

JCTVC-V0066
ON CONSTRAINED INTRA
PREDICTION FOR THE
UNIFICATION FRAMEWORK
OF INTRA BLOCK COPY

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Introduction

- The existing constrained intra prediction (CIP) in HEVC draft 4 when IBC is enabled
 - Intra prediction is **allowed** to use samples of neighboring **intra CUs and IBC CUs** as reference.
 - Intra prediction is **disallowed** to use samples of neighboring **normal inter CUs** (referring to temporal reference) as reference.
 - **TMVP is disabled** when reference picture is current picture
 - **Encoder constraint:** IBC CUs can only refer to decoded samples of intra mode and IBC mode (**currently included in SCM5.2 but missing in HEVC draft 4**).
 - The solution was inherited from **HEVC Rext** where **IBC is signaled as intra mode**.
- **Issues**
 - Inconsistent with the IBC unification framework
 - IBC coding efficiency is significantly reduced

The proposed method

- When CIP is enabled, it is proposed to only use the samples of intra CUs as reference for intra prediction; and the samples of inter CUs (either IBC or normal inter) are disallowed to predict intra CUs.
- TMVP is enabled when the reference picture is current picture.
- The proposed CIP constraint is only applied to P/B slices that use at least one temporal reference picture; otherwise, the CIP constraint is disabled.
- Benefits
 - Improve IBC coding efficiency: inter samples are allowed to be used as reference for IBC prediction
 - Unified design: IBC and inter samples are fully aligned, i.e., disabled, for intra prediction when the CIP constraint is applied
- The same idea was proposed in JCTVC-O155 and JCTVC-U0102

Proposed spec changes

7.4.3.3.1 General picture parameter set RBSP semantics

constrained_intra_pred_flag equal to 0 specifies that intra prediction allows usage of residual data and decoded samples of neighbouring coding blocks coded **using either intra or inter prediction modes** ~~with or without using a reference picture that is not the current picture~~. **constrained_intra_pred_flag** equal to 1 specifies constrained intra prediction, in which case ~~the general~~ intra prediction process **for slices that use at least one reference picture that is not the current picture** only uses residual data and decoded samples from neighbouring coding blocks coded ~~without~~ using **intra prediction mode** ~~a reference picture that is not the current picture~~.

8.4.4.2.1 General intra sample prediction

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- Each sample $p[x][y]$ is derived as follows:
- If one or more of the following conditions are true, the sample $p[x][y]$ is marked as "not available for intra prediction":
 - The variable `availableN` is equal to FALSE.
 - `CuPredMode[xNbY][yNbY]` is not equal to `MODE_INTRA`, **DiffPicOrderCnt(aPic, CurrPic) is not equal to 0 for at least one picture aPic in RefPicList0 and RefPicList1 of the current slice** and `constrained_intra_pred_flag` is equal to 1.
- Otherwise, the sample $p[x][y]$ is marked as "available for intra prediction" and the sample at the location $(xNbCmp, yNbCmp)$ is assigned to $p[x][y]$.

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Proposed spec changes

8.5.3.2.8 Derivation process for temporal luma motion vector prediction

The variables `mvLXCol` and `availableFlagLXCol` are derived as follows:

- If `slice_temporal_mvp_enabled_flag` is equal to 0, both components of `mvLXCol` are set equal to 0 and `availableFlagLXCol` is set equal to 0.
- ~~Otherwise, if the reference picture is the current picture and `constrained_intra_pred_flag` is equal to 1, both components of `mvLXCol` are set equal to 0 and `availableFlagLXCol` is set equal to 0.~~
- Otherwise, the following ordered steps apply:

Simulation

- Three settings for simulation
 - Setting #1
 - Using the current common test condition (CTC)
 - Set ConstrainedIntraPred to 1
 - Setting #2 (CTU-column-based intra refreshing) [1]
 - Picking one CTU column in one picture and force to code them using intra mode
 - Additionally, the intra CTU column moves from left to right along the picture decoding/display order
 - Tested for LB configuration
 - Setting #3 (Slice-based intra refreshing) [1]
 - Dividing pictures evenly into 3 slices
 - Refreshing one slice at one time using intra mode on a cyclic basis
 - Tested for LB configuration

[1] X. Xiu, BoG report on constrained intra prediction for intra block copy unification, JCTVC-U0178, June 2015, Warsaw, Poland.

Thanks to Microsoft for the cross-check!

Performance evaluation of Setting One

- Lossy 444 results using **full frame IBC search**
- Average BD-rate savings
 - RA: {2.0%, 2.1%, 2.1%}
 - LB: {3.1%, 3.2%, 3.3%}

	Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	-5.7%	-5.8%	-5.7%	-7.4%	-7.6%	-7.6%
RGB, mixed content, 1440p & 1080p	-2.6%	-2.7%	-2.8%	-4.6%	-4.8%	-4.9%
RGB, Animation, 720p	-0.1%	-0.2%	-0.2%	-0.3%	-0.5%	-0.4%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
YUV, text & graphics with motion, 1080p & 720p	-5.1%	-5.1%	-5.1%	-7.2%	-7.1%	-7.2%
YUV, mixed content, 1440p & 1080p	-2.5%	-2.7%	-2.7%	-4.7%	-5.1%	-5.0%
YUV, Animation, 720p	-0.1%	-0.1%	-0.1%	-0.2%	-0.5%	-0.7%
YUV, camera captured, 1080p	-0.1%	-0.1%	-0.1%	0.0%	0.0%	-0.3%
Enc Time[%]	98%			100%		
Dec Time[%]	100%			97%		

Performance evaluation of Setting One

- Lossy 420 results
- Average BD-rate savings
 - RA: {3.3%, 3.5%, 3.5%}
 - LB: {4.6%, 4.8%, 4.8%}

	Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V
YUV, text & graphics with motion, 1080p & 720p	-6.7%	-6.9%	-7.0%	-8.7%	-9.0%	-9.1%
YUV, mixed content, 1440p & 1080p	-2.8%	-3.1%	-3.1%	-4.5%	-4.5%	-4.5%
YUV, Animation, 720p	-0.2%	-0.4%	-0.5%	-0.4%	-0.7%	-0.6%
Enc Time[%]	97%			100%		
Dec Time[%]	100%			99%		

Performance evaluation of Setting Two

- Lossy 444 results using full frame IBC search
- Average BD-rate savings
 - LB: {1.6%, 1.5%, 1.6%}

	Low delay B		
	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	-3.6%	-3.7%	-3.7%
RGB, mixed content, 1440p & 1080p	-2.5%	-2.7%	-2.7%
RGB, Animation, 720p	-0.1%	-0.2%	-0.2%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	-3.2%	-3.3%	-3.3%
YUV, mixed content, 1440p & 1080p	-2.4%	-2.5%	-2.5%
YUV, Animation, 720p	-0.3%	-0.4%	0.0%
YUV, camera captured, 1080p	0.0%	0.1%	0.1%
Enc Time[%]		99%	
Dec Time[%]		99%	

Performance evaluation of Setting Two

- Lossy 420 results
- Average BD-rate savings
 - LB: {2.4%, 2.5%, 2.5%}

	Low delay B		
	G/Y	B/U	R/V
YUV, text & graphics with motion, 1080p & 720p	-4.6%	-4.6%	-4.7%
YUV, mixed content, 1440p & 1080p	-2.5%	-2.2%	-2.7%
YUV, Animation, 720p	-0.3%	-0.5%	-0.2%
Enc Time[%]	98%		
Dec Time[%]	101%		

Performance evaluation of Setting Three

- Lossy 444 results using **full frame IBC search**
- Average BD-rate savings
 - LB: {0.3%, 0.4%, 0.4%}

	Low delay B		
	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	-1.1%	-1.1%	-1.1%
RGB, mixed content, 1440p & 1080p	-0.4%	-0.4%	-0.4%
RGB, Animation, 720p	0.0%	-0.1%	-0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	-0.9%	-1.0%	-1.0%
YUV, mixed content, 1440p & 1080p	-0.3%	-0.4%	-0.4%
YUV, Animation, 720p	-0.1%	-0.1%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%
Enc Time[%]	102%		
Dec Time[%]	104%		

Performance evaluation of Setting Three

- Lossy 420 results
- Average BD-rate savings
 - LB: {0.6%, 0.6%, 0.6%}

	Low delay B		
	G/Y	B/U	R/V
YUV, text & graphics with motion, 1080p & 720p	-1.3%	-1.3%	-1.3%
YUV, mixed content, 1440p & 1080p	-0.3%	-0.4%	-0.4%
YUV, Animation, 720p	-0.1%	-0.1%	-0.2%
Enc Time[%]	99%		
Dec Time[%]	101%		

Closing remarks

- Propose one CIP solution to the current IBC unification framework
- Benefits
 - Improved IBC coding efficiency
 - Being consistent with the unification framework of IBC and inter modes