

# **RCE2: Sample-based weighted intra prediction for lossless coding (JCTVC-M0052/M0193)**

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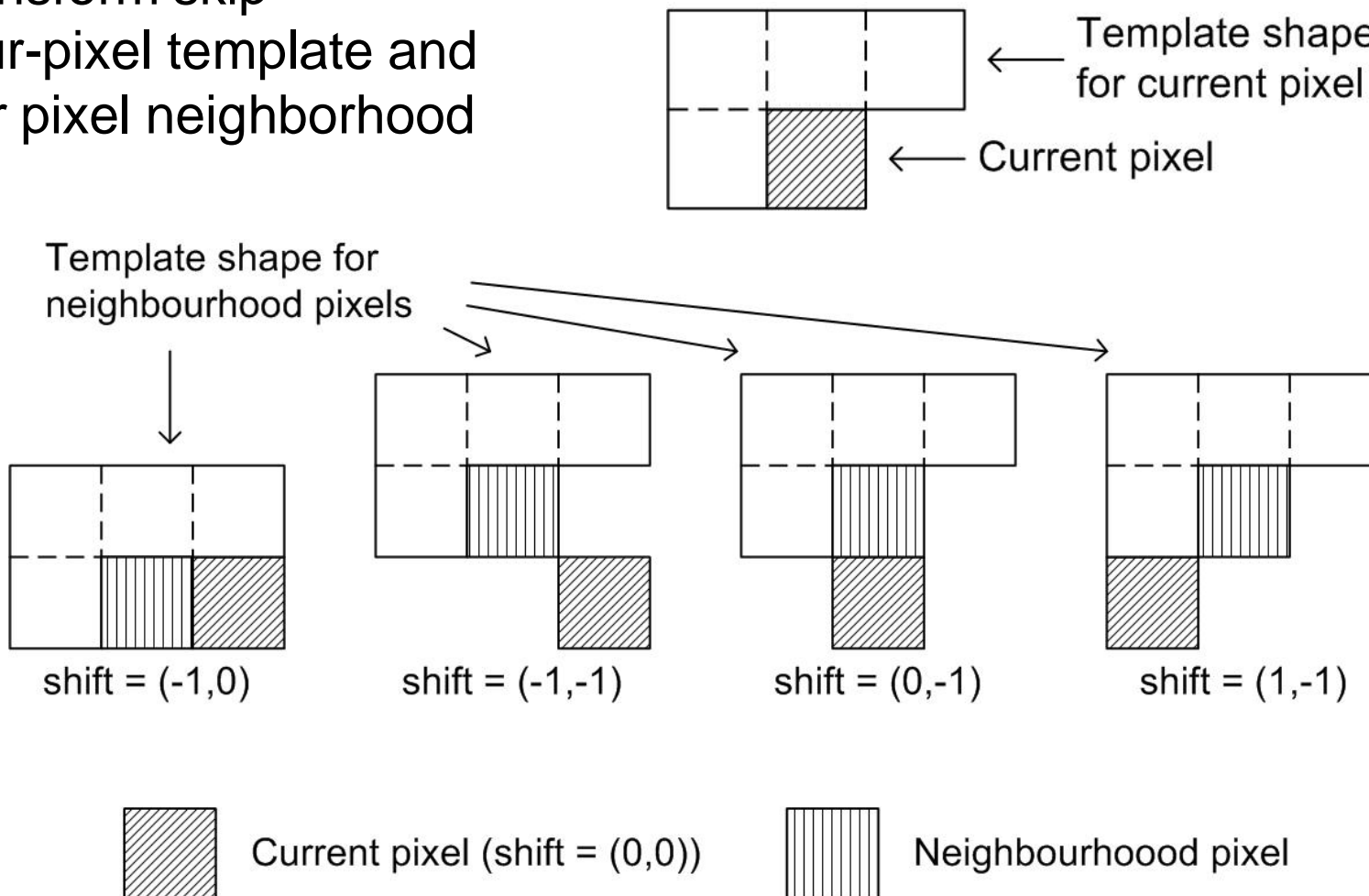
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## Motivation

- Lossless image compression for professional applications required
- Example application: medical imaging
  - Coding artifacts might degrade the quality of a diagnosis  
→ Lossless compression is needed
  - Large amounts of medical image data that have to be archived in repositories (e.g., PACS – Picture Archiving and Communication System)  
→ High coding efficiency is important
- Other application examples
  - Automotive vision
  - Video conferencing
  - Long-distance education
  - ...

## Proposal overview

- Pixel-wise intra prediction mode replacing PLANAR mode for “transform skip”
- Four-pixel template and four pixel neighborhood



## Proposal algorithm

1. Similarity (i.e., SAD) between template around current pixel and neighborhood template:

$$SAD_{i,j} = \sum_{n \in N_0} |p[i-n] - p[j-n]|$$
$$N_0 = \{n = (x, y) \mid (0, -1), (-1, -1), (-1, 0), (-1, 1)\}$$

2. Weights (exponential decay) from look-up table:

$$w_{i,j} = LUT[SAD_{i,j}]$$

3. Predictor for current pixel:

$$\hat{p}[i] = (w_{\text{sum}} / 2 + \sum_{j \in i + N_0} w_{i,j} \cdot p[j]) / w_{\text{sum}}$$

## Proposal variants

- Original: **L0161** (RCE2, test 2): if all weights are 0, (only) three pixels of neighborhood averaged with equal weight (upper-right pixel was forgotten)
- Bug fix: **M0052v1**: if all weights are 0, all four pixels of neighborhood averaged with equal weight
- Improved: **M0052v2**: if all weights are 0, pixel with highest similarity of template (i.e., lowest SAD) used as a predictor → less operations needed (i.e, no averaging)
- Two-mode: **M0193**: escape mode of M0052v2 signaled as a separate mode (replacing DC mode → all weights not necessarily are 0)

## Results L0161 (RCE2, test 2)

	All Intra Main			Random Access Main			Low delay B Main		
	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving
	Reference	Tested		Reference	Tested		Reference	Tested	
Class F	4.6	5.1	-7.8%	29.3	30.9	-3.9%	47.4	48.9	-3.0%
Class B	2.1	2.3	-6.8%	2.6	2.6	-1.8%	2.6	2.6	-1.5%
SC(GBR)	7.5	8.2	-7.2%	88.8	95.8	-5.2%	301.9	323.0	-5.0%
RangeExt	2.2	2.3	-4.7%	2.5	2.6	-1.2%	2.5	2.6	-1.1%
Overall (w/o SC)	3.2	3.4	-6.4%	13.3	13.9	-2.4%	20.5	21.1	-1.9%
Overall (w/ SC)	5.3	5.8	-6.8%	51.0	54.9	-3.8%	161.2	172.1	-3.5%
Enc Time[%]	102%			101%			100%		
Dec Time[%]	98%			98%			101%		

## Results M0052v1 (bug fix)

	All Intra Main			Random Access Main			Low delay B Main		
	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving
	Reference	Tested		Reference	Tested		Reference	Tested	
Class F	4.6	5.1	-7.9%	29.3	30.9	-3.9%	47.4	48.9	-3.0%
Class B	2.1	2.3	-6.8%	2.6	2.6	-1.8%	2.6	2.6	-1.5%
SC(GBR)	7.5	8.2	-7.6%	88.8	96.6	-5.5%	301.9	324.8	-5.2%
RangeExt	2.2	2.3	-4.8%	2.5	2.6	-1.2%	2.5	2.6	-1.1%
Overall (w/o SC)	3.2	3.4	-6.4%	13.3	13.9	-2.4%	20.5	21.1	-1.9%
Overall (w/ SC)	5.3	5.8	-7.0%	51.0	55.3	-4.0%	161.2	173.0	-3.6%
Enc Time[%]	102%			101%			101%		
Dec Time[%]	98%			99%			101%		

## Results M0052v2 (modified escape mode)

	All Intra Main			Random Access Main			Low delay B Main		
	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving
	Reference	Tested		Reference	Tested		Reference	Tested	
Class F	4.6	5.2	-9.1%	29.3	31.3	-4.5%	47.4	49.2	-3.3%
Class B	2.1	2.3	-6.8%	2.6	2.6	-1.8%	2.6	2.6	-1.5%
SC(GBR)	7.5	8.8	-12.1%	88.8	103.0	-8.9%	301.9	349.5	-8.3%
RangeExt	2.2	2.3	-4.8%	2.5	2.6	-1.2%	2.5	2.6	-1.1%
Overall (w/o SC)	3.2	3.5	-6.9%	13.3	14.1	-2.7%	20.5	21.2	-2.1%
Overall (w/ SC)	5.3	6.2	-9.5%	51.0	58.5	-5.8%	161.2	185.4	-5.2%
Enc Time[%]	102%			101%			101%		
Dec Time[%]	99%			100%			101%		



## Results M0193 (two-mode)

	All Intra Main			Random Access Main			Low delay B Main		
	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving	compression ratio		Bit-rate saving
	Reference	Tested		Reference	Tested		Reference	Tested	
Class F	4.6	5.3	-11.2%	29.3	31.9	-6.3%	47.4	50.0	-5.0%
Class B	2.1	2.3	-6.8%	2.6	2.6	-1.8%	2.6	2.6	-1.4%
SC(GBR)	7.5	9.0	-14.3%	88.8	104.7	-10.4%	301.9	354.5	-9.6%
RangeExt	2.2	2.3	-4.4%	2.5	2.6	-1.1%	2.5	2.6	-1.0%
Overall (w/o SC)	3.2	3.5	-7.6%	13.3	14.3	-3.3%	20.5	21.5	-2.7%
Overall (w/ SC)	5.3	6.3	-11.0%	51.0	59.5	-6.9%	161.2	188.0	-6.1%
Enc Time[%]	102%			101%			101%		
Dec Time[%]	99%			100%			101%		

## Results for combination with other proposals

	All Intra Main							
	Bit-rate savings							
	L0161 +L0117	L0161 +L0176	M0052v2 +L0117	M0052v2 +L0176	M0052v2 +SAP-HV	M0193 +L0117	M0193 +L0176	M0193 +SAP-HV
Class F	-11.4%	-12.6%	-12.1%	-13.2%	-12.6%	-12.7%	-13.6%	-13.1%
Class B	-7.2%	-7.5%	-7.3%	-7.5%	-7.2%	-7.2%	-7.4%	-7.1%
SC(GBR)	-12.9%	-11.8%	-15.4%	-14.7%	-16.2%	-16.4%	-15.5%	-17.1%
RangeExt	-4.9%	-5.3%	-5.0%	-5.3%	-5.0%	-4.6%	-4.9%	-4.6%
Overall (w/o SC)	-8.0%	-8.7%	-8.3%	-8.9%	-8.5%	-8.3%	-8.8%	-8.5%
Overall (w/ SC)	-10.5%	-10.3%	-11.8%	-11.8%	-12.3%	-12.3%	-12.2%	-12.8%
Enc Time[%]	105%	103%	104%	103%	101%	106%	103%	103%
Dec Time[%]	100%	97%	98%	96%	96%	99%	97%	97%

## Results for combination with other proposals

	Random Access Main							
	Bit-rate savings							
	L0161 +L0117	L0161 +L0176	M0052v2 +L0117	M0052v2 +L0176	M0052v2 +SAP-HV	M0193 +L0117	M0193 +L0176	M0193 +SAP-HV
Class F	-6.6%	-7.3%	-7.0%	-7.6%	-7.3%	-7.4%	-7.8%	-7.6%
Class B	-1.9%	-2.0%	-1.9%	-2.0%	-1.9%	-1.8%	-1.8%	-1.8%
SC(GBR)	-9.4%	-8.5%	-11.5%	-11.0%	-12.0%	-12.1%	-11.6%	-12.7%
RangeExt	-1.3%	-1.4%	-1.3%	-1.4%	-1.3%	-1.2%	-1.3%	-1.2%
Overall (w/o SC)	-3.6%	-3.9%	-3.7%	-4.0%	-3.8%	-3.8%	-4.0%	-3.9%
Overall (w/ SC)	-6.5%	-6.2%	-7.6%	-7.5%	-7.9%	-8.0%	-7.8%	-8.3%
Enc Time[%]	101%	101%	101%	101%	101%	101%	101%	101%
Dec Time[%]	99%	98%	99%	99%	98%	99%	99%	98%

## Results for combination with other proposals

	Low delay B Main							
	Bit-rate savings							
	L0161 +L0117	L0161 +L0176	M0052v2 +L0117	M0052v2 +L0176	M0052v2 +SAP-HV	M0193 +L0117	M0193 +L0176	M0193 +SAP-HV
Class F	-5.4%	-5.9%	-5.6%	-6.1%	-5.7%	-6.0%	-6.3%	-6.1%
Class B	-1.6%	-1.6%	-1.6%	-1.6%	-1.6%	-1.5%	-1.5%	-1.5%
SC(GBR)	-9.0%	-7.8%	-10.8%	-10.3%	-11.3%	-11.2%	-10.7%	-11.9%
RangeExt	-1.2%	-1.3%	-1.2%	-1.3%	-1.2%	-1.1%	-1.2%	-1.1%
Overall (w/o SC)	-2.9%	-3.2%	-3.0%	-3.3%	-3.1%	-3.1%	-3.3%	-3.2%
Overall (w/ SC)	-6.0%	-5.5%	-6.9%	-6.8%	-7.2%	-7.1%	-7.0%	-7.5%
Enc Time[%]	101%	101%	101%	101%	101%	101%	101%	101%
Dec Time[%]	101%	100%	101%	101%	101%	101%	100%	100%

## Conclusions

- Pixel-wise intra prediction mode based on similarity within a small neighborhood
  - Modifying PLANAR mode only (“L0161” and “M0052v2”)
    - Implementation in HEVC Test Model HM-10.0\_RExt2.0
    - Core proposal (“L0161”) evaluated in Core Experiment (RCE2)
    - Simplification with higher compression efficiency (“M0052v2”)
  - Higher gains with two-mode signalling, modifying PLANAR and DC mode (“M0193”)
  - Even higher gains when combined with other proposals in CE (i.e., “L0117”, “L0176” and “SAP-HV”)
  - Proposal: Adopt one of the following technologies:
    - “M0193” (or “M0193+L0117” or “M0193+0176” or “M0193+HV”)
 

7.6% / 11.0 %	8.3% / 12.3%	8.8% / 12,2%	8.5% / 12.8%
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    - M0052v2 (or M0052v2 +L0117 or M0052v2 +0176 or M0052v2+HV)
 

6.9% / 9.5%	8.3% / 11.8%	8.9% / 11.8%	8.5% / 12.3%
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- (Gains: All Intra Main, w/o and w/ SC)