CCITT SGXV
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TITLE: A comparison between VQ and DCT in RM5 based coding system

1. Introduction

In order to choose a quantization scheme for the recommendation, a comparison between VQ and DCT has been carried out in the RM5 based coding system. The results show the performance of VQ is comparable to DCT.

2. Vector quantization scheme

The part between DCT and IDCT in RM5 is replaced by an adaptive Gain/Shape VQ. The main features of the VQ are shown in Table 1.

Table 1. Main feature of the VQ

Item	Specification
VQ scheme	Adaptive Gain/Shape VQ
VQ block size	4 x 4
Code book	Minimum 3bits, Maximum 12 bits
Searching scheme	8 branch tree search by calculating inner product
Adaptation	The number of VQ index bits changes adaptively accordong to the quantization error variance
Quantization schcme for average and variance	Uniform quantization with deadzone
Entropy coding for VQ	3-dimensinal coding of an average, a variance (gain) and an information indicating the number of VQ index bits for a VQ block

3. Simulation

The simulation results are shown in Tables 2-6. First, RM5VQ was implemented by only replacing the DCT-IDCT part of RM5. Then, the simulation have carried out changing the loop filter. In case of DCT, the loop filter described in doc #356 is used (DCTFIL). For VQ, the loop filter in the section 2.2 of Doc #356 is utilized (VQFIL).
We could not find a significant difference between VQFIL and DCTFIL. Generally speaking, VQ is slightly better when busy images or images including higher spatial frequen-

cies are input. On the other hand, DCT is better when input images do not have higher spatial frequencies.

4 Consideration and Conclusion

A comparison between DCT and VQ has been presented. According to the simulation results, the performances of both schemes are comparable for the present.

The major difference between DCT and VQ schemes in this document is in the quantization scheme itself and the block size of the quantization. We should clarify which factor is more concerned in the coding characteristics difference; quantization scheme itself or the quantization block size. This study will lead us to derive an improved scheme, which is superior in performance to current DCT and VQ schems.

END.

Table 2.

Evaluation table for RM5
Statistics RM5
Sequence : CLAIRE
Modification : VQ and loop filter

INSTITUTE : NTT
Date : Sep. 1
bit rate : 59400 (bits)
frame rate : 10.0 (Hz)

Item			RM5	RM5VQ	DCTFIL	VQFIL		
Frame number			ave	ave	ave	ave		
1) R.M.S. for Luminance			3.4	3.7	3.2	3.4		
2) SNR for Luminance			37.60	36.87	38.13	37.62		
3) Mean value of the step size			23.43	6.21	21.77	5.59		
4) Mean value of the number of non-zero coefficients			2.76	7.04	2.83	6.33		
5) Mean value of the number of zeroes before the last non-zero coefficient			8.16	0.00	7.91	0.00		
6) Block type of MACRO	Fixed		287	292	285	293		
	Fixed MC		8	11	8	11		
	Coded		55	43	57	46		
	Coded MC		47	49	46	47		
7) Block type of Luminance	Fixed		1273	1265	1275	1273		
	Fixed MC		94	120	95	110		
	Coded		93	77	93	82		
	Coded MC		124	121	121	119		
8) Block type of Chrominance	Fixed		758	763	759	761		
	Coded		34	29	33	31		
9) Number of bits	MACRO block Attributes		511	495	517	489		
	EOB		1220	1464	1229	1475		
	Motion Vectors		436	483	432	458		
	Coefficients	Y	3513	3276	3491	3240		
		U (Cb)	165	137	172	147		
		V (Cr)	69	55	72	65		
		Total	3747	3468	3735	3451		
	Total		5913	5909	5912	5873		

RM5: Original RM5
RM5VQ: Adaptive Gain/Shape VQ is used insted of DCT and scaler quantization.
DCTFIL: RM5 + improved loop filter
VQFIL: RM5VQ + improved loop filter

In case of VQ:

3) Means value of the step size for block average quantization
4) Means value of the step size for block variance quantization
9) EOB: bits for indicating which 4x4 block(s) is significant in a 8x8 block
Coeff: VQ index, bits for coding average and variance

Table 3.

Evaluation table for RM5
Statistics RM5
Sequence : MSAM
Modification : VQ and loop filter

INSTITUTE : NTT
Date : Sep. 1
bit rate : 59400 (bits)
frame rate : 10.0 (Hz)

Item			RM5	RM5VQ	DCTFIL	VQFIL		
Frame number			ave	ave	ave	ave		
1) R.M.S. for Luminance			3.4	3.5	3.3	3.4		
2) SNR for Luminance			37.59	37.33	37.86	37.63		
3) Mean value of the step size			24.10	6.13	22.82	5.77		
4) Mean value of the number of non-zero coefficients			1.94	6.95	1.95	6.52		
5) Mean value of the number of zeroes before the last non-zero coefficient			5.11	0.00	5.16	0.00		
6) Block type of MACRO	Fixed		229	238	231	240		
	Fixed MC		27	30	26	29		
	Coded		68	59	68	57		
	Coded MC		72	69	71	70		
7) Block type of Luminance	Fixed		1129	1132	1133	1133		
	Fixed MC		271	279	265	276		
	Coded		60	53	62	54		
	Coded MC		124	119	123	121		
8) Block type of Chrominance	Fixed		701	717	703	717		
	Coded		91	75	89	75		
9) Number of bits	MACRO block Attributes		646	627	641	620		
	EOB		1676	1819	1666	1812		
	Motion Vectors		790	797	777	795		
	Coefficients	Y	2130	2052	2184	2116		
		U (Cb)	281	206	288	200		
		V (Cr)	326	332	288	283		
		Total	2738	2590	2760	2600		
	Total		5849	5833	5845	5826		

RM5: Original RM5
RM5VQ: Adaptive Gain/Shape VQ is used insted of DCT and scaler quantization.
DCTFIL: RM5 + improved loop filter
VQFIL: RM5VQ + improved loop filter

In case of VQ:

3) Means value of the step size for block average quantization
4) Means value of the step size for block variance quantization
9) EOB: bits for indicating which 4x4 block(s) is significant in a 8x8 block
Coeff: VQ index, bits for coding average and variance

Table 4.

Evaluation table for RM5
Statistics RM5
Sequence : SALESMAN
Modification : VQ and loop filter

INSTITUTE : NTT
Date : Sep. 1
bit rate : 59400 (bits)
frame rate : 10.0 (Hz)

Item			RM5	RM5VQ	DCTFIL	VQFIL		
Frame number			ave	ave	ave	ave		
1) R.M.S. for Luminance			8.3	8.1	7.7	7.6		
2) SNR for Luminance			29.72	29.96	30.37	30.50		
3) Mean value of the step size			35.48	8.34	33.50	8.16		
4) Mean value of the number of non-zero coefficients			2.16	9.58	2.24	9.35		
5) Mean value of the number of zeroes before the last non-zero coefficient			10.84	0.00	10.47	0.00		
6) Block type of MACRO	Fixed		259	261	257	255		
	Fixed MC		8	8	9	9		
	Coded		94	94	96	98		
	Coded MC		35	34	34	34		
7) Block type of Luminance	Fixed		1258	1259	1256	1253		
	Fixed MC		86	81	89	86		
	Coded		154	160	157	162		
	Coded MC		86	84	82	83		
8) Block type of Chrominance	Fixed		784	782	784	785		
	Coded		8	10	8	7		
9) Number of bits	MACRO block Attributes		601	594	608	611		
	EOB		1544	1716	1562	1740		
	Motion Vectors		344	330	341	337		
	Coefficients	Y	3385	3204	3369	3203		
		U (Cb)	25	41	21	17		
		V (Cr)	16	33	14	11		
		Total	3427	3279	3405	3230		
	Total		5916	5919	5916	5918		

RM5: Original RM5
RM5VQ: Adaptive Gain/Shape VQ is used insted of DCT and scaler quantization.
DCTFIL: RM5 + improved loop filter
VQFIL: RM5VQ + improved loop filter

In case of VQ:

3) Means value of the step size for block average quantization
4) Means value of the step size for block variance quantization
9) EOB: bits for indicating which 4x4 block(s) is significant in a 8x8 block
Coeff: VQ index, bits for coding average and variance

Table 5.

Evaluation table for RM5
Statistics RM5
Sequence : SWING
Modification : VQ and loop filter

INSTITUTE : NTT
Date : Sep. 1
bit rate : 59400 (bits)
frame rate : 10.0 (Hz)

Item			RM5	RM5VQ	DCTFIL	VQFIL		
Frame number			ave	ave	ave	ave		
1) R.M.S. for Luminance			9.1	8.6	8.7	9.2		
2) SNR for Luminance			28.99	29.48	29.30	28.89		
3) Mean value of the step size			29.70	6.57	30.88	7.78		
4) Mean value of the number of non-zero coefficients			1.96	7.64	2.08	9.02		
5) Mean value of the number of zeroes before the last non-zero coefficient			19.68	0.00	19.10	0.00		
6) Block type of MACRO	Fixed		275	254	271	264		
	Fixed MC		2	2	3	3		
	Coded		111	132	115	122		
	Coded MC		8	8	7	7		
7) Block type of Luminance	Fixed		1378	1350	1378	1366		
	Fixed MC		20	21	24	25		
	Coded		167	194	166	178		
	Coded MC		19	20	16	15		
8) Block type of Chrominance	Fixed		753	745	755	761		
	Coded		39	47	37	31		
9) Number of bits	MACRO block Attributes		581	648	611	632		
	EOB		1422	1723	1463	1577		
	Motion Vectors		79	80	81	80		
	Coefficients	Y	3290	2894	3247	3240		
		U (Cb)	356	355	342	252		
		V (Cr)	177	195	160	119		
		Total	3823	3444	3750	3611		
	Total		5906	5896	5905	5900		

RM5: Original RM5
RM5VQ: Adaptive Gain/Shape VQ is used insted of DCT and scaler quantization.
DCTFIL: RM5 + improved loop filter
VQFIL: RM5VQ + improved loop filter

In case of VQ:

3) Means value of the step size for block average quantization
4) Means value of the step size for block variance quantization
9) EOB: bits for indicating which 4x4 block(s) is significant in a 8x8 block
Coeff: VQ index, bits for coding average and variance

Table 6.

Evaluation table for RM5
Statistics RM5
Sequence : BLUE JACKET
Modification : VQ and loop filter

INSTITUTE : NTT
Date : Sep. 1
bit rate : 59400 (bits)
frame rate : 10.0 (Hz)

Item			RM5	RM5VQ	DCTFIL	VQFIL		
Frame number			ave	ave	ave	ave		
1) R.M.S. for Luminance			5.7	5.6	5.4	5.2		
2) SNR for Luminance			32.97	33.13	33.54	33.75		
3) Mean value of the step size			29.03	6.98	27.54	6.68		
4) Mean value of the number of non-zero coefficients			3.05	7.95	2.98	7.60		
5) Mean value of the number of zeroes before the last non-zero coefficient			11.80	0.00	11.35	0.00		
6) Block type of MACRO	Fixed		292	294	287	295		
	Fixed MC		4	4	4	4		
	Coded		78	74	82	73		
	Coded MC		23	24	23	24		
7) Block type of Luminance	Fixed		1343	1332	1344	1333		
	Fixed MC		48	48	50	49		
	Coded		133	141	132	140		
	Coded MC		60	63	58	62		
8) Block type of Chrominance	Fixed		760	771	756	772		
	Coded		32	21	36	20		
9) Number of bits	MACRO block Attributes		488	476	503	471		
	EOB		1207	1433	1263	1417		
	Motion Vectors		215	222	215	221		
	Coefficients	Y	3782	3634	3675	3620		
		U (Cb)	98	47	115	42		
		V (Cr)	127	88	145	88		
		Total	4007	3770	3935	3750		
	Total		5917	5901	5916	5860		

RM5: Original RM5
RM5VQ: Adaptive Gain/Shape VQ is used insted of DCT and scaler quantization.
DCTFIL: RM5 + improved loop filter
VQFIL: RM5VQ + improved loop filter

In case of VQ:

3) Means value of the step size for block average quantization
4) Means value of the step size for block variance quantization
9) EOB: bits for indicating which 4x4 block(s) is significant in a 8x8 block
Coeff: VQ index, bits for coding average and variance