AHG7: Residual Quad-tree for HEVC Lossless Coding

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Contents

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Introduction

Residual quad-tree in lossless coding

- HEVC lossless coding is enabled by bypassing transform, quantization and in-loop filters.
- Since transform and quantization are bypassed, residual quad-tree has no functionality as to provide various sizes of transform.
  - It still provides how to code Cbf according to chosen residual quad-tree structure
- Especially for intra prediction, leaf node size affects which reference samples are used to generate the predicted samples.
  - Smaller leaf nodes enable to use closer reference sample
  - Larger leaf nodes use far reference sample
    ➔ In lossless coding, smaller leaf nodes are always beneficial in intra!

CU   RQT splits

# RQT in Lossless Coding (1/2)
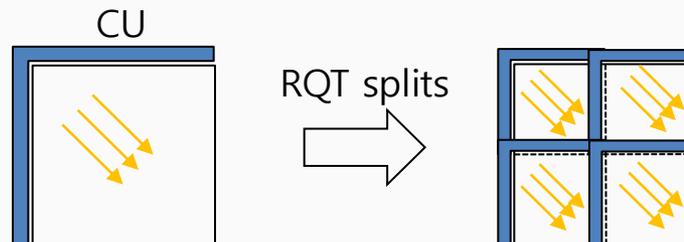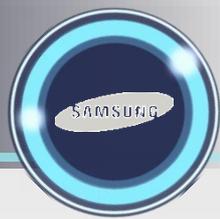
Proposed encoder-only changes

- To reach up to 4x4 leaf nodes in any CU size, RQT depth of intra prediction is changed from 3 to 5.
  - Motivation: It is always beneficial to use the smallest size of leaf nodes in lossless intra prediction.
  - The encoder of S/W is modified to use 4x4 leaf nodes always in case of lossless intra prediction.
- RQT depth of inter prediction is reduced from 3 to 1.
  - Motivation: It is meaningless to try various transform sizes in inter, since the transform is bypassed in lossless coding.

RQT in Lossless Coding (2/2)
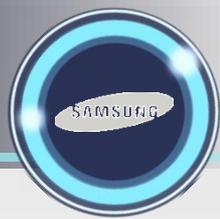
Test configuration and results

- The proposed method is implemented on top of HEVC range extension S/W recommended by AHG7.
- The common test condition of HEVC range extension specified in JCTVC-K1006 is used, while the following modified options.
  - QuadtreeTUMaxDepthInter = 1, QuadtreeTUMaxDepthIntra = 5, TransquantBypassEnableFlag = 1, CUTransquantBypassFlagForce = 1
- By this encoder-only changes, bit rate can be reduced by 2.9% in AI and encoder complexity can be reduced by 25% in RA and LDB.

|	AI	RA	LDB
RGB 4:4:4	-4.0%	-0.6%	-0.2%
YCbCr 4:4:4	-2.9%	-0.4%	-0.2%
YCbCr 4:2:2	-1.8%	-0.3%	-0.2%
Overall	**-2.9%**	**-0.4%**	**-0.2%**
Enc Time[%]	141%	74%	77%
Dec Time[%]	109%	103%	103%

Redundant Symbols in Lossless Coding
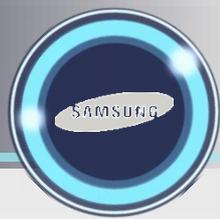
Motivation

- RQT split flags are not necessary if the proposed RQT structure is always used for CUs coded as lossless.
- Delta QP values are not necessary since quantization is bypassed.

Proposed changes

- RQT split flags
  - If it is assumed to use always the highest RQT depth for intra and the lowest RQT depth for inter prediction in CUs coded as lossless.
  - RQT structure is known and therefore RQT split flags (i.e. split_transform_flag) can be inferred.
  - It is proposed to fix RQT structure and skip RQT split flag coding.
- Delta QP values
  - Delta QP values are not necessary when quantization is bypassed.
  - It is proposed to skip Delta QP coding for CUs which have the same size with the quantization group and being signaled as transform quantization bypassed.

Conclusion
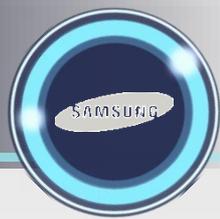
Encoder modification test configuration

- By setting the maximum RQT depth for intra prediction and the minimum RQT depth for inter prediction, and modification to use minimum TU sizes in intra prediction always in lossless coding
  - ➔ Coding gain in intra and complexity reduction in inter
- This proposed encoder modification helps to understand how much coding gain the current specification can achieve by encoder-only changes.

Redundant symbols in lossless coding

- It is proposed to bypass RQT split flags for lossless coding assuming that the above proposed test configuration is always enabled.
- It is also proposed to bypass delta QP for lossless coding if quantization group size matches with the CU size.
- Although coding gain by skipping such symbols is not noticeable due to dominant coefficients bits overhead, it can remove redundant syntax elements in lossless coding.