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Title:	RExt: [non-RCE3] Sign coding for transform skipped blocks	
Status:	Input Document to JCT-VC	
Purpose:	Proposal	
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Abstract

The HEVC video codec provides a mechanism for transform skipping. It is observed that in the case of transform skipping, the assumption that the probability of a quantized coefficient's sign being positive or negative is 0.5 does not necessarily hold. This proposal describes a sign coding scheme to address the biased sign distribution for individual transform skipping blocks.

1 Introduction

Sign coding is part of the transform coefficient coding process, which codes the sign of a non-zero transform coefficient (in the case of transform skipping, the equivalent transform would be an identity transform). In the current HEVC range extensions design, sign is coded as a 1-bit flag, i.e., a bit "1" is coded if the corresponding coefficient is negative and a bit "0" is coded if the coefficient is positive. The underlying assumption is that, statistically, a similar number of negative coefficients and positive coefficients.

It is observed that such assumptions do not necessarily hold in the case of transform skipping. In particular, although the probability of a sign being positive or negative is generally 1/2 over a large number of transform skipping blocks, for individual transform skipping blocks, one of the signs tends to be dominant. The test was performed for several standard test sequences coded at different QPs using the HM12.0+RExt-4.0 reference software under range extension common test conditions[1]. Table 1 summarizes the probabilities of the dominant sign in a transform skipping block with at least 2 coded signs.

The biased sign distribution for transform skipping blocks suggests that the current sign coding scheme may be improved for better compression efficiency and two schemes are proposed in this proposal.

Table 1 – Probabilities of the dominant sign in a block with transform skipping

	QP			
Sequences	22	27	32	37
BasketballDrillText	0.73	0.77	0.80	0.87
SlideEditing	0.73	0.73	0.74	0.76
SlideShow	0.77	0.78	0.79	0.81
ChinaSpeed	0.75	0.76	0.77	0.78

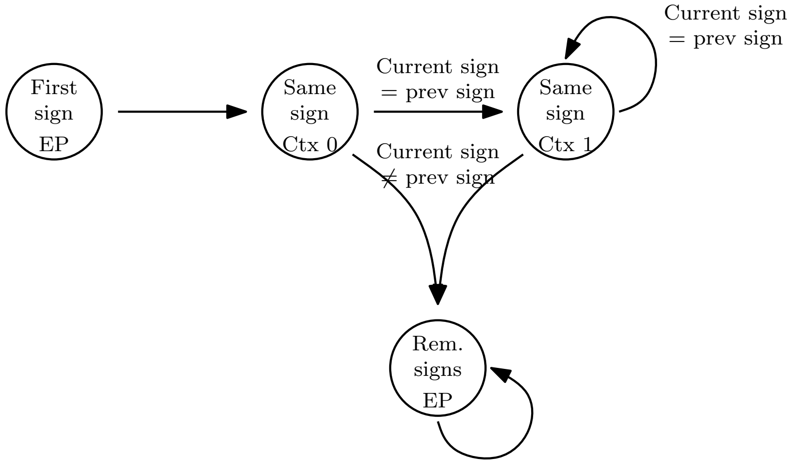
2 Proposed Scheme

A hybrid scheme that predicts and adaptively encodes each sign flag (or a prediction of the sign flag) using either bypass coding (as per the current behaviour) or using CABAC is proposed. Adaptation is performed using a finite state machine as illustrated in Figure 1.

Given a sequence of coefficient signs $s_0, s_1, s_2, \ldots, s_n$, the following steps are used in encoding:

- the first sign, s_0 is encoded directly using bypass mode,
- each subsequent sign is predicted from the previous sign, $p_i = \neg(s_i \oplus s_{i-1})$ and encoded using CABAC as a *same_sign_flag* until $p_{i-1} = 0$, whereupon,

Figure 1 – Representation of proposed scheme using a finite state machine.



- all subsequent signs are directly encoded using bypass mode.

Ie, an initial run of same signs are encoded using CABAC, with all subsequent signs being directly encoded as EP bins.

To further increase compression efficiency, the encoding of the *same_sign_flag* uses one of four contexts, the selection of which is according to component type (luma vs chroma) and the number of previous *same_sign_flag*s encoded. When described as an FSM as in the above figure, the context index for a given colour component may be derived from the state.

3 Results

Tables 2 and 3 shows the coding performance using the RCE3 common conditions [2].

It is observed that in the presence of intra block copying, the efficiency of the proposed scheme is diminished. Table 4 shows the coding performance when the RCE3 common conditions are modified to disable the intra block copy mode.

Table 2 – Proposed sign coding modification for transform skipped blocks against RCE3 anchor (Non-lossless)

Configuration	Runtime (%)	BD-Rate Luma	Cb	Cr
ra_rce3-scc-yuv444-mt	101.7	0	0.1	0.1
ra_rce3-classB-mt	101.5	0	0.1	−0.1
ra_rce3-anim-rgb444-mt	101.8	0	0	0
ra_rce3-classF-mt	104.5	0	0	0.1
ra_rce3-anim-yuv444-mt	102.1	0	0	0
ra_rce3-scc-rgb444-mt	100.9	0	0	0
ra_rce3-rext-mt	101.4	0	0	0
ld_rce3-scc-yuv444-mt	102.2	−0.2	−0.1	−0.3
ld_rce3-classB-mt	102.3	0	0.1	0
ld_rce3-anim-rgb444-mt	101.8	0	0	0
ld_rce3-classF-mt	99.2	0	0.4	−0.1
ld_rce3-anim-yuv444-mt	101.6	0	0	0
ld_rce3-scc-rgb444-mt	101.4	0	0.1	0.2
ld_rce3-rext-mt	101.9	0	0	0
i_rce3-scc-yuv444-mt	103.5	−0.1	−0.2	−0.2
i_rce3-classB-mt	104	0	0	0
i_rce3-anim-rgb444-mt	105.7	0	0	0
i_rce3-classF-mt	102.4	−0.1	−0.2	−0.3
i_rce3-anim-yuv444-mt	104.7	0	0	0
i_rce3-scc-rgb444-mt	103.5	−0.2	−0.2	−0.2
i_rce3-rext-mt	109.2	0	0	0
ra_rce3-scc-yuv444-ht	101.9	0	0.1	0
ra_rce3-classB-ht	101.6	0	0.1	0
ra_rce3-anim-rgb444-ht	104.2	0	0	0
ra_rce3-classF-ht	105.2	0	0	0
ra_rce3-anim-yuv444-ht	102.7	0	0	0
ra_rce3-scc-rgb444-ht	101.1	0	0	0
ra_rce3-rext-ht	101.6	0	0	0
ld_rce3-scc-yuv444-ht	102.1	0.3	0.1	0.1
ld_rce3-classB-ht	102.9	0	0.1	0
ld_rce3-anim-rgb444-ht	101.6	0	0	0
ld_rce3-classF-ht	96.6	0	0.2	0
ld_rce3-anim-yuv444-ht	102	0	0	0
ld_rce3-scc-rgb444-ht	101.6	0	0	0
ld_rce3-rext-ht	102	0	0	0
i_rce3-scc-yuv444-ht	103.6	−0.1	−0.2	−0.1
i_rce3-classB-ht	104.8	0	0	0
i_rce3-anim-rgb444-ht	102.7	0	0	0
i_rce3-classF-ht	103.2	−0.1	−0.1	−0.1
i_rce3-anim-yuv444-ht	105.4	0	0	0
i_rce3-scc-rgb444-ht	103.3	−0.2	−0.1	−0.2
i_rce3-rext-ht	109.1	0	0	0
i_rce3-scc-yuv444-sht	106.3	−0.1	−0.1	−0.1
i_rce3-classB-sht	104.6	0	0	0
i_rce3-anim-rgb444-sht	105.2	0	0	0
i_rce3-classF-sht	103.9	−0.1	−0.1	−0.1
i_rce3-anim-yuv444-sht	106.7	0	0	0
i_rce3-scc-rgb444-sht	106.4	−0.2	−0.1	−0.1
i_rce3-rext-sht	107.4	0	0	0

Table 3 – Proposed sign coding modification for transform skipped blocks against RCE3 anchor (Lossless)

Configuration	Runtime (%)	Saving %
ra_rce3-scc-yuv444-lossless	96.18	−0.61
ra_rce3-anim-rgb444-lossless	103.04	−0.08
ra_rce3-classF-lossless	81.49	−0.7
ra_rce3-anim-yuv444-lossless	82.16	−0.08
ra_rce3-scc-rgb444-lossless	94.11	−0.51
ld_rce3-scc-yuv444-lossless	99.26	−0.32
ld_rce3-classF-lossless	115.23	−0.33
ld_rce3-scc-rgb444-lossless	96.69	−0.32
i_rce3-scc-yuv444-lossless	102.23	−0.89
i_rce3-classB-lossless	103.68	−0.56
i_rce3-anim-rgb444-lossless	103.42	−1.13
i_rce3-classF-lossless	105.22	−1.1
i_rce3-anim-yuv444-lossless	101.48	−0.66
i_rce3-scc-rgb444-lossless	98.86	−0.87
i_rce3-rext-lossless	102.6	−0.21

Table 4 – Proposed sign coding modification for transform skipped blocks against modified RCE3 anchor with IntraBC disabled (Non-lossless)

Configuration	Runtime (%)	BD-Rate Luma	Cb	Cr
ra_rce3-scc-yuv444-mt	100.7	−0.4	−0.5	−0.5
ra_rce3-classB-mt	99	0	0	−0.1
ra_rce3-anim-rgb444-mt	102	0	0	0
ra_rce3-classF-mt	105.2	−0.3	−0.2	−0.3
ra_rce3-anim-yuv444-mt	104.8	0	0	0
ra_rce3-scc-rgb444-mt	104.2	−0.7	−0.7	−0.7
ra_rce3-rext-mt	100.9	0	0	0
ld_rce3-scc-yuv444-mt	100.8	−0.5	−0.5	−0.4
ld_rce3-classB-mt	100.8	0	0	0.1
ld_rce3-anim-rgb444-mt	100.9	0	0	0
ld_rce3-classF-mt	108.8	−0.1	−0.3	−0.1
ld_rce3-anim-yuv444-mt	97.9	0	0	0
ld_rce3-scc-rgb444-mt	100.8	−0.8	−0.8	−0.9
ld_rce3-rext-mt	100.5	0	0	0
i_rce3-scc-yuv444-mt	102.6	−0.6	−0.6	−0.7
i_rce3-classB-mt	101.8	0	0	0
i_rce3-anim-rgb444-mt	101.8	0	0	0
i_rce3-classF-mt	103.6	−0.4	−0.4	−0.4
i_rce3-anim-yuv444-mt	103.8	0	0	0
i_rce3-scc-rgb444-mt	103.3	−0.7	−0.7	−0.7
i_rce3-rext-mt	101.6	0	0	0
ra_rce3-scc-yuv444-ht	101.7	−0.3	−0.3	−0.3
ra_rce3-classB-ht	100.4	0	0	0
ra_rce3-anim-rgb444-ht	101.2	0	0	0
ra_rce3-classF-ht	110	−0.2	−0.2	−0.2
ra_rce3-anim-yuv444-ht	104.3	0	0	0
ra_rce3-scc-rgb444-ht	106.6	−0.7	−0.7	−0.7
ra_rce3-rext-ht	101.8	0	0	0
ld_rce3-scc-yuv444-ht	100.9	−0.5	−0.5	−0.5
ld_rce3-classB-ht	101.1	0	0	0
ld_rce3-anim-rgb444-ht	102	0	0	0
ld_rce3-classF-ht	103.5	0	−0.2	0
ld_rce3-anim-yuv444-ht	100.6	0	0	0
ld_rce3-scc-rgb444-ht	100.8	−0.7	−0.7	−0.7
ld_rce3-rext-ht	101.1	0	0	0
i_rce3-scc-yuv444-ht	103	−0.6	−0.6	−0.6
i_rce3-classB-ht	102.4	0	0	0
i_rce3-anim-rgb444-ht	102.5	0	0	0
i_rce3-classF-ht	104.2	−0.3	−0.3	−0.3
i_rce3-anim-yuv444-ht	109	0	0	0
i_rce3-scc-rgb444-ht	103.9	−0.6	−0.6	−0.6
i_rce3-rext-ht	105.1	0	0	0
i_rce3-scc-yuv444-sht	104.9	−0.5	−0.5	−0.5
i_rce3-classB-sht	102.7	0	0	0
i_rce3-anim-rgb444-sht	105	0	0	0
i_rce3-classF-sht	104.3	−0.2	−0.3	−0.2
i_rce3-anim-yuv444-sht	110	0	0	0
i_rce3-scc-rgb444-sht	104.5	−0.5	−0.5	−0.5
i_rce3-rext-sht	105.7	0	0	0

4 Remarks

While the intra block copying mode provides obvious benefits to screen content coding, it does come at significant cost for an encoder. Consequentially, it is probable that such a mode will not always be implemented in encoder designs, and, as such, the coding performance in the absence of this mode should also be considered.

5 Specification text

Please see the enclosed document for the proposed specification text.

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References

[1] D. Flynn, K. Sharman, and C. Rosewarne, “Common test conditions and software reference configurations for hevc range extensions,” JCTVC-N1006, JCT-VC, Jul. 2013.

[2] A. Saxena, D. Kwon, M. Naccari, and C. Pang, “Hevc range extensions core experiment 3 (rce3): Intra prediction techniques,” JCTVC-N1123, JCT-VC, Jul. 2013.