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| *Title:* | **TE4.3.1: Inter-layer SAO** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

The inter-layer sample adaptive offset (IL-SAO) has been proposed as a coding tool in JCTVC-K0033 [1] to respond to the Call for Proposals (CfP) on Scalable Video Coding Extensions of High Efficiency Video Coding (HEVC). This contribution reports the IL-SAO results on SMuC0.1.1 [3]. In general, IL-SAO processes the up-sampled base layer (BL) samples by using a SAO like procedure to reduce the distortion between the original enhancement layer (EL) and BL. IL-SAO can adaptively split one picture of a color component into four regions or treat the entire picture of a color component as one region. IL-SAO parameters are coded in slice header. It is reported that when SMuC0.1.1 is used as the anchor, BD rate reductions of IL-SAO are -0.1%, -0.1%, -0.2%, -0.1%, -0.3%, -0.3%, -0.2%, and -0.5% for AI-2x, AI-1.5x, RA-2x, RA-1.5x, RA-SNR, LD-2x, LD-1.5x and LD-SNR, respectively, and the corresponding “EL-only” BD-rate reductions are -0.3%, -0.2%, -0.5%, -0.2%, -0.7%, -0.6%, -0.5%, and -1.0%.

Introduction

The up-sampled base layer samples can be used as the predictors of the enhancement layer samples by inter-layer texture prediction. The difference between the up-sampled BL samples and the EL samples can be further reduced to improve the compression efficiency. In order to reduce the distortion between the original EL samples and the up-sampled BL samples, the inter-layer SAO has been proposed as a coding tool in JCTVC-K0033 [1] to respond to the CfP on Scalable Video Coding Extensions of HEVC. The IL-SAO block in the entire encoder block diagram is shown in Figure 1.

# Proposed methods

The proposed IL-SAO is based on the SAO in HEVC. It classifies up-sampled BL samples of a region into several bands or categories. An offset can be derived for each band or category. The sample classification is done at both the encoder and the decoder to avoid transmitting sample-level side information. Similar to the SAO in HEVC Draft International Standard (DIS) , one of the two IL-SAO types, inter-layer band offset (IL-BO) and inter-layer edge offset (IL-EO), or IL-SAO off is selected for each region. IL-BO uses the sample intensity of each up-sampled BL sample to classify the up-sampled BL sample into one of 32 bands. Offsets of four consecutive bands and the starting band position are signaled. IL-EO uses the relations between each up-sampled BL sample and its two neighboring samples to classify the up-sampled BL sample into one of five categories. There are four EO classes choosing different 1-D patterns of neighboring samples. Offsets of four fixed categories among the five categories and one EO class are signaled. Unlike the SAO in HEVC where each region is a fixed coding tree block (CTB) of a color component, IL-SAO can adaptively split one picture of a color component into four regions or treat the entire picture of a color component as one region. IL-SAO parameters are coded in slice header. The picture-level on/off decision of IL-SAO is done before encoding any coding tree unit (CTU) of the EL picture, so the encoding flow of the EL picture is single-pass.

Figure 1. Scalable Video Coding diagram with inter-layer SAO.

# Simulation results and discussion

The proposed methods are implemented on top of the SMuC0.1.1 software [3]. The test conditions defined in the TE4 [4] are used.

Simulation results of full length test are shown in Table 1. In summary, BD rate reductions of full length test are -0.1%, -0.1%, -0.2%, -0.1%, -0.3%, -0.3%, -0.2%, and -0.5% for AI-2x, AI-1.5x, RA-2x, RA-1.5x, RA-SNR, LD-2x, LD-1.5x and LD-SNR, respectively, and the corresponding “EL-only” BD-rate reductions are -0.3%, -0.2%, -0.5%, -0.2%, -0.7%, -0.6%, -0.5%, and -1.0%.

Table 1. BD rate comparison results of the proposed IL-SAO

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | -0.4% | -1.1% | -1.1% |  |  |  |  |  |  |
| Class B | -0.1% | -0.3% | -0.3% | -0.1% | -0.2% | -0.2% |  |  |  |
| **Overall (EL+BL)** | -0.1% | -0.5% | -0.5% | -0.1% | -0.2% | -0.2% |  |  |  |
| **Overall (EL)** | -0.3% | -1.1% | -1.2% | -0.2% | -0.4% | -0.5% |  |  |  |
| Enc Time[%] | 100.0% | | | 100.2% | | |  |  |  |
| Dec Time[%] | 103.1% | | | 102.1% | | |  |  |  |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.4% | -0.6% | -1.0% |  |  |  | -0.6% | -1.0% | -1.4% |
| Class B | -0.1% | -0.2% | -0.2% | -0.1% | -0.2% | -0.2% | -0.2% | -0.3% | -0.2% |
| **Overall (EL+BL)** | -0.2% | -0.3% | -0.4% | -0.1% | -0.2% | -0.2% | -0.3% | -0.5% | -0.5% |
| **Overall (EL)** | -0.5% | -0.6% | -0.9% | -0.2% | -0.5% | -0.4% | -0.7% | -1.3% | -1.4% |
| Enc Time[%] | 100.2% | | | 99.9% | | | 100.1% | | |
| Dec Time[%] | 103.8% | | | 101.3% | | | 103.6% | | |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | | #DIV/0! | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.4% | -0.8% | -1.1% |  |  |  | -0.7% | -1.2% | -1.6% |
| Class B | -0.2% | -0.6% | -0.5% | -0.2% | -0.6% | -0.6% | -0.5% | -1.0% | -0.9% |
| **Overall (EL+BL)** | -0.3% | -0.7% | -0.7% | -0.2% | -0.6% | -0.6% | -0.5% | -1.1% | -1.1% |
| **Overall (EL)** | -0.6% | -1.3% | -1.3% | -0.5% | -1.4% | -1.1% | -1.0% | -2.4% | -2.4% |
| Enc Time[%] | 100.4% | | | 99.7% | | | 100.1% | | |
| Dec Time[%] | 104.8% | | | 102.8% | | | 106.1% | | |
| Enc Mem[%] | #DIV/0! | | | #DIV/0! | | | #DIV/0! | | |
| BL Match | Matched | | | Matched | | | Matched | | |

# Conclusions

This contribution reports the IL-SAO results on SMuC0.1.1. IL-SAO adaptively split one picture of a color component into four regions or treat the entire picture of a color component as one region. The results show BD rate reductions with -0.1%, -0.1%, -0.2%, -0.1%, -0.3%, -0.3%, -0.2%, and -0.5% for AI-2x, AI-1.5x, RA-2x, RA-1.5x, RA-SNR, LD-2x, LD-1.5x and LD-SNR, respectively. The corresponding “EL-only” BD-rate reductions are -0.3%, -0.2%, -0.5%, -0.2%, -0.7%, -0.6%, -0.5%, and -1.0%.

# Patent rights declaration(s)

**MediaTek Inc. may have IPR relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

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