CCITT SGXV
Specialists Group in Coding
for Visual Telephony

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Title: Methods to reduce clipping effects

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1. Introduction

In the Hardware Specification for the Flexible Prototype n x 384 kbit/s (Document 249) the code for the transform coefficients ranges from -101 to +101. Coefficients with absolute values larger than + 101 are clipped. In special situations this leads to a significant loss of picture quality (clipping effects). Especially when the buffer fullness decreases to zero and blocks are coded in intra-frame-mode with stepsize 4 clipping effects are visible. They are mostly seen in blocks which include a great variation of intensity. To overcome this problem it should be ensured that no clipping occures.
We studied several modifications of the VLC and its effects on the coding efficiency to decrease clipping effects.

2. Structure of the present code

The basic structure of the present code includes the following items.

a) Zero is coded with 1 bit. This is essential for effective coding

b) $\pm$ 1 and EOB are coded with 3 bits

c) The range from -5 to 5 (excluding a, b) is coded with $|value|$ +3 bits

d) The range from -101 to +101 (excluding a, b, c) is coded with 8 bit Pre-Fix-Code and 8 bit FLC.

Due to the rule for allowed words of the FLC (Doc. 249, p. 27) only three quarter of the possible words are used. To avoid interaction with the PSC or GBSC only 0000 0000 must be forbidden. Other forbidden words increase the resistancy against false interpretation of PSC or GBSC in case of transmission errors.

3. Range of possible values for AC and DC coefficients

The extremal values of the AC coefficients depend on their frequency. Because we do not want a code depending on the frequency we must focus our considerations on the extremal values of all AC coefficients.

Under the assumption that the input signal for the transformation in intra mode ranges from 0 to 240 and in inter mode from -240 to +240 the extremal values for the coefficients (normalized to quantizer stepsize 4) are

Intra mode:
DC: min. = 0 max. = 480
AC: min. = -240 max. = 240

Inter mode:
DC: min. = -480 max. = 480
AC: min. = -480 max. = 480

4. Different codes for reduction of clipping effects

To overcome the problems which are caused by clipping effects we need one or several codes which cover more coefficient values. There is also the need that the quantizer has the possibility to deliver these values. In case of several codes the coding efficiency can be improved but a code selection rule must be defined. In any case with the given condition for the code (max. 16 bit) the coding efficiency will be decreased.

Code selection can be done by the quantizer stepsize, the inter-intra-mode or the motion vector. Control by the motion vector will not be considered because motion compensation is optional. Control by the quantizer stepsize has the neg. effect that, if the stepsize is decreasing, the coefficient values increase. Thus the VLC part of the selected code covers fewer code words decreasing the coding efficiency. However this strategy is better than coding with one code.
Another strategy is to take advantage of the fact that clipping only seems to be disturbing when background blocks are coded in intra mode where its possible values are reduced. Therefore controlling by the inter-intra-mode will be considered in the following.

To study the influence of the code on the coding efficiency we first built a simulation model which is close to the Hardware Spec. Especially coding of the transform coefficients and block addresses was done in the same manner.
For all simulations we assume a min. quantizer stepsize of 4. We also present the codes without modification for the end of block trick. However the end of block trick was used.

To overcome the clipping effects we employed the following code for the transform coefficients (Table 1).

Code	Length (a)	TCOEFF (a)
1	1	V0
001	3	EOB
010	3	V1
011	3	V-1
00010	5	V2
00011	5	V-2
000010	6	V3
000011	6	V-3
0000010000000111	16	V4
0000010000001000	16	V-4
0000010000001001	16	V5
0000010000001010	16	V-5
⋮		
0000011111111100	16	V+511
0000011111111101	16	V-511
0000011111111110	16	V512
0000011111111111	16	V-512

Table 1 Code 1 without clipping effects

For this code no clipping occurs, but error resistancy may be decreased.
As can be seen from table 3 (case B) the loss in S/N for the test scenes is not that high, but it may increase for complex scenes and high bitrates.
We also employed a code keeping the rule for the allowed words (Table 2).

Code	Length (a)	TCOEFF (a)
1	1	V0
001	3	EOB
010	3	V1
011	3	V-1
00010	5	V2
00011	5	V-2
000010	6	V3
000011	6	V-3
0000010000000001	16	V4
0000010000000010	16	V-4
0000010000000011	16	V5
0000010000000101	16	V-5
⋮		
0000011111111011	16	V386
0000011111111101	16	V-386
0000011111111110	16	V387
0000011111111111	16	V-387

Table 2 Code 2 with reduced clipping effects

For this code clipping can only occur on high coefficient values in inter mode (case C in table 3).

Finally we used code 2 only for the intra mode and maintain the code of Doc. 249 for the inter mode (case D in table 3). Thus clipping effects do not occur in intra mode for this method.

	Scene	Bitrate	Code	S/N
A	Split/Trevor	300 kbit/s	Hardware Spec.	37,2
	Miss A	"		40,2
B	Split/Trevor	300 kbit/s	Code 1 (table 1)	36,9
	Miss A	"		40,1
C	Split/Trevor	300 kbit/s	Code 2 (table 2)	36,9
	Miss A	"		40,1
D	Split/Trevor	300 kbit/s	inter = Hardware Spec.	37,1
	Miss A	"	intra = Code 2	40,2

Table 3 Results of the simulations

5. Conclusion

Our results show that it is possible to eliminate the most visible clipping effects without decreasing the S/N significantly. We prefer method D because it is simple, maintains the error resistancy against false interpretation of PSC or GBSC and does not decrease coding efficiency significantly.