H.264/AVC Fine Grain Scalability Using Bitplane Coding

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Introduction

❒ **Main goal:**

⇒ **To propose a new scalable video coding scheme based on the MPEG-4 FGS bitplane coding tool, and some of the tools specified in the recent H.264/AVC standard.**

❒ **AVC-FGS characteristics:**

⇒ The base layer is H.264/AVC compliant (baseline profile).

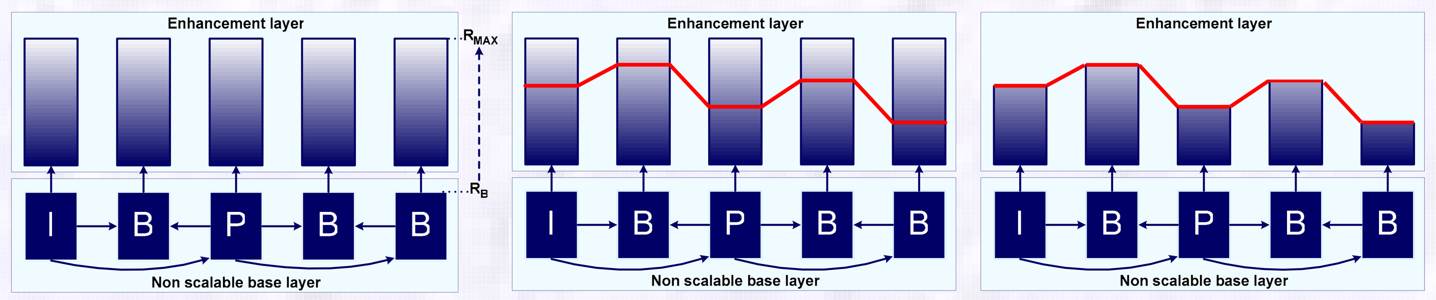
⇒ In the enhancement layer, the tools of the H.264/AVC base layer are reused as much as possible to take maximum advantage of them.

⇒ The transform and the entropic coding tools are the most important ones in the context of FGS-like bitplane coding.

❒ **Expected improvements:**

⇒ Avoids the burden of having duplicate tools for the same functionality, e.g. H.264/AVC 4×4 pixels Integer DCT transform and the 8×8 pixels DCT as defined in older standards.

⇒ Takes advantage of the new tools present in the H.264/AVC standard, e.g. increased efficiency, no transform mismatch error, low complexity, etc.



Test Conditions

❒ **Two base layer codecs:**

⇒ H.264/AVC Joint Model 5.0 and the MPEG-4 Reference Software (part 5).

❒ **Two enhancement layer codecs:**

⇒ Fully compliant with MPEG-4 FGS and the proposed AVC-FGS scheme.

❒ **To evaluate the performance the Bjontegaard measures were used:**

⇒ **dPSNR**: average PSNR difference in dB over the range of bitrates defined for each scenario

⇒ **dRate**: average bitrate difference in % over the whole range of PSNR.

❒ **Experimental test conditions:**

⇒ Wide range of bitrates, spatial and temporal resolutions.

⇒ Large number of sequences with different motion and texture characteristics.

❒ **To evaluate the coding efficiency of the proposed AVC-FGS scheme, two sets of experiments were performed:**

⇒ **Base Layer Test**: Evaluates the coding efficiency gain when the base layer is the H.264/AVC standard is used instead of the Advanced Simple Profile used in the MPEG-4 FGS standard.

⇒ **Enhancement Layer Test**: Evaluates the relative performance of the AVC-FGS enhancement layer in comparison with MPEG-4 FGS always using the H.264/AVC standard (Baseline profile) in the base layer.

AVC-FGS Architecture

❒ **The AVC-FGS architecture is based on the MPEG-4 FGS architecture with two separate layers:**

⇒ The base layer uses a H.264/AVC encoder conformant to the Baseline profile; this solution provides a good quality with a relatively low complexity.

⇒ The enhancement layer provides fine granularity scalability through bitplane encoding.

❒ **Implements in the enhancement layer the H.264/AVC following tools:**

⇒ Integer transform, entropic coding and separate encoding of DC luma coefficients.

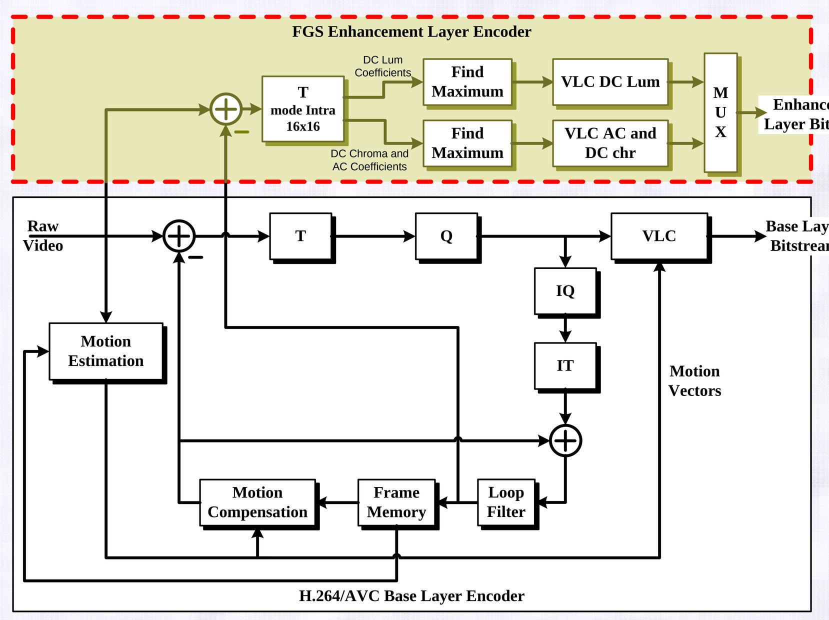
❒ **The enhancement layer is not used as prediction:**

⇒ Offers excellent error recovery capabilities when data losses or errors occur in the enhancement layer.

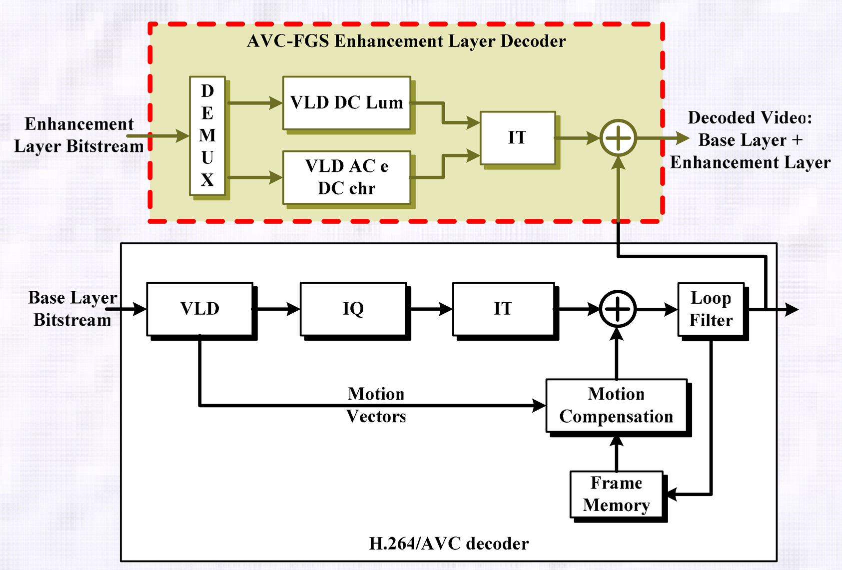
❒ **The enhancement layer bitstream syntax was redefined in order to support the new tools and is significantly different from the MPEG-4 FGS standard.**

❒ **The corresponding decoder is able to reconstruct the video from the base layer and the truncated enhancement layer bitstream.**

AVC-FGS Encoder



AVC-FGS Decoder



Experimental Results

[Rb, Rmax] in kbit/s	Boat		Canoa		Rugby		Stefan		Table Tennis	
	<u>Base Layer Test</u>: **Enhancement Layer:** MPEG-4 FGS; **Base Layer:** H.264/AVC vs. MPEG-4 ASP									
	dPSNR	dRate	dPSNR	dRate	dPSNR	dRate	dPSNR	dRate	dPSNR	dRate
S1: [16, 64]	4.767	99.98	0.681	15.41	0.301	6.75	0.016	1.69	2.445	47.43
S2: [32, 128]	4.017	99.95	0.931	24.75	0.933	21.95	0.691	25.16	2.660	62.54
S3: [64, 256]	6.465	99.83	3.086	54.63	3.027	52.24	3.011	61.07	3.914	77.75
S4: [128, 512]	2.025	71.56	1.829	42.70	1.795	37.73	2.446	56.92	3.083	69.37
S5: [256, 1024]	3.850	99.99	1.113	42.24	1.605	44.54	2.494	71.40	2.341	77.81
S6: [512, 2048]	2.258	75.05	2.212	45.64	2.523	47.60	2.311	51.64	2.047	61.21
Average	**3.897**	**91.06**	**2.649**	**50.135**	**2.775**	**49.92**	**2.566**	**60.26**	**2.748**	**66.02**
	<u>Enhancement Layer Test</u>: **Base layer**: H.264/AVC; **Enhancement Layer**: MPEG-4 FGS vs. AVC-FGS									
S1: [16, 64]	0.099	6.26	0.259	5.58	0.313	6.70	0.327	9.96	0.322	8.49
S2: [32, 128]	0.051	4.89	0.353	9.96	0.247	6.36	0.275	10.29	0.152	6.25
S3: [64, 256]	0.119	7.04	0.324	8.71	0.395	8.40	0.392	10.20	0.162	5.53
S4: [128, 512]	0.123	8.96	0.320	9.61	0.377	9.39	0.319	10.77	0.180	8.52
S5: [256, 1024]	0.038	4.22	0.132	5.03	0.202	6.66	0.148	7.45	0.077	5.68
S6: [512, 2048]	0.075	5.76	0.348	10.51	0.399	11.00	0.276	9.50	0.148	8.47
Average	**0.084**	**6.19**	**0.289**	**8.23**	**0.322**	**8.08**	**0.289**	**9.69**	**0.174**	**7.16**

Transform

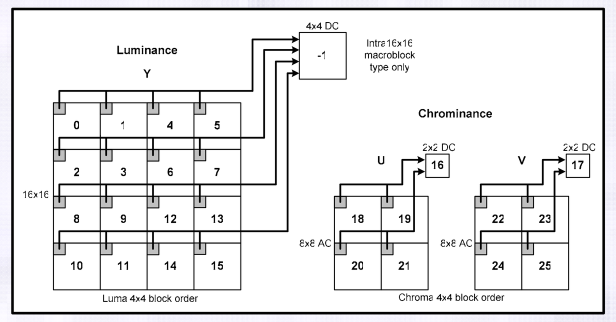
❒ **The enhancement layer encoder uses the same base layer transform for Intra macroblocks (mode Intra16×16).**

⇒ Explores very well the correlation among the DC coefficients of neighboring blocks.

❒ **1st step**: all 16 4×4 luma blocks in a macroblock are first transformed with the Integer DCT transform.

❒ **2nd step**: the DC coefficients of the 4×4 blocks are transformed again using a 4×4 Hadamard transform.

❒ **Chroma blocks:** the only difference is the size of the Hadamard transform (2×2).



Encoding of DC Luma Coefficients

❒ **In the enhancement layer, the DC Luma blocks which belong to a bitplane are grouped and transmitted together to the decoder before the remaining coefficients.**

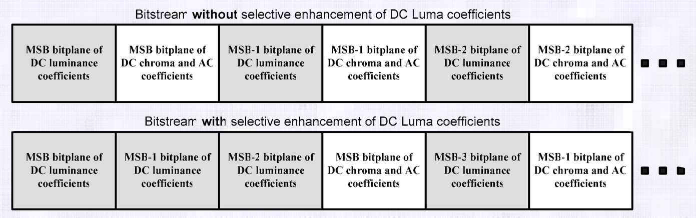
⇒ The entropic coding is tailored to the statistical distributions of the DC Luma coefficients.

❒ **Attributes more precision to the DC luma coefficients:**

⇒ Enhances visual quality and has less artifacts.

⇒ Is only necessary a reorganization of the bitstream.

❒ **The DC coefficients are multiplexed with the remaining coefficients in the same bitstream.**



Entropy Coding

❒ **The UVLC entropy coding scheme was the chosen as the entropy coding scheme (from H.264/AVC) to be used in the enhancement layer.**

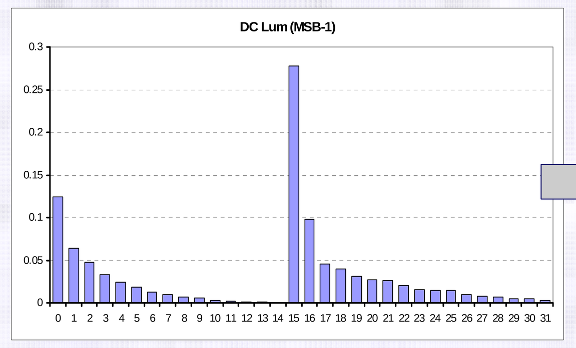
❒ **The UVLC entropy coding works with variable length exp-Golomb codes with symmetric and regular structure.**

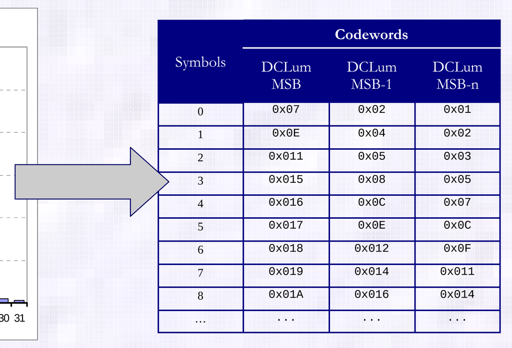
❒ **Main advantages:**

⇒ Reduced complexity and simplicity.

⇒ Single VLC table to map all coefficients at all levels into UVLC codewords.

⇒ Lower number of codewords when compared to MPEG-4 FGS.





Conclusions

❒ **The experimental results show:**

⇒ The use of the H.264/AVC in the base layer improves the coding efficiency up to 3.9 dB in average PSNR over the MPEG-4 FGS scheme (MPEG-4 ASP in the base layer).

⇒ Slight decrease in coding efficiency of AVC-FGS in relation to the MPEG-4 FGS with an H.264/AVC base layer.

⇒ **Main reason**: A single code is used to capture the statistics of all syntax elements for all bitplanes.

❒ **Main advantages of the AVC-FGS scheme**:

⇒ Reuse in the enhancement layer of the tools already present in the H.264/AVC base layer.

⇒ Retains MPEG-4 FGS characteristics, e.g. adaptation to dynamic changes in network conditions.

⇒ Low complexity solution in the enhancement layer by the use of DCT Integer transform and the UVLC encoding scheme (single VLC table).

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