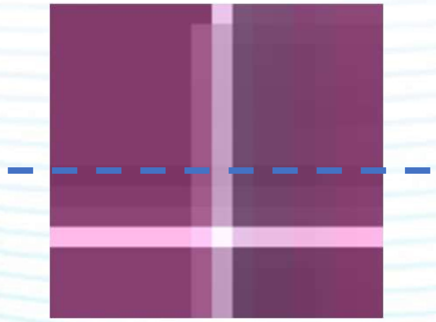
Deblocking filter modifications

- Turning off deblocking may help SCC performance, but difficult to handle mixed screen and camera content
- Deblocking features in AVS3 v1
  - In BS derivation, boundary p0, p1, p2, q0, q1, q2 pixels are used
  - BS=4, 3 samples each side are modified;
  - BS=3, 2 samples each side are modified;
  - BS=2 and 1, 1 sample each side are modified;
  - BS=0, no filter applied
- Modifications for SCC considerations in v2
  - Additional boundary strength (BS) derivation changes provided
  - Switchable at picture level (SCC/non-SCC)
  - No harm for non-SCC content
- When SCC is considered, sharp edges should not be blurred. Changes are:
  - When boundary pixel difference |p0-q0| is greater than a threshold, set BS=0, for edge preservation
  - Reduce BS value, when neighboring boundary pixels are not smooth enough





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Summary of SCC features in different standards

- Adoption status of SCC tools in various standards

Tools	HEVC SCC	VVC	AV1	EVC	AVS3
IBC	✓	✓	✓	✓	✓
PLT	✓	✓	✓		
TSM	✓	✓			✓
BDPCM		✓			
ISC	studied				✓
DBK					✓

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SCC coding tools (II)

- Some tools are designed for generic content but show good performance on SCC
  - IMVD (AMVR)
  - ISP
  - GPMBO
  - ACT
- Encoder only algorithm
  - HashME

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Integer MV difference(I)

- Motion across pictures may not fall into integer sample positions
  - Fractional-pel MV with interpolation can improve prediction efficiency
  - MVs are represented with lower bits as Fractional MV
- Computer generated samples are located in integer positions across different frames
  - If integer-pel MVs are frequently selected, the bits for fractional part are zero and redundant
  - Using integer-pel MVs for SCC is beneficial (3~4% BD rate reduction)
- In HEVC SCC, a slice level flag is to indicate that only integer MV is used for this slice
  - Fractional MV bits are saved.
  - MV are still stored in fractional-pel for future usage.
- In VVC, a block level flag is signaled to indicate the resolution of MV
  - ¼-pel, ½-pel, 1-pel or 4-pel MV can be selected.
  - Selecting 1-pel or even 4-pel resolution can help camera contents, especially for high-resolution video (1~2% BD rate reduction).

Integer MV difference(II)

- In VVC/EVC/AVS3, a technique called MMVD (merge with MV difference)
  - One value is selected from a set of pre-defined offset values (in fractional-pel accuracy) (the index is signaled)
  - This value is added to the selected merge MV candidate as the final MV
  - This tool helps to reduce the cost of coding MV difference
  - The smallest offsets are in fractional-pels.
- For SCC content, MVs are usually in integer positions
  - Adding fractional-offsets may not form a good MV predictor
- The offset values are shifted into integer values for SCC
  - Controlled by a slice level flag;
  - When SCC content is detected,
    the offsets for this slice become integer values
  - 1~2% BD rate reduction

mmvd_distance_idx	MmvdDistance Non SCC	MmvdDistance For SCC
0	1	4
1	2	8
2	4	16
3	8	32
4	16	64
5	32	128
6	64	256
7	128	512

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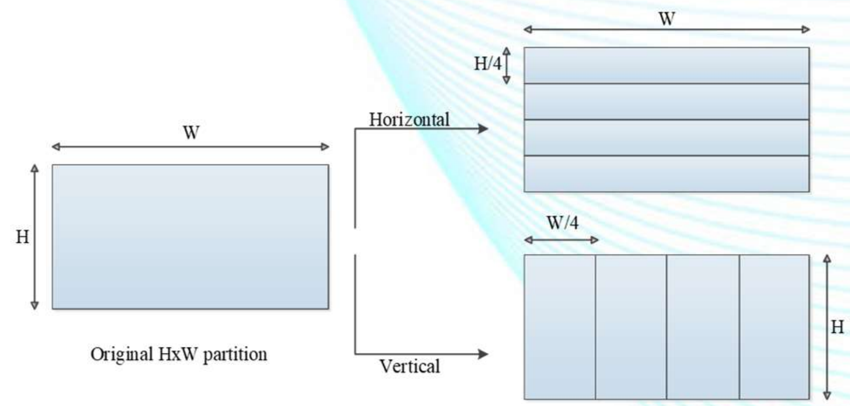
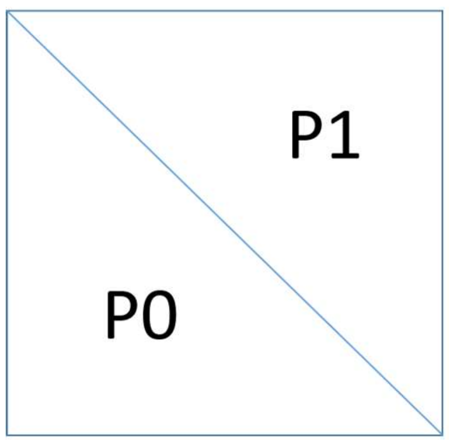
Intra sub-partitioning

- In VVC, a coding block is partitioned into 4 sub-partitions in horizontal or vertical directions
  - Each sub-partition should have at least 4 samples (4x8, 8x4 will have only 2 sub-partitions)
  - Previous reconstructed sub-partition become reference for the next sub-partition in prediction
  - Transform block can be as small as 1xN
  - Up to 10% BD rate reduction
  - Benefit from small transform



Geometry partition blending off

- Geometry partitions/Compound wedge prediction(In VVC, AV1 and AVS3)
  - The prediction is formed by two block predictors P0 and P1
  - P = (w0*P0 + w1*P1)/N, w0+w1=N
  - w0 is specified for each position in the block as follows
- Blending at boundary
  - w0 is gradually reduced from 8 to 0 towards the other partition
- Blending off switch for SCC considerations (VVC*, AVS3)
  - For SCC, blending may cause boundary blur and should be turned off
  - A slice/picture level flag to indicate which template is used, 1~2% gain



4	3	2	1	0	0	0	0
5	4	3	2	1	0	0	0
6	5	4	3	2	1	0	0
7	6	5	4	3	2	1	0
8	7	6	5	4	3	2	1
8	8	7	6	5	4	3	2
8	8	8	7	6	5	4	3
8	8	8	8	7	6	5	4

8	0	0	0	0	0	0	0
8	8	0	0	0	0	0	0
8	8	8	0	0	0	0	0
8	8	8	8	0	0	0	0
8	8	8	8	0	0	0	0
8	8	8	8	8	0	0	0
8	8	8	8	8	8	0	0
8	8	8	8	8	8	8	0

* Not adopted

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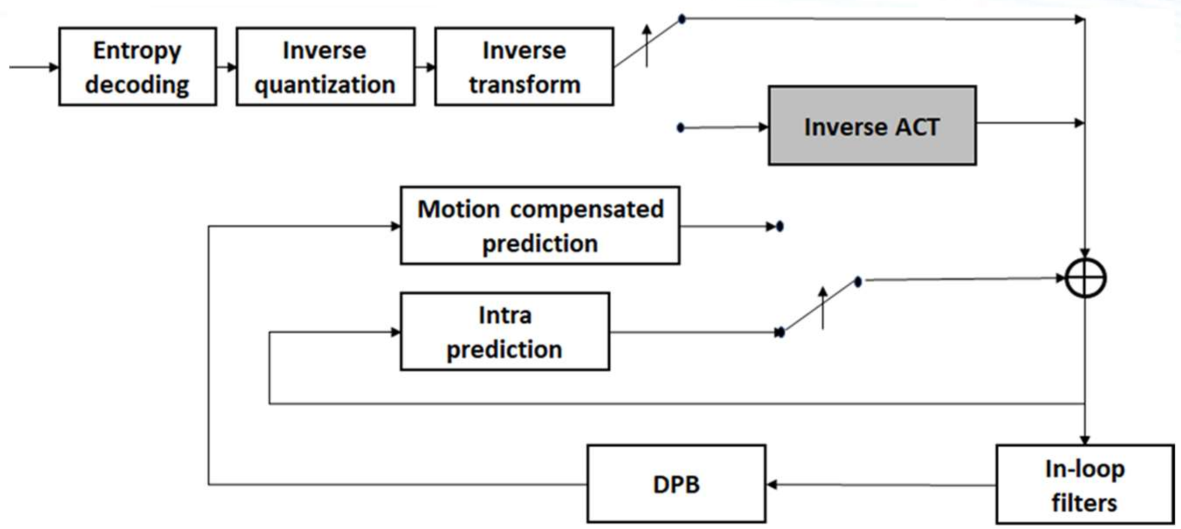
Adaptive Color Transform

- Color space transform is performed to the prediction residue (HEVC SCC and VVC)
  - RGB <--> YCoCg
  - Useful for RGB color format (8%~16% gain in AI/LD config)
  - No apparent gain for YCbCr (disabled in CTC)
  - A CU level flag is used to choose it
  - Applicable only for 4:4:4



Lossy:

Forward conversion

$$\begin{bmatrix} Y' \\ C_o \\ C_g \end{bmatrix} = \begin{bmatrix} -1 & 2 & 1 \\ 2 & 0 & -2 \\ -1 & 2 & -1 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \cdot \begin{bmatrix} 1/4 \\ 1/4 \\ 1/4 \end{bmatrix}$$

Backward conversion ($Y'C_oC_g$ to $R'G'B'$):

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} 1 & 1 & -1 \\ 1 & 0 & 1 \\ 1 & -1 & -1 \end{bmatrix} \begin{bmatrix} Y' \\ C_o \\ C_g \end{bmatrix}$$

Lossless:

$$\textit{Forward:}\quad \begin{aligned} Co &= R - B \\ t &= B + (Co \gg 1) \\ Cg &= G - t \\ Y &= t + (Cg \gg 1) \end{aligned}$$

$$\textit{Inverse:}\quad \begin{aligned} t &= Y - (Cg \gg 1) \\ G &= Cg + t \\ B &= t - (Co \gg 1) \\ R &= Co + b. \end{aligned}$$

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Hash based ME search

- For SCC, hash-based ME can perform effectively to find a block's match
- For each reference picture, a hash table is generated for each position
  - CRC value is calculated as hash value for smallest block size.
  - Bottom-up strategy for other block sizes by summing up the corresponding sub-blocks' hash value.
  - Hash table is established as a linked list, containing positions of the same key.
- To control the length of hash table, some hash values will not be added into the table if their corresponding blocks satisfy the following conditions:
  - There is only one-pixel value in every row or column.
  - The horizontal (vertical) position is not integral multiples of block width (height).
- If a good match is found from the hash table, conventional ME and other inter modes can be skipped
- Adopted in HEVC SCC and VVC reference software
  - Up to 15% BD rate reduction/10% runtime reduction (in VVC proposal).

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Tutorial Outline

- Introduction of screen content coding and recently developed video coding standards
- Screen content coding tools (I)
  - IBC, PLT, ISC, TSRC, BDPCM, DBK
- Screen content coding tools (II)
  - IMVD, ISP, GPBO, ACT, HashME
- Performance/complexity analysis
  - Performance and complexity of SCC tools in various standards
- Conclusion and discussion
  - Implementation hints, future directions, etc.

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Simulation setup

- Common test conditions (software configurations by default) from each reference software
- Sequences selection
  - 11 TGM class (primary focus)
  - 1 gaming animation (auxiliary reference)
  - 1 camera-captured (auxiliary reference)

Sequences	Acronym	Resolution	Frame Rate	Bit Depth
FlyingGraphics	FLY	1920x1080	60	8
Desktop	DKT	1920x1080	60	8
Console	CNS	1920x1080	60	8
ChineseDocument-Editing	CDE	1920x1080	30	8
EnglishDocument-Editing	EDE	1920x1080	30	8
Spreadsheet	SPS	1920x1080	30	8
BitstreamAnalyzer	BSA	1920x1080	30	8
CircuitLayout-Presentation	CLP	1920x1080	30	8
Program	PRG	1920x1080	60	8
WebEn	WBE	1920x1080	60	8
WordExcel	WDE	1920x1080	60	8
ArenaOfValor	AOV	1920x1080	60	8
BQTerrace	BQT	1920x1080	60	8

- All intra (AI) and Random Access (RA) configurations are tested
- BD-rate derived from four QP points
  - Positive numbers are performance improvements
- HashME disabled in the tests
  - Only implemented in SCM/ VTM but feasible for other codecs

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Performance Analysis (I)

- HEVC SCC, SCC tools off as anchor

Sequences	All Intra				Random Access			
	IBC	PLT	IMVD*	Overall	IBC	PLT	IMVD*	Overall
TGM AVE.	51.68%	34.50%	-	58.60%	40.94%	25.48%	0.58%	46.74%
AOV	3.46%	0.74%	-	3.85%	0.62%	0.12%	0.00%	0.63%
BQT	2.16%	-0.01%	-	2.17%	0.26%	0.05%	0.00%	0.15%

*results based on HashME enabled

#Encoder choice not to use IMVD for AOV/BQT

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Performance Analysis (II)

- VVC, SCC tools off as anchor

Sequences	All Intra					Random Access				
	IBC	PLT	TSM	BDPCM*	Overall	IBC	PLT	TSM	BDPCM*	Overall
TGM AVE.	46.51%	38.44%	27.22%	2.74%	61.38%	36.66%	31.85%	22.98%	2.35%	52.06%
AOV	2.53%	0.30%	1.00%	0.16%	3.61%	0.27%	0.10%	0.85%	0.09%	1.14%
BQT	1.59%	-0.02%	0.23%	0.01%	1.83%	0.73%	0.09%	0.38%	-0.05%	0.97%

*results based on TSM enabled

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Performance Analysis (III)

- AVS3 , SCC tools off as anchor

Sequences	All Intra					Random Access				
	IBC	TSM	ISC*	DBK	Overall	IBC	TSM	ISC*	DBK	Overall
TGM AVE.	46.43%	17.08%	19.32%	2.42%	64.37%	35.19%	13.68%	15.37%	5.75%	55.16%
AOV	1.71%	0.00%	0.00%	0.00%	1.71%	0.21%	0.00%	0.00%	0.00%	0.19%
BQT	0.86%	0.00%	0.00%	0.00%	0.86%	0.34%	0.00%	0.00%	0.00%	0.33%

*results based on IBC enabled

#Encoder choice not to use some tools for AOV/BQT

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Performance Analysis (IV)

- AV1 , SCC tools off as anchor

Sequences	All Intra			Random Access		
	IBC	PLT	Overall	IBC	PLT	Overall
TGM AVE.	43.92%	26.54%	54.01%	26.98%	17.81%	35.30%
AOV	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BQT	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

#Encoder choice not to use SCC for AOV/BQT

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Performance Analysis (V)

- Comparison among standards (HEVC v1, HM results as anchor)
- SCC tools off

Sequences	SCM		VTM		HPM		AV1		ETM	
	AI	RA	AI	RA	AI	RA	AI	RA	AI	RA
TGM AVE.	1.66%	1.66%	11.30%	16.64%	-13.25%	-0.22%	17.12%	45.60%	-22.00%	-9.08%
AOV	-0.55%	-0.17%	25.30%	34.12%	16.41%	25.23%	12.37%	26.43%	10.31%	23.44%
BQT	-0.48%	-0.36%	17.96%	32.03%	13.41%	25.74%	10.63%	42.21%	6.44%	18.73%

- SCC tools on

Sequences	SCM		VTM		HPM		AV1		ETM	
	AI	RA	AI	RA	AI	RA	AI	RA	AI	RA
TGM AVE.	58.60%	46.74%	65.84%	60.72%	59.90%	55.87%	61.99%	63.62%	30.37%	23.09%
AOV	3.85%	0.63%	28.04%	34.80%	17.87%	25.39%	12.37%	26.43%	12.67%	23.48%
BQT	2.17%	0.15%	19.50%	32.70%	14.21%	25.98%	10.63%	42.21%	8.55%	19.19%

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Complexity Analysis

- IBC
  - Local-IBC implementation impact lies mainly on cost
  - Processing logic align with what in MC
  - Encoder strategy may borrow ideas from ME
- PLT/ISC
  - Pixel level processing may cause throughput issue
  - Existing design attempted to partially resolve
    - 16-sample CG in PLT, 4-sample resolution in ISC
- TSM/BDPCM/DBK
  - Relatively straightforward w/o too much complexity added

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Conclusions (I)

- SCC coding tools introduced in recently developed video coding standards have significantly improved coding efficiency on screen content materials
- Combination of tools at block level can further improve the efficiency
  - IBC+TSM, IBC+PLT, etc.
- Mechanism overlapping among existing tools need to be considered, e.g.,
  - IBC vs ISC
  - PLT vs ISC vs TSRC
  - DBK vs tools without deblocking

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Conclusions (II)

- SCC codec: standard compliant vs proprietary
  - SCC tools are relatively independent of other building blocks that exist in the traditional video codecs
  - For enclosed eco-systems, it may not be difficult to customize the selection of needed coding tools
- Mode decision between SCC tools and other tools can help encoder speed-up
  - SCC tools with sufficiently good results may indicate other modes are not as necessary
  - In some implementations, SCC may be even faster than non-SCC codec*
- Hash based search methods can enable fast and efficient encoder design
  - Applied to IBC, ISC and ME

*X. Xu, et al, "An Optimized Video Encoder Implementation with Screen Content Coding Tools", VCIP 2020.

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References

- Primary reference: the references and more technical details of this tutorial have been provided in the following preprint paper, as the tutorial handout:
  - X. Xu, S. Liu, “Overview of Screen Content Coding in Recently Developed Video Coding Standards”, pre-published in arXiv.org: http://arxiv.org/abs/2011.14068
- Additional references:
  - X. Xu, et al, “An Optimized Video Encoder Implementation with Screen Content Coding Tools”, VCIP 2020.
  - X. Xu, Shan. Liu, “Performance Comparison of Screen Content Coding between HEVC and VVC”, JVET-S0264
  - B. Zhu, S. Liu, X. Xu, et al, “Performance of a VVC software decoder”, JVET-T0095

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Q & A