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| *Title:* | **Non-SCCE1: Adaptive switching between differential and direct coding for intra block copy vectors** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes to adaptively switch between differential and direct coding for each block vector in intra block copy to improve coding performance of the vectors. In the proposed method, a flag is transmitted with a block vector to indicate whether the vector is predicted or not. In this document, two methods are proposed, the first method keeps the current process as unchanged as possible, while the second method modifies the coding process of sign flags of vectors to exploit the fact that the horizontal and vertical components of block vector cannot be both non-negative. For lossy test conditions, average gains over the anchor for various content types were up to 3.0% and 3.5% for the first and second methods, respectively. For lossless test conditions, average gains were up to 2.2% and 2.5% for the first and second methods, respectively. Moreover, this document also reports that the performance of the related techniques studied in SCCE1 (Tests 3.5 and 3.6) can be improved by the proposed methods.

# Introduction

At the last meeting, Screen Content Coding Core Experiment 1 (SCCE1) for intra block copying extensions was established [1]. One of the main studies in the SCCE1 is to improve the performance of block vector coding (Tests 3.5 and 3.6). At present, a block vector in intra block copy is always predicted and its prediction error is encoded, however, the prediction of block vector is inherently difficult and often degrades the coding efficiency compared to encoding a vector directly without prediction. Addressing this problem, this contribution proposes to adaptively switch between differential and direct coding for each block vector.

# Proposed methods

In the proposed method, a flag is transmitted with a block vector in intra block copy to indicate whether the vector is predicted or not. In order to reduce the overhead of sending flags, we don't use separate flags for horizontal and vertical components of a vector, but employ a single flag which indicates if both horizontal and vertical components are predicted or not.

In this contribution, two methods are proposed. The first method just adds a flag, and keeps the current process as unchanged as possible, while the second method additionally modifies the coding process of sign flags of vectors to reduce the overhead of sending them by exploiting the fact that the horizontal and vertical components of block vector cannot be both non-negative. Note that in the proposed methods, exponential-Golomb codes with order 3 are used to encode the absolute values of vectors for both differential coding and direct coding, because they provide better performance for coding of block vectors compared to the current method (i.e., first order exponential-Golomb codes) [2], [3].

## Method 1

In method 1, only a flag, **intra\_bc\_bv\_pred\_flag**, is added to the current process as shown in Fig. 1. When **intra\_bc\_bv\_pred\_flag** is equal to 1, the block vector is predicted and its prediction error is encoded, while the flag is equal to 0, the block vector is encoded directly. **intra\_bc\_bv\_pred\_flag** is present only when one or both components of a vector are not equal to 0, since the two components of block vector cannot be both 0. Thus, if **intra\_bc\_bv\_pred\_flag** is not present, the value of **intra\_bc\_bv\_pred\_flag** is inferred to be equal to 1 (i.e., the block vector is predicted).



Fig. 1 Decoding process of a block vector in method 1

## Method 2

In method 2, **intra\_bc\_bv\_pred\_flag** is encoded after absolute values of block vector, and if the flag is equal to 1, the sign flags of horizontal and vertical components are encoded as shown in Fig. 2. On the other hand, if **intra\_bc\_bv\_pred\_flag** is equal to 0 (i.e., the block vector is encoded directly without prediction), we can reduce the overhead of sending sign flags by exploiting the fact that the horizontal and vertical components of block vector cannot be both non-negative. When one component is equal to 0, it is not necessary to encode the sign flag of the other component since it is always negative. When the two components are both non-zero, we introduce a new flag, **intra\_bc\_bv\_sign\_flag**, to indicate whether the horizontal and vertical components are both negative or not. When this flag is equal to 1, the two components are both negative, while this flag is equal to 0, there are two possibilities: (i) the horizontal component is negative and the vertical component is positive, and (ii) the horizontal component is positive and the vertical component is negative. So we additionally encode **intra\_bc\_bvd\_sign\_flag[ 0 ]** to distinguish these two cases when **intra\_bc\_bv\_sign\_flag** is equal to 0.



Fig. 2 Decoding process of a block vector in method 2

# Experimental results

In this section, experimental results are presented for the proposed methods. The methods are implemented in SCM-1.0 (HM-14.0+RExt-7.0+SCM-1.0). SCC common test conditions are be used [4]. The performance is compared to the anchor for lossy and lossless configuration in terms of BD-rates and rate savings, respectively. Moreover, this section also reports the performance of the proposed methods when they are combined with the related techniques studied in SCCE1 (Test 3.5 [5] and Test 3.6 [3]).

## On top of SCM-1.0

### Method 1

Table 1 Lossy results of method 1 on top of SCM-1.0

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -2.5% | -2.5% | -2.5% |
| RGB, text & graphics with motion,720p | -1.2% | -1.2% | -1.2% |
| RGB, mixed content, 1440p | -0.9% | -0.9% | -0.9% |
| RGB, mixed content, 1080p | -1.1% | -1.1% | -1.1% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -3.0% | -3.0% | -2.9% |
| YUV, text & graphics with motion,720p | -1.5% | -1.5% | -1.6% |
| YUV, mixed content, 1440p | -1.2% | -1.1% | -1.2% |
| YUV, mixed content, 1080p | -1.4% | -1.3% | -1.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.4% | -1.3% | -1.4% |
| RGB, text & graphics with motion,720p | -0.8% | -0.8% | -0.9% |
| RGB, mixed content, 1440p | -0.6% | -0.6% | -0.5% |
| RGB, mixed content, 1080p | -0.8% | -0.8% | -0.8% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -1.5% | -1.5% | -1.5% |
| YUV, text & graphics with motion,720p | -1.0% | -0.9% | -1.1% |
| YUV, mixed content, 1440p | -0.7% | -0.8% | -0.8% |
| YUV, mixed content, 1080p | -1.0% | -1.2% | -0.9% |
| YUV, Animation, 720p | 0.0% | -0.1% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.0% | -1.0% | -0.9% |
| RGB, text & graphics with motion,720p | -0.3% | -0.4% | -0.3% |
| RGB, mixed content, 1440p | -0.4% | -0.6% | -0.4% |
| RGB, mixed content, 1080p | -0.4% | -0.2% | -0.4% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.1% |
| RGB, camera captured, 1080p | -0.1% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p | -1.0% | -1.0% | -1.1% |
| YUV, text & graphics with motion,720p | -0.6% | -0.5% | -0.4% |
| YUV, mixed content, 1440p | -0.4% | -0.9% | -0.5% |
| YUV, mixed content, 1080p | -0.3% | -1.0% | -0.3% |
| YUV, Animation, 720p | 0.0% | -0.4% | -0.2% |
| YUV, camera captured, 1080p | 0.0% | 0.1% | 0.0% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

Table 2 Lossless results of method 1 on top of SCM-1.0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 2.0% | 2.0% | 1.3% | 2.7% |
| RGB, text & graphics with motion,720p | 0.4% | 0.5% | 0.1% | 1.2% |
| RGB, mixed content, 1440p | 0.2% | 0.2% | 0.1% | 0.2% |
| RGB, mixed content, 1080p | 0.2% | 0.2% | 0.2% | 0.2% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.2% | 2.2% | 1.3% | 2.7% |
| YUV, text & graphics with motion,720p | 0.4% | 0.6% | 0.1% | 1.4% |
| YUV, mixed content, 1440p | 0.2% | 0.2% | 0.1% | 0.3% |
| YUV, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 101% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.0% | 1.3% | 0.7% | 2.2% |
| RGB, text & graphics with motion,720p | 0.1% | 0.3% | 0.0% | 1.0% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.1% | 1.4% | 1.0% | 2.2% |
| YUV, text & graphics with motion,720p | 0.1% | 0.4% | 0.1% | 1.2% |
| YUV, mixed content, 1440p | 0.0% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.0% | 1.1% | 0.5% | 1.6% |
| RGB, text & graphics with motion,720p | 0.1% | 0.1% | 0.0% | 0.3% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.0% | 1.1% | 0.7% | 1.5% |
| YUV, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.4% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 100% | | | |

### Method 2

Table 3 Lossy results of method 2 on top of SCM-1.0

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -2.9% | -2.9% | -2.9% |
| RGB, text & graphics with motion,720p | -1.4% | -1.5% | -1.4% |
| RGB, mixed content, 1440p | -1.1% | -1.1% | -1.1% |
| RGB, mixed content, 1080p | -1.4% | -1.3% | -1.4% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | -0.1% | -0.1% |
| YUV, text & graphics with motion, 1080p | -3.5% | -3.4% | -3.4% |
| YUV, text & graphics with motion,720p | -1.7% | -1.7% | -1.8% |
| YUV, mixed content, 1440p | -1.4% | -1.4% | -1.4% |
| YUV, mixed content, 1080p | -1.6% | -1.6% | -1.6% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 98% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.5% | -1.6% | -1.6% |
| RGB, text & graphics with motion,720p | -1.0% | -1.0% | -1.0% |
| RGB, mixed content, 1440p | -0.7% | -0.7% | -0.7% |
| RGB, mixed content, 1080p | -0.9% | -0.9% | -0.9% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -1.7% | -1.7% | -1.8% |
| YUV, text & graphics with motion,720p | -1.1% | -1.2% | -1.3% |
| YUV, mixed content, 1440p | -0.8% | -1.1% | -0.9% |
| YUV, mixed content, 1080p | -1.1% | -1.2% | -1.1% |
| YUV, Animation, 720p | 0.0% | -0.2% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.1% | -1.1% | -1.1% |
| RGB, text & graphics with motion,720p | -0.4% | -0.5% | -0.3% |
| RGB, mixed content, 1440p | -0.4% | -0.7% | -0.5% |
| RGB, mixed content, 1080p | -0.4% | -0.3% | -0.4% |
| RGB, Animation, 720p | 0.1% | 0.0% | 0.2% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -1.2% | -1.2% | -1.2% |
| YUV, text & graphics with motion,720p | -0.6% | -0.5% | -0.6% |
| YUV, mixed content, 1440p | -0.5% | -0.6% | -0.7% |
| YUV, mixed content, 1080p | -0.5% | -0.5% | -0.6% |
| YUV, Animation, 720p | 0.0% | -0.3% | -0.2% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |

Table 4 Lossless results of method 2 on top of SCM-1.0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 2.3% | 2.3% | 1.5% | 3.0% |
| RGB, text & graphics with motion,720p | 0.5% | 0.6% | 0.1% | 1.4% |
| RGB, mixed content, 1440p | 0.2% | 0.2% | 0.1% | 0.3% |
| RGB, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.5% | 2.5% | 1.5% | 3.1% |
| YUV, text & graphics with motion,720p | 0.5% | 0.7% | 0.1% | 1.6% |
| YUV, mixed content, 1440p | 0.2% | 0.2% | 0.2% | 0.3% |
| YUV, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.2% | 1.5% | 0.9% | 2.5% |
| RGB, text & graphics with motion,720p | 0.1% | 0.4% | 0.1% | 1.1% |
| RGB, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.2% | 1.6% | 1.1% | 2.5% |
| YUV, text & graphics with motion,720p | 0.1% | 0.5% | 0.1% | 1.3% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 101% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.1% | 1.2% | 0.6% | 1.8% |
| RGB, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.4% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.1% | 1.2% | 0.8% | 1.8% |
| YUV, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.4% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 98% | | | |

## On top of Test 3.5

### Method 1

Table 5 Lossy results of method 1 on top of SCCE1 Test 3.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -3.8% | -3.7% | -3.7% |
| RGB, text & graphics with motion,720p | -2.1% | -2.2% | -2.1% |
| RGB, mixed content, 1440p | -1.3% | -1.3% | -1.3% |
| RGB, mixed content, 1080p | -1.7% | -1.6% | -1.6% |
| RGB, Animation, 720p | -0.1% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | -0.1% | -0.1% | -0.1% |
| YUV, text & graphics with motion, 1080p | -4.5% | -4.4% | -4.4% |
| YUV, text & graphics with motion,720p | -2.7% | -2.7% | -2.7% |
| YUV, mixed content, 1440p | -1.7% | -1.7% | -1.7% |
| YUV, mixed content, 1080p | -2.0% | -1.9% | -1.9% |
| YUV, Animation, 720p | -0.1% | -0.1% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 96% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -2.2% | -2.1% | -2.2% |
| RGB, text & graphics with motion,720p | -1.4% | -1.4% | -1.4% |
| RGB, mixed content, 1440p | -0.9% | -0.9% | -0.9% |
| RGB, mixed content, 1080p | -1.2% | -1.1% | -1.1% |
| RGB, Animation, 720p | -0.1% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -2.3% | -2.3% | -2.3% |
| YUV, text & graphics with motion,720p | -1.7% | -1.8% | -1.9% |
| YUV, mixed content, 1440p | -1.0% | -1.2% | -1.1% |
| YUV, mixed content, 1080p | -1.4% | -1.4% | -1.5% |
| YUV, Animation, 720p | -0.1% | -0.2% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | -0.1% | 0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.6% | -1.6% | -1.5% |
| RGB, text & graphics with motion,720p | -0.8% | -0.6% | -0.5% |
| RGB, mixed content, 1440p | -0.4% | -0.6% | -0.5% |
| RGB, mixed content, 1080p | -0.7% | -0.3% | -1.1% |
| RGB, Animation, 720p | 0.0% | -0.1% | 0.1% |
| RGB, camera captured, 1080p | -0.1% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p | -1.8% | -1.6% | -1.7% |
| YUV, text & graphics with motion,720p | -0.9% | -0.5% | -1.1% |
| YUV, mixed content, 1440p | -0.6% | -1.0% | -0.5% |
| YUV, mixed content, 1080p | -0.6% | -1.2% | -0.4% |
| YUV, Animation, 720p | -0.1% | -0.7% | -0.2% |
| YUV, camera captured, 1080p | 0.0% | 0.1% | -0.2% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |



Table 6 Lossless results of method 1 on top of SCCE1 Test 3.5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 2.3% | 2.4% | 1.4% | 3.4% |
| RGB, text & graphics with motion,720p | 0.5% | 0.7% | 0.1% | 1.7% |
| RGB, mixed content, 1440p | 0.2% | 0.2% | 0.2% | 0.3% |
| RGB, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.5% | 2.5% | 1.5% | 3.4% |
| YUV, text & graphics with motion,720p | 0.5% | 0.8% | 0.1% | 2.0% |
| YUV, mixed content, 1440p | 0.2% | 0.3% | 0.2% | 0.3% |
| YUV, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 95% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.2% | 1.6% | 0.9% | 2.7% |
| RGB, text & graphics with motion,720p | 0.1% | 0.5% | 0.1% | 1.3% |
| RGB, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.2% | 1.7% | 1.1% | 2.7% |
| YUV, text & graphics with motion,720p | 0.1% | 0.5% | 0.1% | 1.6% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 97% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.1% | 1.2% | 0.6% | 2.0% |
| RGB, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.4% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.1% | 1.3% | 0.8% | 1.9% |
| YUV, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.5% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 99% | | | |

### Method 2



Table 7 Lossy results of method 2 on top of SCCE1 Test 3.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -4.2% | -4.2% | -4.1% |
| RGB, text & graphics with motion,720p | -2.4% | -2.4% | -2.3% |
| RGB, mixed content, 1440p | -1.6% | -1.5% | -1.5% |
| RGB, mixed content, 1080p | -2.0% | -1.9% | -1.9% |
| RGB, Animation, 720p | -0.1% | -0.1% | -0.1% |
| RGB, camera captured, 1080p | -0.1% | -0.1% | -0.1% |
| YUV, text & graphics with motion, 1080p | -5.1% | -5.0% | -4.9% |
| YUV, text & graphics with motion,720p | -3.0% | -3.0% | -3.0% |
| YUV, mixed content, 1440p | -2.0% | -2.0% | -2.0% |
| YUV, mixed content, 1080p | -2.3% | -2.3% | -2.2% |
| YUV, Animation, 720p | -0.1% | -0.2% | -0.1% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 96% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -2.5% | -2.3% | -2.4% |
| RGB, text & graphics with motion,720p | -1.7% | -1.6% | -1.6% |
| RGB, mixed content, 1440p | -1.1% | -1.0% | -1.0% |
| RGB, mixed content, 1080p | -1.3% | -1.2% | -1.3% |
| RGB, Animation, 720p | -0.2% | -0.2% | -0.1% |
| RGB, camera captured, 1080p | -0.1% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -2.6% | -2.6% | -2.6% |
| YUV, text & graphics with motion,720p | -2.0% | -1.9% | -2.0% |
| YUV, mixed content, 1440p | -1.2% | -1.3% | -1.3% |
| YUV, mixed content, 1080p | -1.6% | -1.5% | -1.5% |
| YUV, Animation, 720p | 0.1% | 0.0% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | -0.1% | 0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.8% | -1.8% | -1.7% |
| RGB, text & graphics with motion,720p | -1.0% | -0.8% | -0.8% |
| RGB, mixed content, 1440p | -0.6% | -0.9% | -0.6% |
| RGB, mixed content, 1080p | -0.9% | -0.3% | -1.0% |
| RGB, Animation, 720p | -0.1% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | -0.1% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p | -2.0% | -1.9% | -1.9% |
| YUV, text & graphics with motion,720p | -1.0% | -1.0% | -1.0% |
| YUV, mixed content, 1440p | -0.8% | -0.9% | -0.7% |
| YUV, mixed content, 1080p | -0.7% | -1.0% | -0.3% |
| YUV, Animation, 720p | 0.0% | -0.5% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | -0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 101% | | |

Table 8 Lossless results of method 2 on top of SCCE1 Test 3.5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 2.7% | 2.7% | 1.6% | 3.8% |
| RGB, text & graphics with motion,720p | 0.6% | 0.8% | 0.2% | 1.9% |
| RGB, mixed content, 1440p | 0.2% | 0.3% | 0.2% | 0.3% |
| RGB, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.9% | 2.9% | 1.7% | 3.8% |
| YUV, text & graphics with motion,720p | 0.6% | 0.9% | 0.2% | 2.2% |
| YUV, mixed content, 1440p | 0.3% | 0.3% | 0.2% | 0.4% |
| YUV, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 95% | | | |
| Dec Time[%] | 101% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.4% | 1.8% | 1.0% | 3.0% |
| RGB, text & graphics with motion,720p | 0.2% | 0.5% | 0.1% | 1.5% |
| RGB, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.4% | 1.9% | 1.3% | 3.0% |
| YUV, text & graphics with motion,720p | 0.2% | 0.6% | 0.1% | 1.7% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 100% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.3% | 1.4% | 0.7% | 2.3% |
| RGB, text & graphics with motion,720p | 0.1% | 0.2% | 0.1% | 0.5% |
| RGB, mixed content, 1440p | 0.0% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.3% | 1.5% | 0.9% | 2.2% |
| YUV, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.6% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 99% | | | |

## On top of Test 3.6

### Method 1



Table 9 Lossy results of method 1 on top of SCCE1 Test 3.6

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -3.3% | -3.2% | -3.2% |
| RGB, text & graphics with motion,720p | -1.7% | -1.7% | -1.7% |
| RGB, mixed content, 1440p | -1.2% | -1.2% | -1.2% |
| RGB, mixed content, 1080p | -1.5% | -1.5% | -1.5% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | -0.1% | -0.1% |
| YUV, text & graphics with motion, 1080p | -3.9% | -3.8% | -3.8% |
| YUV, text & graphics with motion,720p | -2.1% | -2.1% | -2.2% |
| YUV, mixed content, 1440p | -1.5% | -1.6% | -1.7% |
| YUV, mixed content, 1080p | -1.8% | -1.8% | -1.8% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.9% | -1.8% | -1.9% |
| RGB, text & graphics with motion,720p | -1.1% | -1.2% | -1.1% |
| RGB, mixed content, 1440p | -0.8% | -0.8% | -0.8% |
| RGB, mixed content, 1080p | -1.0% | -1.1% | -1.0% |
| RGB, Animation, 720p | -0.1% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -2.0% | -2.1% | -2.1% |
| YUV, text & graphics with motion,720p | -1.4% | -1.4% | -1.6% |
| YUV, mixed content, 1440p | -0.9% | -1.2% | -1.1% |
| YUV, mixed content, 1080p | -1.3% | -1.3% | -1.4% |
| YUV, Animation, 720p | 0.0% | -0.1% | 0.1% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.5% | -1.5% | -1.3% |
| RGB, text & graphics with motion,720p | -0.7% | -0.7% | -0.6% |
| RGB, mixed content, 1440p | -0.6% | -0.8% | -0.7% |
| RGB, mixed content, 1080p | -0.6% | -0.4% | -0.8% |
| RGB, Animation, 720p | -0.2% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | -0.1% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p | -1.5% | -1.6% | -1.6% |
| YUV, text & graphics with motion,720p | -0.8% | -0.6% | -0.8% |
| YUV, mixed content, 1440p | -0.7% | -0.9% | -0.8% |
| YUV, mixed content, 1080p | -0.6% | -0.4% | -0.4% |
| YUV, Animation, 720p | -0.1% | -0.4% | -0.2% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | -0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |



Table 10 Lossless results of method 1 on top of SCCE1 Test 3.6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 2.1% | 2.2% | 1.3% | 3.0% |
| RGB, text & graphics with motion,720p | 0.4% | 0.6% | 0.1% | 1.4% |
| RGB, mixed content, 1440p | 0.2% | 0.2% | 0.1% | 0.3% |
| RGB, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.3% | 2.3% | 1.4% | 3.0% |
| YUV, text & graphics with motion,720p | 0.5% | 0.7% | 0.1% | 1.6% |
| YUV, mixed content, 1440p | 0.2% | 0.2% | 0.2% | 0.3% |
| YUV, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 101% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.1% | 1.4% | 0.8% | 2.4% |
| RGB, text & graphics with motion,720p | 0.1% | 0.4% | 0.1% | 1.1% |
| RGB, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.2% | 1.5% | 1.1% | 2.4% |
| YUV, text & graphics with motion,720p | 0.1% | 0.4% | 0.1% | 1.3% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | | | |
| Dec Time[%] | 98% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.0% | 1.2% | 0.6% | 1.8% |
| RGB, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.4% |
| RGB, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.1% | 1.2% | 0.8% | 1.7% |
| YUV, text & graphics with motion,720p | 0.1% | 0.2% | 0.0% | 0.4% |
| YUV, mixed content, 1440p | 0.0% | 0.0% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | | | |
| Dec Time[%] | 100% | | | |

### Method 2



Table 11 Lossy results of method 2 on top of SCCE1 Test 3.6

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -3.7% | -3.7% | -3.7% |
| RGB, text & graphics with motion,720p | -2.0% | -2.0% | -1.9% |
| RGB, mixed content, 1440p | -1.4% | -1.4% | -1.4% |
| RGB, mixed content, 1080p | -1.8% | -1.7% | -1.7% |
| RGB, Animation, 720p | -0.1% | -0.1% | 0.0% |
| RGB, camera captured, 1080p | -0.1% | -0.1% | -0.1% |
| YUV, text & graphics with motion, 1080p | -4.4% | -4.4% | -4.3% |
| YUV, text & graphics with motion,720p | -2.4% | -2.5% | -2.5% |
| YUV, mixed content, 1440p | -1.8% | -1.9% | -1.9% |
| YUV, mixed content, 1080p | -2.1% | -2.1% | -2.0% |
| YUV, Animation, 720p | 0.0% | -0.1% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | | |
| Dec Time[%] | 99% | | |
|  |  |  |  |
|  | **Random Access** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -2.2% | -2.1% | -2.2% |
| RGB, text & graphics with motion,720p | -1.3% | -1.4% | -1.3% |
| RGB, mixed content, 1440p | -1.0% | -1.0% | -0.9% |
| RGB, mixed content, 1080p | -1.1% | -1.1% | -1.2% |
| RGB, Animation, 720p | -0.2% | -0.2% | -0.1% |
| RGB, camera captured, 1080p | -0.1% | -0.1% | 0.0% |
| YUV, text & graphics with motion, 1080p | -2.3% | -2.2% | -2.3% |
| YUV, text & graphics with motion,720p | -1.5% | -1.6% | -1.7% |
| YUV, mixed content, 1440p | -1.1% | -1.5% | -1.2% |
| YUV, mixed content, 1080p | -1.6% | -1.4% | -1.5% |
| YUV, Animation, 720p | -0.1% | -0.3% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 100% | | |
|  |  |  |  |
|  | **Low delay B** | | |
|  | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -1.6% | -1.6% | -1.6% |
| RGB, text & graphics with motion,720p | -0.9% | -0.8% | -0.8% |
| RGB, mixed content, 1440p | -0.7% | -0.7% | -0.5% |
| RGB, mixed content, 1080p | -0.9% | -0.3% | -0.9% |
| RGB, Animation, 720p | -0.1% | -0.1% | 0.1% |
| RGB, camera captured, 1080p | -0.1% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -1.7% | -1.9% | -1.8% |
| YUV, text & graphics with motion,720p | -0.9% | -0.6% | -0.8% |
| YUV, mixed content, 1440p | -0.7% | -1.0% | -0.9% |
| YUV, mixed content, 1080p | -0.7% | -1.5% | -0.3% |
| YUV, Animation, 720p | 0.0% | -0.6% | -0.2% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | -0.1% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 99% | | |



Table 12 Lossless results of method 2 on top of SCCE1 Test 3.6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **All Intra** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 2.4% | 2.5% | 1.5% | 3.4% |
| RGB, text & graphics with motion,720p | 0.5% | 0.7% | 0.1% | 1.5% |
| RGB, mixed content, 1440p | 0.2% | 0.2% | 0.2% | 0.3% |
| RGB, mixed content, 1080p | 0.3% | 0.3% | 0.3% | 0.3% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 2.6% | 2.7% | 1.6% | 3.4% |
| YUV, text & graphics with motion,720p | 0.6% | 0.8% | 0.1% | 1.8% |
| YUV, mixed content, 1440p | 0.3% | 0.3% | 0.2% | 0.4% |
| YUV, mixed content, 1080p | 0.4% | 0.4% | 0.4% | 0.4% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | | | |
| Dec Time[%] | 99% | | | |
|  |  |  |  |  |
|  | **Random Access** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.3% | 1.6% | 1.0% | 2.7% |
| RGB, text & graphics with motion,720p | 0.1% | 0.4% | 0.1% | 1.2% |
| RGB, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.3% | 1.7% | 1.2% | 2.7% |
| YUV, text & graphics with motion,720p | 0.1% | 0.5% | 0.1% | 1.4% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.1% | 0.1% | 0.1% | 0.1% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 98% | | | |
|  |  |  |  |  |
|  | **Low Delay B** | | | |
|  | Total | Average | Min | Max |
| RGB, text & graphics with motion, 1080p | 1.2% | 1.3% | 0.7% | 2.1% |
| RGB, text & graphics with motion,720p | 0.1% | 0.2% | 0.1% | 0.5% |
| RGB, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| RGB, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | 1.2% | 1.4% | 0.9% | 2.0% |
| YUV, text & graphics with motion,720p | 0.1% | 0.2% | 0.1% | 0.5% |
| YUV, mixed content, 1440p | 0.1% | 0.1% | 0.0% | 0.1% |
| YUV, mixed content, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | |
| Dec Time[%] | 98% | | | |

# Complexity

Table 13 shows the comparison of complexity between SCM and the proposed methods for block vector coding from the viewpoints of the number of context coded bins per vector, the number of additional contexts, and binarization. The proposed methods add one or two flags (intra\_bc\_bv\_pred\_flag and intra\_bc\_bv\_sign\_flag) to be encoded and the flags are encoded with equal probability. Therefore, in the proposed methods, there are no changes on the number of context coded bins per vector and the number of additional contexts compared with SCM. The proposed methods only change binarization process of IBC block vector.

Table 13 Complexity comparison between SCM and the proposed methods for block vector coding

|  |  |  |  |
| --- | --- | --- | --- |
|  | SCM | Proposed | |
| Method 1 | Method 2 |
| # context coded bins per BV | 4 | 4 | 4 |
| # additional contexts | 0 | 0 | 0 |
| Binarization as in HEVC | Yes | No  (just add a flag) | No  (add two flags, and  modify sign flag coding) |

# Conclusions

In this contribution, we have proposed to adaptively switch between differential and direct coding for each block vector in intra block copy to improve coding performance of the vectors. In the proposed method, a flag is transmitted with a block vector to indicate whether the vector is predicted or not. We have proposed two methods, the first method keeps the current process as unchanged as possible, while the second method modifies the coding process of sign flags of vectors to exploit the fact that the horizontal and vertical components of block vector cannot be both non-negative. For lossy test conditions, average gains over the anchor for various content types were up to 3.0% and 3.5% for the first and second methods, respectively. For lossless test conditions, average gains were up to 2.2% and 2.5% for the first and second methods, respectively. Moreover, the proposed methods can improve the performance of the related techniques studied in SCCE1 (Tests 3.5 and 3.6). For example, when our second method is implemented on top of SCCE1 Test 3.5, the coding gain is up to 5.1% for lossy configuration (the original gain of Test 3.5 is up to 3.7%). We recommend to adopt one of the proposed methods into the new SCC draft text.

# Text specification

The proposed text changes are based on the document JCTVC-P1005-v1.doc. The changes are marked in yellow. Method 1 and Method 2 have the same coding unit syntax and prediction unit syntax.

**7.3 Syntax in tabular form**

**7.3.8.5 Coding unit syntax**

|  |  |
| --- | --- |
| coding\_unit( x0, y0, log2CbSize ) { | **Descriptor** |
| if( transquant\_bypass\_enabled\_flag ) |  |
| **cu\_transquant\_bypass\_flag** | ae(v) |
| **….** |  |
| **….** |  |
| if( CuPredMode[ x0 ][ y0 ] = = MODE\_INTRA && ! intra\_bc\_flag[ x0 ][ y0 ] ) { |  |
| if( PartMode = = PART\_2Nx2N && pcm\_enabled\_flag &&   ~~!intra\_bc\_flag[ x0 ][ y0 ] &&~~   log2CbSize >= Log2MinIpcmCbSizeY &&  log2CbSize <= Log2MaxIpcmCbSizeY ) |  |
| **pcm\_flag**[ x0 ][ y0 ] | ae(v) |
| if( pcm\_flag[ x0 ][ y0 ] ) { |  |
| while( !byte\_aligned( ) ) |  |
| **pcm\_alignment\_zero\_bit** | f(1) |
| pcm\_sample( x0, y0, log2CbSize ) |  |
| ~~} else if( intra\_bc\_flag[ x0 ][ y0 ] ) {~~ |  |
| ~~mvd\_coding( x0, y0, 2)~~ |  |
| ~~if( PartMode = = PART\_2NxN )~~ |  |
| ~~mvd\_coding( x0, y0 + ( nCbS / 2 ), 2)~~ |  |
| ~~else if( PartMode = = PART\_Nx2N )~~ |  |
| ~~mvd\_coding( x0 + ( nCbS / 2 ), y0, 2)~~ |  |
| ~~else if( PartMode = = PART\_NxN ) {~~ |  |
| ~~mvd\_coding( x0 + ( nCbS / 2 ), y0, 2)~~ |  |
| ~~mvd\_coding( x0, y0 + ( nCbS / 2 ), 2)~~ |  |
| ~~mvd\_coding( x0 + ( nCbS / 2 ), y0 + ( nCbS / 2 ), 2)~~ |  |
| ~~}~~ |  |
| } else { |  |
| pbOffset = ( PartMode = = PART\_NxN ) ? ( nCbS / 2 ) : nCbS |  |
| **….** |  |
| **….** |  |
| **….** |  |
| } |  |

**7.3.8.6 Prediction unit syntax**

|  |  |
| --- | --- |
| prediction\_unit( x0, y0, nPbW, nPbH ) { | **Descriptor** |
| if( cu\_skip\_flag[ x0 ][ y0 ] ) { |  |
| if( MaxNumMergeCand > 1 ) |  |
| **merge\_idx**[ x0 ][ y0 ] | ae(v) |
| } else if ( intra\_bc\_flag[ x0 ][ y0 ]){ /\* Intra BC\*/ |  |
| intra\_bc\_bvd\_coding( x0, y0, 2) |  |
| } else { /\* MODE\_INTER \*/ |  |
| **….** | ae(v) |
| **….** |  |
| } |  |

**7.3.8.x Intra BC block vector difference syntax**

**Method 1**

|  |  |
| --- | --- |
| intra\_bc\_bvd\_coding ( x0, y0, refList ) { | **Descriptor** |
| **intra\_bc\_abs\_bvd\_greater0\_flag**[ 0 ] | ae(v) |
| **intra\_bc\_abs\_bvd\_greater0\_flag**[ 1 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 0 ] | | intra\_bc**\_**abs\_bvd\_greater0\_flag[ 1 ] ) |  |
| **intra\_bc\_bv\_pred\_flag** | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 0 ] ) |  |
| **intra\_bc\_abs\_bvd\_greater1\_flag**[ 0 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 1 ] ) |  |
| **intra\_bc\_abs\_bvd\_greater1\_flag**[ 1 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 0 ] ) { |  |
| if( intra\_bc**\_**abs\_bvd\_greater1\_flag[ 0 ] ) |  |
| **intra\_bc\_abs\_bvd\_minus2**[ 0 ] | ae(v) |
| **intra\_bc\_bvd\_sign\_flag**[ 0 ] | ae(v) |
| } |  |
| if( intra\_bc\_abs\_bvd\_greater0\_flag[ 1 ] ) { |  |
| if( intra\_bc\_abs\_bvd\_greater1\_flag[ 1 ] ) |  |
| **intra\_bc\_abs\_bvd\_minus2**[ 1 ] | ae(v) |
| **intra\_bc\_bvd\_sign\_flag**[ 1 ] | ae(v) |
| } |  |
| } |  |

**Method 2**

|  |  |
| --- | --- |
| intra\_bc\_bvd\_coding ( x0, y0, refList ) { | **Descriptor** |
| **intra\_bc\_abs\_bvd\_greater0\_flag**[ 0 ] | ae(v) |
| **intra\_bc\_abs\_bvd\_greater0\_flag**[ 1 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 0 ] ) |  |
| **intra\_bc\_abs\_bvd\_greater1\_flag**[ 0 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 1 ] ) |  |
| **intra\_bc\_abs\_bvd\_greater1\_flag**[ 1 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater1\_flag[ 0 ] ) |  |
| **intra\_bc\_abs\_bvd\_minus2**[ 0 ] | ae(v) |
| if( intra\_bc\_abs\_bvd\_greater1\_flag[ 1 ] ) |  |
| **intra\_bc\_abs\_bvd\_minus2**[ 1 ] | ae(v) |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 0 ] | | intra\_bc**\_**abs\_bvd\_greater0\_flag[ 1 ] ) |  |
| **intra\_bc\_bv\_pred\_flag** | ae(v) |
| if( intra\_bc\_bv\_pred\_flag ) { |  |
| if( intra\_bc\_abs\_bvd\_greater0\_flag[ 0 ] ) |  |
| **intra\_bc\_bvd\_sign\_flag**[ 0 ] | ae(v) |
| if( intra\_bc\_abs\_bvd\_greater0\_flag[ 1 ] ) |  |
| **intra\_bc\_bvd\_sign\_flag**[ 1 ] | ae(v) |
| } |  |
| else { |  |
| if( intra\_bc**\_**abs\_bvd\_greater0\_flag[ 0 ] && intra\_bc**\_**abs\_bvd\_greater0\_flag[ 1 ] ) { |  |
| **intra\_bc\_bv\_sign\_flag** | ae(v) |
| if( ! intra\_bc\_bv\_sign\_flag ) |  |
| **intra\_bc\_bvd\_sign\_flag**[ 0 ] | ae(v) |
| } |  |
| } |  |
| } |  |

**7.4 Semantics**

**7.4.9.x Intra BC block vector difference semantics**

**intra\_bc\_abs\_bvd\_greater0\_flag**[ compIdx ] specifies whether the absolute value of a block vector component difference is greater than 0.

**intra\_bc\_abs\_bvd\_greater1\_flag**[ compIdx ] specifies whether the absolute value of a block vector component difference is greater than 1.

When intra\_bc\_abs\_bvd\_greater1\_flag[ compIdx ] is not present, it is inferred to be equal to 0.

**intra\_bc\_abs\_bvd\_minus2**[ compIdx ] plus 2 specifies the absolute value of a block vector component difference.

When intra\_bc\_abs\_bvd\_minus2[ compIdx ] is not present, it is inferred to be equal to −1.

**intra\_bc\_bvd\_sign\_flag**[ compIdx ] specifies the sign of a block vector component difference as follows:

If intra\_bc\_bvd\_sign\_flag[ compIdx ] is equal to 0, the corresponding block vector component difference has a positive value.

Otherwise (intra\_bc\_bvd\_sign\_flag[ compIdx ] is equal to 1), the corresponding block vector component difference has a negative value.

When intra\_bc\_bvd\_sign\_flag[ compIdx ] is not present, it is inferred to be equal to 0.

The block vector difference BvdIntra [ compIdx ] for compIdx = 0..1 is derived as follows:

BvdIntra [ compIdx ] = intra\_bc\_abs\_bvd\_greater0\_flag [ compIdx ] \*  
 ( intra\_bc\_abs\_bvd\_minus2 [ compIdx ] + 2 ) \* ( 1 − 2 \* intra\_bc\_bvd\_sign\_flag [ compIdx ] )

**intra\_bc\_bv\_pred\_flag** specifies whether the block vector is predicted or not.

When intra\_bc\_bv\_pred\_flag is not present, it is inferred to be equal to 1.

(The following is only for Method 2)

**intra\_bc\_bv\_sign\_flag** specifies the sign of a block vector as follows:

If intra\_bc\_bv\_sign\_flag is equal to 1, all components of a block vector have negative values.

Otherwise (intra\_bc\_bv\_sign\_flag is equal to 0), the block vector components have different signs.

When intra\_bc\_bv\_sign\_flag is not present, it is inferred to be equal to 0.

**9.3.3 Binarization process**

**9.3.3.1 General**

| **Table 9‑34 – Syntax elements and associated binarizations** | | | |
| --- | --- | --- | --- |
| **Syntax structure** | **Syntax element** | **Binarization** | |
| **Process** | **Input parameters** |
| slice\_segment\_data( ) | end\_of\_slice\_segment\_flag | FL | cMax = 1 |
| end\_of\_sub\_stream\_one\_bit | FL | cMax = 1 |
| sao( ) | sao\_merge\_left\_flag | FL | cMax = 1 |
| sao\_merge\_up\_flag | FL | cMax = 1 |
| sao\_type\_idx\_luma | TR | cMax = 2, cRiceParam = 0 |
| sao\_type\_idx\_chroma | TR | cMax = 2, cRiceParam = 0 |
| sao\_offset\_abs[ ][ ][ ][ ] | TR | cMax = ( 1  <<  ( Min( bitDepth, 10 ) − 5 ) ) − 1, cRiceParam = 0 |
| sao\_offset\_sign[ ][ ][ ][ ] | FL | cMax = 1 |
| sao\_band\_position[ ][ ][ ] | FL | cMax = 31 |
| sao\_eo\_class\_luma | FL | cMax = 3 |
| sao\_eo\_class\_chroma | FL | cMax = 3 |
| coding\_quadtree( ) | split\_cu\_flag[ ][ ] | FL | cMax = 1 |
| coding\_unit( ) | cu\_transquant\_bypass\_flag | FL | cMax = 1 |
| cu\_skip\_flag | FL | cMax = 1 |
| intra\_bc\_flag | FL | cMax = 1 |
| pred\_mode\_flag | FL | cMax = 1 |
| part\_mode | 9.3.3.5 | ( xCb, yCb ) = ( x0, y0), log2CbSize |
| pcm\_flag[ ][ ] | FL | cMax = 1 |
| prev\_intra\_luma\_pred\_flag[ ][ ] | FL | cMax = 1 |
| mpm\_idx[ ][ ] | TR | cMax = 2, cRiceParam = 0 |
| rem\_intra\_luma\_pred\_mode[ ][ ] | FL | cMax = 31 |
| intra\_chroma\_pred\_mode[ ][ ] | 9.3.3.6 | - |
| rqt\_root\_cbf | FL | cMax = 1 |
| prediction\_unit( ) | merge\_flag[ ][ ] | FL | cMax = 1 |
| merge\_idx[ ][ ] | TR | cMax = MaxNumMergeCand − 1, cRiceParam = 0 |
| inter\_pred\_idc[ x0 ][ y0 ] | 9.3.3.7 | nPbW, nPbH |
| ref\_idx\_l0[ ][ ] | TR | cMax = num\_ref\_idx\_l0\_active\_minus1, cRiceParam = 0 |
| mvp\_l0\_flag[ ][ ] | FL | cMax = 1 |
| ref\_idx\_l1[ ][ ] | TR | cMax = num\_ref\_idx\_l1\_active\_minus1, cRiceParam = 0 |
| mvp\_l1\_flag[ ][ ] | FL | cMax = 1 |
| transform\_tree( ) | split\_transform\_flag[ ][ ][ ] | FL | cMax = 1 |
| cbf\_luma[ ][ ][ ] | FL | cMax = 1 |
| cbf\_cb[ ][ ][ ] | FL | cMax = 1 |
| cbf\_cr[ ][ ][ ] | FL | cMax = 1 |
| mvd\_coding( ) | abs\_mvd\_greater0\_flag[ ] | FL | cMax = 1 |
| abs\_mvd\_greater1\_flag[ ] | FL | cMax = 1 |
| abs\_mvd\_minus2[ ] | EG1 | - |
| mvd\_sign\_flag[ ] | FL | cMax = 1 |
| intra\_bc\_bvd\_coding ( ) | intra\_bc\_abs\_bvd\_greater0\_flag[ ] | FL | cMax = 1 |
| intra\_bc\_abs\_bvd\_greater1\_flag[ ] | FL | cMax = 1 |
| intra\_bc\_abs\_bvd\_minus2 [ ] | EG3 | - |
| intra\_bc\_bvd\_sign\_flag [ ] | FL | cMax = 1 |
| intra\_bc\_bv\_pred\_flag | FL | cMax = 1 |
| intra\_bc\_bv\_sign\_flag  (only for Method 2) | FL | cMax = 1 |
| transform\_unit( ) | cu\_qp\_delta\_abs | 9.3.3.8 | - |
| cu\_qp\_delta\_sign\_flag | FL | cMax = 1 |
| cu\_chroma\_qp\_adjustment\_flag | FL | cMax = 1 |
| cu\_chroma\_qp\_adjustment\_idc | TR | cMax = chroma\_qp\_adjustment\_table\_size\_minus1, cRiceParam = 0 |
| cross\_comp\_pred( ) | log2\_res\_scale\_abs\_plus1 | TR | cMax = 4, cRiceParam = 0 |
| res\_scale\_sign\_flag | FL | cMax = 1 |
| residual\_coding( ) | transform\_skip\_flag[ ][ ][ ] | FL | cMax = 1 |
| explicit\_rdpcm\_flag[ ][ ][ ] | FL | cMax = 1 |
| explicit\_rdpcm\_dir\_flag[ ][ ][ ] | FL | cMax = 1 |
| last\_sig\_coeff\_x\_prefix | TR | cMax = ( log2TrafoSize << 1 ) − 1, cRiceParam = 0 |
| last\_sig\_coeff\_y\_prefix | TR | cMax = ( log2TrafoSize << 1 ) − 1, cRiceParam = 0 |
| last\_sig\_coeff\_x\_suffix | FL | cMax = ( 1  <<  ( ( last\_sig\_coeff\_x\_prefix  >>  1 ) − 1 ) − 1 ) |
| last\_sig\_coeff\_y\_suffix | FL | cMax = ( 1  <<  ( ( last\_sig\_coeff\_y\_prefix  >>  1 ) − 1 ) − 1 ) |
| coded\_sub\_block\_flag[ ][ ] | FL | cMax = 1 |
| sig\_coeff\_flag[ ][ ] | FL | cMax = 1 |
| coeff\_abs\_level\_greater1\_flag[ ] | FL | cMax = 1 |
| coeff\_abs\_level\_greater2\_flag[ ] | FL | cMax = 1 |
| coeff\_abs\_level\_remaining[ ] | 9.3.3.9 | current sub-block scan index i, baseLevel |
| coeff\_sign\_flag[ ] | FL | cMax = 1 |

# References

1. J. Sole and S. Liu, “HEVC Screen Content Coding Core Experiment 1 (SCCE1): Intra Block Copying Extensions,” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-Q1121, 17th Meeting: Valencia, ES, March, 2014.
2. C. Pang, J. Sole, R. Joshi, and M. Karczewicz, “Non-RCE3: Block vector signaling for intra block copy,” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-P0149, 16th Meeting: San José, US, Jan., 2014.
3. J. Chen, Y. Chen, T. Hsieh, R. Joshi, M. Karczewicz, W.-S. Kim, X. Li, C. Pang, W. Pu, K. Rapaka, J. Sole, L. Zhang, and F. Zou, “Description of screen content coding technology proposal by Qualcomm,” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-Q0031, 17th Meeting: Valencia, ES, March, 2014.
4. H. Yu, R. Cohen, K. Rapaka, and J. Xu, “Common conditions for screen content coding tests,” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-Q1015, 17th Meeting: Valencia, ES, March, 2014.
5. S.-T. Hsiang, T.-D. Chuang, and S. Lei, “AHG8: Coding the prediction differences of the intra BC vectors,” Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-Q0095, 17th Meeting: Valencia, ES, March, 2014.

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