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TITLE: Simulation results from a subband splitting coding scheme compatible with MPEG1/H261.

PURPOSE: Information

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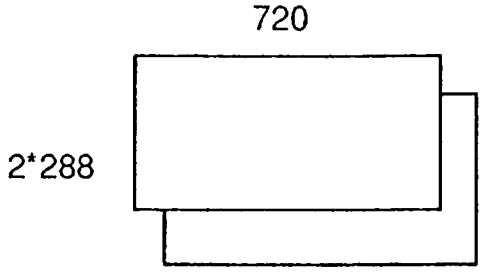
1. Basic principles

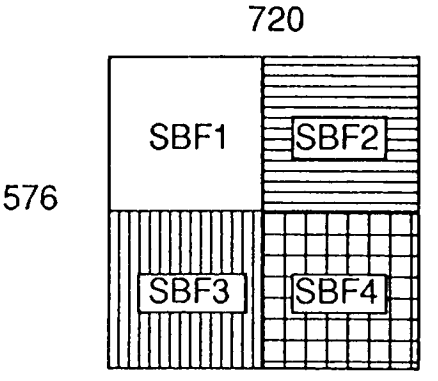
In VADIS #GR1/15 (COST211ter #SIM/91/41) we presented a brief description and block diagrams of a coding scheme for CCIR 601 pictures ensuring compatibility with the MPEG1 and H.261 standards , which inputs are SIF pictures.

The basis of this scheme is a split up of the CCIR 601 sequences (720 pels * 288 lines * 2 fields * 25 Hz) into four subbands sequences of SIF resolution (4 subbands * 360 pels * 288 lines * 25 Hz) (cf VADIS #GR1/5).

These subbands are obtained by using a 2D filter (Hadamard transform matrix) , which is the simplest possible filter. On the other hand it is likely that it is not the best method regarding aliasing aspects, but it allows exact reconstruction.



CCIR 601 4:2:2



4*CIF 4:2:0

SBF1 is the average on a 2*2 pel basis of the CCIR 601 picture. It has the SIF625 resolution(360 pels * 288 lines * 25 Hz) for luminance. After the filter, the number of lines for chrominance is 288, i.e twice SIF resolution. In a first step, we estimated that a 4:2:0 resolution for chrominance , as in SIF , is sufficient.

Hence we perform a subsampling of chrominance. Then we obtain a SIF sequence that can be forwarded to a MPEG1 or a H.261 codec.

If the decoder can only cope with SIF format , SIF frames are coded using the base codec and the enhancement codec.

If we want to transmit CCIR 601 pictures , the input three other subbands are coded in three independant loops.

In VADIS #GR1/15 , we reported some discussion about forward/backward compatibility and its consequences on the transmitted bit rate. Depending on the desired compatibility :

a) the bit rate of the base codec is fixed (e.g 2.54 Mbit/s in case of MPEG1) and a trade-off for the bit rate left between the enhancement coderand the 3 subband coders has to be found.

b) the bit rate can exceed the MPEG1 requirement and the enhancement coder is not used , except may be if we want to code 4:2:2 resolution for chrominance.

2 Brief description

The CCIR 601 picture is split in 4 subbands.

The splitting is made by a Hadamard (2 * 2) transform on CCIR 601 frames.

1) First step is a vertical/temporal separation.
The fields are first transformed in the following way (Had (1 x 2)):

odd field + even field =====> Input Frame (IF)

odd field - even field =====> Input Frame Difference (IFD)

2) Motion compensation is performed on these input frames (which have 720 pels and 288 lines for the luminance).It allows to compute half pel accuracy motion vectors on SIF pictures without performing horizontal interpolation.

3) The Input Frames are Hadamard (2 x 1) transformed in the horizontal direction: the result is two subband frames (SBF1 and SBF2).

SBF1 pictures have the SIF25 resolution for luminance and twice the number of lines for the chrominance.So an extra vertical chrominance subsampling is performed.

4) Input Frames Differences are also Hadamard (2 x 1) transformed to

give two other subband frames (SBF3 and SBF4).

5) SBF1 is encoded by the MPEG1/H261 encoder. This ensures the compatibility.

6) The coding error is coded in a finer way using an enhancement coder. (hybrid DCT/DPCM algorithm without motion compensation)

6) SBF2, SBF3 and SBF4 are encoded independently through the subband coder (hybrid DCT algorithm with motion compensation). The motion vectors used are the same as for the MPEG1/H261 encoder.

7) All the data are video multiplexed

The encoder and decoder schemes are given in fig 1 and fig 2.

3. Implemented algorithm

We implemented this 4 subband algorithm based upon SM3 (cf MPEG/COMIS documentation).

The base coder is SM3.

The enhancement and the subband coders are the SM3 predictive mode coders.

Motion compensation is performed on a 720*288 Input Frame. The algorithm used is a full search pel accuracy on these 720*288 pictures, equivalent to half pel accuracy on the 360*288 corresponding pictures, but no horizontal interpolation is done. The resulting motion vectors are used for the "DC" subband as well as for the "HF" subbands.

SM3 parameters :	bitrate	2.5344 Mbit/s (352*288*25 bits/s)
	Intra interval	N=10
	Predicted interval	M=2
	Picture format	352*288*25 Hz , 4:2:0
	Buffer size	SM3 ==> 264 kbit

The quantizer stepsize in Intra mode is half the QS in predictive mode.

Enhancement and subband coders: unfortunatly, we had no time to implement the bitrate control mechanism. These 4 coders are running in open loop, the stepsize being ajusted to obtain approximatly the aimed bitrate.

The Intra and Predicted pictures correspond to the MPEG1 ones. For bidirectional frames, the 3 HF subbabds are not coded.

4. Simulation results

The simulation have been performed on the following sequences:
- Mobile & calendar, Table Tennis, Flower Garden.

As we haven't recived yet our D1 machine, we could not get the agreed original sequences from the D1 tape distributed in MPEG and the pictures we show are recorded on a U-MATIC.

In tables 1 to 9 we give some results concerning this simulation work.

5. Some preliminary conclusions.

The encoded pictures we get are not so good as those obtained by other COST/VADIS partners with different schemes.
Some reasons for that could be the following ones:

☞ Our SM3 simulation model does not give the expected picture quality (it probably contains some missunderstandings or bugs). A poor quality in the base coder where SM3 is used heavily penalizes the final result (taht is true for many compatible schemes).

☞ The simple splitting used implies a serious aliasing.

☞ Use a 8x8 DCT ont the SIF basic band means that the transformation blocksize is 16x16 on the CCIR 601 pictures which maybe is too large.

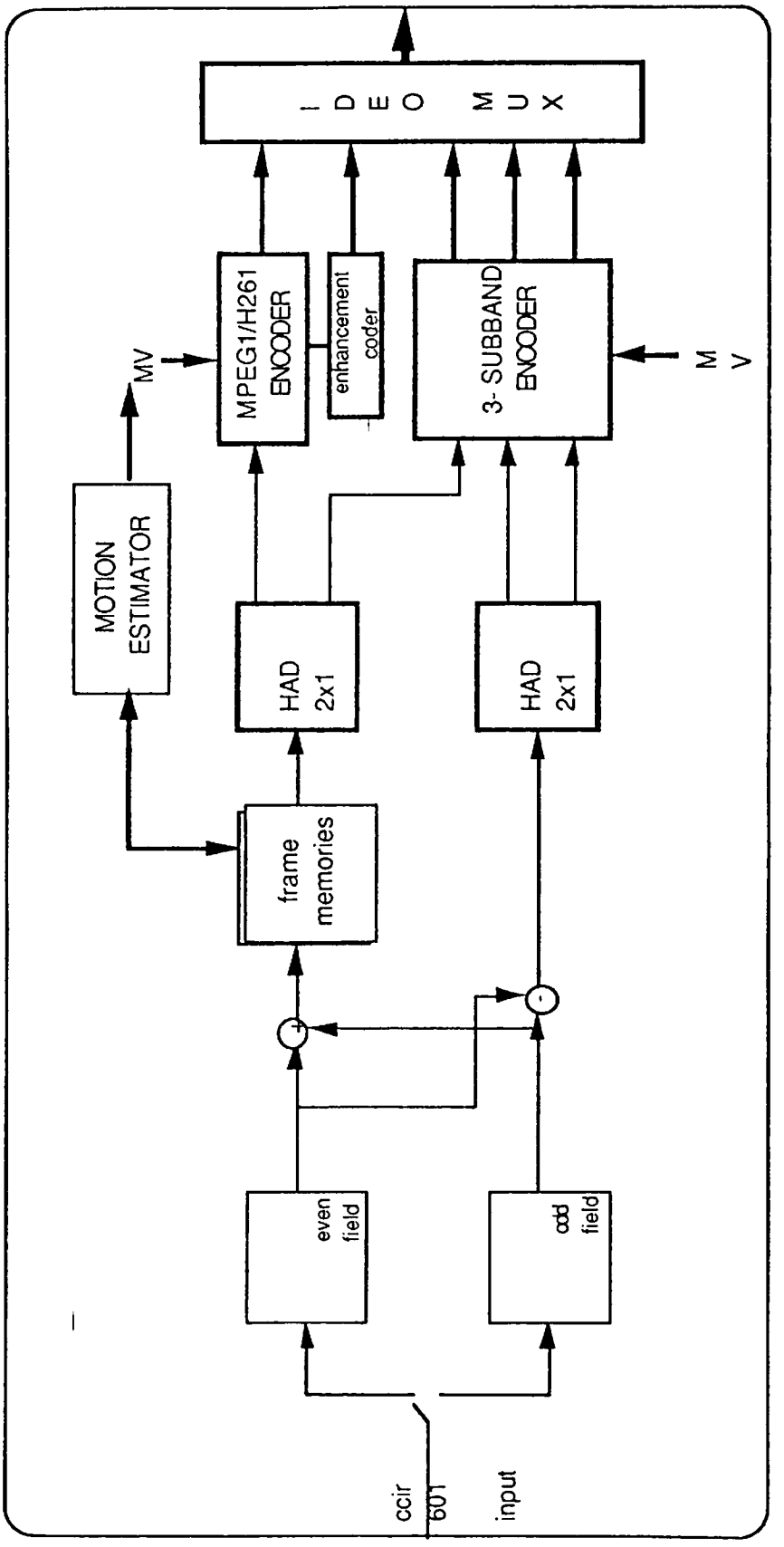
☞ In order to simplify the simulation work, the accuracy of the 2D filter is reduced to 8 bits instead of the 9 bits required. That is equivalent to have a pre-quantization process which is not optimized.

☞ The 3 "HF" subbands are now encoded in the same way as SM3 with the same parameters- due to the fact that the characteristics of these "HF" pictures are highly different from the base band, it is clear that VLCs and the videomultiplex arrangement should be modified. In addition it should be envisaged to use a different way to encode the enhancement bands (blocksize, coding modes, separate motion estimation....).

In conclusion, this simple scheme is probably less efficient that other more complicated schemes. Nevertheless more investigations are needed in order to definitly know the interest of such a method, in particular in terms of tradeoff between loss of efficiency and simplicity.

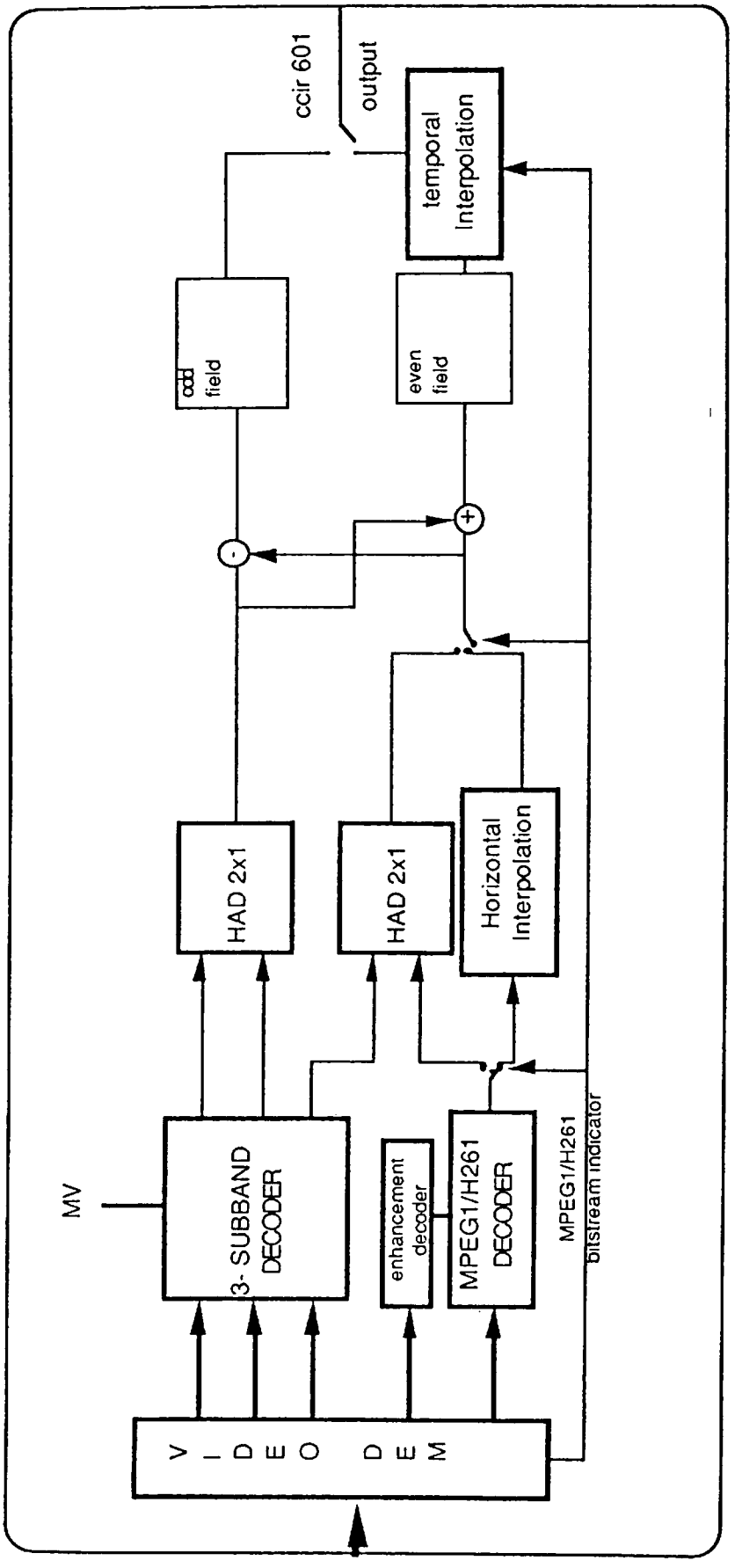
References :

#GR1/5	STA	"Compatibility between CIF and CCIR 601 coders"
#GR1/15	CNET	"Proposal for a MPEG2/H.26x compatible algorithm"



- Encoder scheme -

-Fig 1-



- Decoder scheme -

-Fig 2-

MPEG SM3	All	Intra	Predicted	Bidir.
RMS for Luminance	6.98	5.4	5.74	8.13
RMS for Chrominance	5.51	6.04	5.06	5.74
SNR for Luminance	31.25	33.48	32.95	29.93
SNR for Chrominance	33.31	32.52	34.05	32.95
Mean value of Stepsize	15.58	7.2	11.45	20.77
Overflow	0	0	0	0
Fixed	4	0	4	5
Inter	11	0	27	0
Inter MC	141	0	346	0
Fixed MC	3	0	9	0
Intra	44	396	9	0
Bidir. Mixt Fixed	42	0	0	87
Bidir. Mixt Coded	123	0	0	251
Bidir. Back. Fixed	5	0	0	10
Bidir. Back. Coded	6	0	0	13
Bidir. Forw. Fixed	4	0	0	8
Bidir. Forw. Coded	8	0	0	17
Number of coded MB	335	396	382	284
Number of coded blocks (per MB)	3.76	6	4.4	2.39
No of non-zeroes (per block)	11.37	17.78	12.04	5.31
No of zeroes (per block)	24.72	14.38	27.09	27.39
Stuffing	0	0	0	0
Attributes	972	0	874	1257
Motion Vectors	1103	0	1016	1406
CBP	1573	0	2190	1387
DC differential	1880	17002	324	27
Coefficients Y	84359	261765	111029	25175
Coefficients C	9901	32880	15085	795
EOB	2524	4752	3369	1356
Total per frame	102316	316400	133888	31406
Total per MB	258.37	798.99	338.1	79.31
Total in kbit/s	2557.9	807.143	1366.2	384.563

Table 1: "Mobcal" SM3 on basic band

MPEG2 3 sub-band coding	*Enhanced SBF1*	SBF2/4
RMS for Luminance	6.46	4.45
RMS for Chrominance	5.28	2.73
SNR for Luminance	31.92	35.16
SNR for Chrominance	33.68	39.4
Mean value of Stepsize	13.96	8
Overflow	0	0
Fixed	183	27
Inter	212	65
Inter MC	0	214
Fixed MC	0	2
Intra	0	86
Bidir. Mixt Fixed	0	0
Bidir. Mixt Coded	0	0
Bidir. Back. Fixed	0	0
Bidir. Back. Coded	0	0
Bidir. Forw. Fixed	0	0
Bidir. Forw. Coded	0	0
Number of coded MB	212	365
Number of coded blocks (per MB)	2.49	3.82
No of non-zeroes (per block)	3.16	9.58
No of zeroes (per block)	29.56	28
Stuffing	0	0
Attributes	723	1181
Motion Vectors	0	735
CBP	1170	1357
DC differential	0	1619
Coefficients Y	10709	85280
Coefficients C	2325	2705
EOB	1055	2799
Total per frame	15984	95679
Total per MB	40.36	241.61
Total in kbit/s	399.6	3661.19

Bit rates	
MPEG1	2557.9
Enhancement SBF 1	399.6
SBF 2-3-4	3661.2
TOTAL	6618.7

Table 2:"Mobcal" Other bands - total bitrate : 6.6 MBit/s

MPEG2 3 sub-band coding	Enhanced SBF1	SBF2/4
RMS for Luminance	4.43	6.09
RMS for Chrominance	4.04	2.99
SNR for Luminance	35.21	32.44
SNR for Chrominance	36	38.63
Mean value of Stepsize	8	14.1
Overflow	0	0
Fixed	15	79
Inter	380	47
Inter MC	0	150
Fixed MC	0	24
Intra	0	94
Bidir. Mixt Fixed	0	0
Bidir. Mixt Coded	0	0
Bidir. Back. Fixed	0	0
Bidir. Back. Coded	0	0
Bidir. Forw. Fixed	0	0
Bidir. Forw. Coded	0	0
Number of coded MB	380	291
Number of coded blocks (per MB)	4.7	3.39
No of non-zeroes (per block)	9.64	6.81
No of zeroes (per block)	33.11	24.96
Stuffing	0	0
Attributes	1160	1167
Motion Vectors	0	607
CBP	2345	891
DC differential	0	1768
Coefficients Y	85214	43109
Coefficients C	23858	487
EOB	3580	1978
Total per frame	116159	50010
Total per MB	293.33	126.29
Total in kbit/s	2903.98	1913.65

Bit rates	
MPEG1	2557.9
Enhancement SBF 1	2904.0
SBF 2-3-4	1913.6
TOTAL	7375.5

Table 3:"Mobcal" Other bands - **total bitrate : 7.3 MBit/s**

MPEG SM3	All	Intra	Predicted	Bidir.
RMS for Luminance	3.58	4.27	3.12	3.78
RMS for Chrominance	2.47	2.51	2.29	2.6
SNR for Luminance	37.04	35.52	38.24	36.58
SNR for Chrominance	40.28	40.14	40.92	39.83
Mean value of Stepsize	7.85	3.58	5.71	10.53
Overflow	0	0	0	0
Fixed	10	0	1	20
Inter	34	0	84	0
Inter MC	111	0	272	0
Fixed MC	1	0	4	0
Intra	54	396	32	2
Bidir. Mixt Fixed	47	0	0	97
Bidir. Mixt Coded	100	0	0	205
Bidir. Back. Fixed	2	0	0	4
Bidir. Back. Coded	6	0	0	13
Bidir. Forw. Fixed	8	0	0	16
Bidir. Forw. Coded	16	0	0	34
Number of coded MB	324	396	389	255
Number of coded blocks (per MB)	4.14	6	4.69	2.84
No of non-zeroes (per block)	10.07	15.24	10.31	6.05
No of zeroes (per block)	19.09	15.19	21.31	17.09
Stuffing	485	4761	0	0
Attributes	1035	0	1012	1270
Motion Vectors	2204	0	1817	2987
CBP	1402	0	1906	1275
DC differential	1820	12345	1248	104
Coefficients Y	81821	221736	113572	26213
Coefficients C	10243	23876	15384	3119
EOB	2689	4752	3658	1452
Total per frame	101704	267472	138600	36422
Total per MB	256.83	675.43	350	91.97
Total in kbit/s	2542.6	682.327	1414.29	445.984

Table 4:"Table tennis" SM3 on basic band

MPEG2 3 sub-band coding	Enhanced SBF1	SBF2/4
RMS for Luminance	3.41	3.64
RMS for Chrominance	2.47	1.81
SNR for Luminance	37.46	36.92
SNR for Chrominance	40.29	42.96
Mean value of Stepsize	13.96	8
Overflow	0	0
Fixed	385	94
Inter	10	135
Inter MC	0	121
Fixed MC	0	8
Intra	0	35
Bidir. Mixt Fixed	0	0
Bidir. Mixt Coded	0	0
Bidir. Back. Fixed	0	0
Bidir. Back. Coded	0	0
Bidir. Forw. Fixed	0	0
Bidir. Forw. Coded	0	0
Number of coded MB	10	292
Number of coded blocks (per MB)	1.93	3.09
No of non-zeroes (per block)	1.85	5.01
No of zeroes (per block)	40.31	25.05
Stuffing	0	0
Attributes	41	976
Motion Vectors	0	1026
CBP	51	1216
DC differential	0	692
Coefficients Y	408	32052
Coefficients C	31	1807
EOB	40	1811
Total per frame	573	39582
Total per MB	1.45	99.95
Total in kbit/s	14.325	1514.62

Bit rates	
MPEG1	2542.6
Enhancement SBF 1	14.3
SBF 2-3-4	1514.6
TOTAL	4071.5

Table 5: "Table tennis" Other bands - total bitrate : 4.1 MBit/s

MPEG2 3 sub-band coding	Enhanced SBF1	SBF2/4
RMS for Luminance	2.31	2.81
RMS for Chrominance	1.94	1.53
SNR for Luminance	40.87	39.14
SNR for Chrominance	42.36	44.44
Mean value of Stepsize	4	4.36
Overflow	0	0
Fixed	36	9
Inter	359	198
Inter MC	0	152
Fixed MC	0	0
Intra	0	35
Bidir. Mixt Fixed	0	0
Bidir. Mixt Coded	0	0
Bidir. Back. Fixed	0	0
Bidir. Back. Coded	0	0
Bidir. Forw. Fixed	0	0
Bidir. Forw. Coded	0	0
Number of coded MB	359	386
Number of coded blocks (per MB)	4.68	4.27
No of non-zeroes (per block)	8.1	8.92
No of zeroes (per block)	29.1	28.84
Stuffing	0	0
Attributes	1110	1126
Motion Vectors	0	1144
CBP	2092	1633
DC differential	0	693
Coefficients Y	79378	102385
Coefficients C	16793	7377
EOB	3369	3301
Total per frame	102744	117662
Total per MB	259.45	297.13
Total in kbit/s	2568.6	4502.37

Bit rates	
MPEG1	2542.6
Enhancement SBF 1	2568.6
SBF 2-3-4	4502.4
TOTAL	9613.6

Table 6: "Table tennis" Other bands - **total bitrate : 9.6 MBit/s**

MPEG SM3	All	Intra	Predicted	Bidir.
RMS for Luminance	5.94	4	4.32	7.29
RMS for Chrominance	4.75	5.26	4.27	5.01
SNR for Luminance	32.65	36.09	35.42	30.87
SNR for Chrominance	34.6	33.72	35.53	34.14
Mean value of Stepsize	17.87	4.73	10.1	27.08
Overflow	0	0	0	0
Fixed	89	0	96	102
Inter	14	0	36	0
Inter MC	101	0	249	0
Fixed MC	4	0	11	0
Intra	41	396	2	0
Bidir. Mixt Fixed	60	0	0	123
Bidir. Mixt Coded	49	0	0	100
Bidir. Back. Fixed	9	0	0	18
Bidir. Back. Coded	9	0	0	19
Bidir. Forw. Fixed	8	0	0	18
Bidir. Forw. Coded	7	0	0	14
Number of coded MB	223	396	288	134
Number of coded blocks (per MB)	4.21	6	4.56	2.49
No of non-zeroes (per block)	14.38	17.44	15.72	5.46
No of zeroes (per block)	20.77	10.02	26.4	18.23
Stuffing	3799	37238	0	0
Attributes	831	0	747	1074
Motion Vectors	976	0	911	1233
CBP	908	0	1520	588
DC differential	1412	13417	95	8
Coefficients Y	83686	294086	117804	11422
Coefficients C	9181	30539	14455	337
EOB	1885	4752	2629	668
Total per frame	102682	380033	138164	15333
Total per MB	259.3	959.68	348.9	38.72
Total in kbit/s	2567.05	969.472	1409.84	187.751

Table 7:"Flower garden" SM3 on basic band

MPEG2 3 sub-band coding	Enhanced SBF1	SBF2/4
RMS for Luminance	5.03	4.58
RMS for Chrominance	4.39	3.03
SNR for Luminance	34.1	34.91
SNR for Chrominance	35.29	38.49
Mean value of Stepsize	13.96	11.63
Overflow	0	0
Fixed	246	138
Inter	149	30
Inter MC	0	171
Fixed MC	0	18
Intra	0	37
Bidir. Mixt Fixed	0	0
Bidir. Mixt Coded	0	0
Bidir. Back. Fixed	0	0
Bidir. Back. Coded	0	0
Bidir. Forw. Fixed	0	0
Bidir. Forw. Coded	0	0
Number of coded MB	149	239
Number of coded blocks (per MB)	3.05	3.3
No of non-zeroes (per block)	4.32	6.85
No of zeroes (per block)	27.45	25.76
Stuffing	0	0
Attributes	536	814
Motion Vectors	0	665
CBP	802	932
DC differential	0	689
Coefficients Y	11242	34828
Coefficients C	2707	888
EOB	914	1577
Total per frame	16203	40396
Total per MB	40.92	102.01
Total in kbit/s	405.075	1545.77

Bit rates	
MPEG1	2567.1
Enhancement SBF 1	405.1
SBF 2-3-4	1545.8
TOTAL	4517.9

Table 8: "Flower garden" Other bands - **total bitrate : 4.5 MBit/s**

MPEG2 3 sub-band coding	Enhanced SBF1	SBF2/4
RMS for Luminance	2.8	3.57
RMS for Chrominance	2.63	2.73
SNR for Luminance	39.18	37.08
SNR for Chrominance	39.74	39.41
Mean value of Stepsize	5.96	8
Overflow	0	0
Fixed	84	124
Inter	311	33
Inter MC	0	201
Fixed MC	0	3
Intra	0	32
Bidir. Mixt Fixed	0	0
Bidir. Mixt Coded	0	0
Bidir. Back. Fixed	0	0
Bidir. Back. Coded	0	0
Bidir. Forw. Fixed	0	0
Bidir. Forw. Coded	0	0
Number of coded MB	311	267
Number of coded blocks (per MB)	4.53	3.98
No of non-zeroes (per block)	16.54	9.08
No of zeroes (per block)	30.77	29.91
Stuffing	0	0
Attributes	1012	798
Motion Vectors	0	693
CBP	1760	1153
DC differential	0	612
Coefficients Y	103774	61176
Coefficients C	41257	4093
EOB	2821	2130
Total per frame	150626	70658
Total per MB	380.37	178.43
Total in kbit/s	3765.65	2703.75

Bit rates	
MPEG1	2567.1
Enhancement SBF 1	3765.6
SBF 2-3-4	2703.8
TOTAL	9036.4

Table 9: "Flower garden" Other bands - **total bitrate : 9.0 MBit/s**