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Title: **Performance comparison: H.26L intra coding vs. JPEG2000**

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Author(s) or Contact(s): Till Halbach
Tel: +47 - 73 59 44 88
Fax: +47 - 73 59 26 40
Email: halbach@tele.ntnu.no

Source: Norwegian University of Science and Technology (NTNU)
(Department of Telecommunications)
Trondheim, Norway

Abstract
This contribution reports the performance comparison of H.26L's JM-2.0 in intra-frame mode to the well known JPEG2000 still image compression standard for error-free transmission. The results show that H.26L partly outperforms its competitor at very low bit rates and for small picture sizes.

Intellectual Property Rights
The author is not aware of any IPRs that are connected to the proposed techniques. For more information, see the JVT Patent Disclosure Form attached to this document.

Introduction
There are a number of performance comparisons to evaluate the coding performance of H.26L in terms of PSNR and a subjective evaluation, see e.g. [VCEG-N18]. All comparisons, however, are undertaken with regard to the overall performance of H.26L, i.e. considering both I-, P- and B-frames. In contrast to that, here it is investigated if H.26L can be treated as a serious alternative to still-image compression standards if operated in intra-frame mode, i.e. without exploiting temporal video sequence correlation.

Performance evaluation: H.26L – JPEG2000
Testing is carried out under the following conditions. H.26L's JM-2.0 Main Profile without ABT[1] has to compete with VM-9.0[2] of JPEG2000. Since H.26L lacks a rate distortion control, the QPs of JM have been chosen beforehand, and then VM-9.0 is adjusted to the achieved rate of JM-2.0 in several iterations with a tolerance of 0.001 bpp. The following Table shows the results in terms of luminance PSNR [dB] and bit rate [bpp].

[1] The implementation of ABT in the JM is due to July 9, 2002, and was therefore not taken into account under testing which was undertaken prior to that date. JM-2.0 with ABT included would change the results presented here only insignificantly.
[2] This is the Verification Model of the final standard.

Sequence (Size)	Q	QP	Bit rate	PSNR			Difference JM to -	
	JPEG	H.26L		JPEG	JPEG2000	H.26L	JPEG	JPEG2000
Container (QCIF)	93	4	2.711	42.64	48.22	46.75	4.11	-1.47
	76	12	1.446	35.58	40.54	40.19	4.61	-0.35
	25	20	0.674	29.74	33.16	34.41	4.67	1.25
	3	28	0.288	22.03	27.02	28.83	6.80	1.81
News (QCIF)	92	4	2.651	42.61	49.38	47.24	4.63	-2.14
	75	12	1.508	36.11	41.38	40.89	4.78	-0.49
	25	20	0.771	30.19	33.47	34.62	4.43	1.15
	4	28	0.347	23.52	27.31	28.62	5.10	1.31
Tempete (CIF)	95	4	3.707	43.52	50.91	46.68	3.16	-4.23
	84	12	2.123	36.86	41.87	39.69	2.83	-2.18
	43	20	1.031	30.81	33.67	32.95	2.14	-0.72
	9	28	0.407	25.49	27.52	27.01	1.52	-0.51
Mobile (PAL)	95	4	4.310	43.13	50.78	46.38	3.25	-4.40
	85	12	2.518	35.52	41.40	39.30	3.78	-2.10
	52	20	1.306	28.93	33.23	32.57	3.64	-0.66
	13	28	0.555	24.54	26.48	26.37	1.83	-0.11
Total							3.83	-0.87

The achieved bit rate corresponds to the QPs 4, 12, 20, and 28. All values are averaged over 20 pictures of equispaced frame indices from the respective sequence. The last column contains the performance differences, i.e. (JM minus VM) PSNR values. Negative values here means that JPEG2000 outperforms H.26L.

H.26L performs very well in intra mode. It is observed that the difference between both standards becomes smaller with decreasing picture size. Moreover, H.26L approaches JPEG2000 in performance as the rate becomes smaller. For small images and at very low rates, the video coding standard even outperforms JPEG2000 which is specialized in coding still images! This may be explained by the various excellent intra-frame prediction modes of H.26L. In the JPEG2000 standard, prediction is not employed. The average gain over all sequences and all bit rates is -0.87 dB, i.e. JPEG2000 outperforms H.26L slightly (by approximately 4%).

Considering the objective results in the last row of the Table, i.e. a very low bit rate, the JPEG2000 images look generally blurred; they contain further ringing artifacts and lack high-frequency information. This is due to the wavelet transform employed. The H.26L images do not show these artifacts, even though high-frequency information was removed under the coding process at low bit rates as well. Blocking can successfully be avoided by the build-in loop filter. At higher rates however, JPEG2000 outperforms H.26L also subjectively. Examples are given in presentation accompanying this paper.

Performance evaluation: H.26L – JPEG

In addition to JPEG2000, this contribution also records the coding efficiency of JPEG, as the mentioned Table shows. The software implementation version 6b of the IJG was used. The PSNR values given must be interpreted with caution since it is not possible to put a rate constraint on the software directly. Instead, the quality parameter of the JPEG algorithm has been adjusted such that the resulting rate is closest possible to the target bit rate.

JPEG consists, like H.26L, of an integer DCT with subsequent coefficient scan, quantization, and entropy encoding, but lacks a prediction mechanism. Mainly because of this difference, it can be seen that H.26L outperforms JPEG significantly for all image size at all rates. The average gain over all sequences and all bit rates is 3.83 dB, i.e. H.26L performs superior to JPEG (by more than 12%).

A useful side result is the PSNR gain of JPEG2000 over the old JPEG standard; it is on the average 4.7 dB, spanning a range from approximately 2 dB to over 7 dB. This is an improvement of roughly 14%.

Conclusions

In addition to the exploitation of temporal redundancies in video sequences by H.26L, as quantified by other tests, also its intra-frame coding abilities, which reduce the picture's spatial redundancies, perform very well. Compared to the JPEG standard, H.26L operates significantly better, both objectively and subjectively. Considering JPEG2000, H.26L is outperformed for large picture sizes and at moderate to high bit rates. For small image dimensions and at very low rates, however, H.26L's intra mode achieves PSNR results superior to JPEG2000.

Abbreviations

ABT	Adaptive Block Transform
B	Bi-directionally predicted
I	Intra (-frame predicted)
IJG	Independent JPEG group
IPR	Intellectual Property Right
JM	Joint Model
JPEG	Joint Photographic Experts Group
P	Predicted (forwardly)
PSNR	Peak-signal-to-noise ratio
QP	Quantization parameter
VM	Verification Model

References

[VCEG-N18] Pankaj Topiwala, Gary Sullivan, Anthony Joch and Faouzi Kossentini. Performance Evaluation of H.26L, TML 8 vs. H.263++ and MPEG-4. Santa Barbara (CA; USA), September 2001

(Append for Proposal Documents)

JVT Patent Disclosure Form

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Joint Video Coding Experts Group - *Patent Disclosure Form*

(Typically one per contribution and one per Standard | Recommendation)

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JVT Rapporteur Gary Sullivan, Microsoft Corp., One Microsoft Way, Bldg. 9, Redmond WA 98052-6399, USA
Email (preferred): Gary.Sullivan@itu.int Fax: +1 425 706 7329 (+1 425 70MSFAX)

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Organization name	Norwegian University of Science and Technology (NTNU)
Mailing address	Department of Telecommunications O.S. Bragstads veg 2b 7491 Trondheim
Country	Norway
Contact person	Till Halbach
Telephone	+47 - 73 59 44 88
Fax	+47 - 73 59 26 40
Email	halbach@tele.ntnu.no

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Relevant Recommendation | Standard and, if applicable, Contribution:

Name (ex: "JVT")	H.26L/H.264
Title	Joint Committee Draft (C167)
Contribution number	D039

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