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MPEG92/

CCITT SGXV
Working Party XV/1
Experts Group for ATM Video Coding

Document AVC-190

December 26, 1991

SOURCE : JAPAN

TITLE : Considerations on cell loss recovery techniques

PURPOSE : Discussion

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1. Introduction

Cell loss is an inevitable impairment of ATM networks. We have discussed possible techniques for cell loss resilience of source coding algorithm in AVC-120 (MPEG91/321)(JAPAN), identifying the standardization matters and non-standardization ones. This document describes detailed illustrations of cell loss resilience techniques. They are leaky prediction, demand refresh, error concealment, video multiplex structure and packetization.

2. Leaky Prediction

2.1 Block Diagrams

Fig.1 shows two examples of the block daigrams of H.261 based encoder in which leak factor is introduced in the pixel domain. Structure (1) gives leak only to the coded area, while structure (2) gives it to the whole area. The algorithm described in the document MPEG91/073 (PIP) has the structure equivalent to Fig.1(1) and leak factor α is forced to be 1 when MB is skipped(fixed).

The effect of leaky prediction without MC was demonstrated in Annex to the document AVC-84(MPEG91/139)(JAPAN), which introduced the leak factor in the coefficient domain.

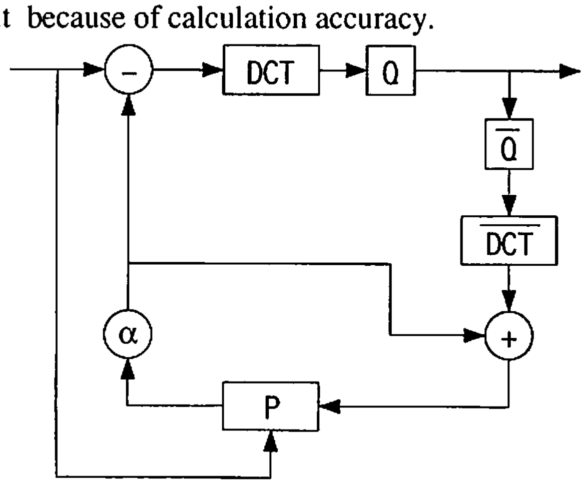
The efficiency loss of MC caused by leaky prediction needs further study.

2.2 Definition of Leak Factor

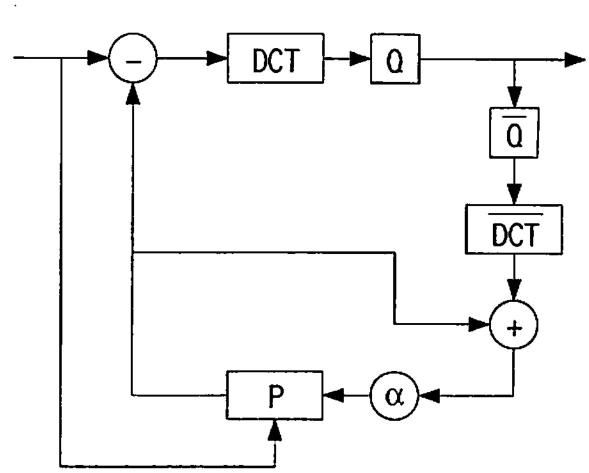
According to the document MPEG91/073(PIP), Leak Factor Code (5 bits, 1to31) is added to picture layer header. Leak factor α is derived from the equation;

$$\alpha = (\text{Leak Factor Code} - 1) / 30.0$$

However, when the input data takes relatively small value compared with α, multiplication of α is supposed to make no difference. The error by cell loss may not also completely fade out because of calculation accuracy.



structure (1)



structure (2)

Fig.1 Block Diagrams.

3. Demand Refresh

The receiver indicates and requests to refresh the damaged area by cell loss to the transmitter as shown in Fig.2. The C&I signal from receiver to transmitter direction including location information (e.g. MBA) should be defined.

Encoder is necessary to have the mechanism to encode in Intra mode according to above C&I signal.

The affect of cell loss may be propagated by motion compensated prediction. Encoder or decoder should detect the dependency of MBs or surrounding region of the lost MBs may be refreshed in consideration of the range of motion compensation.

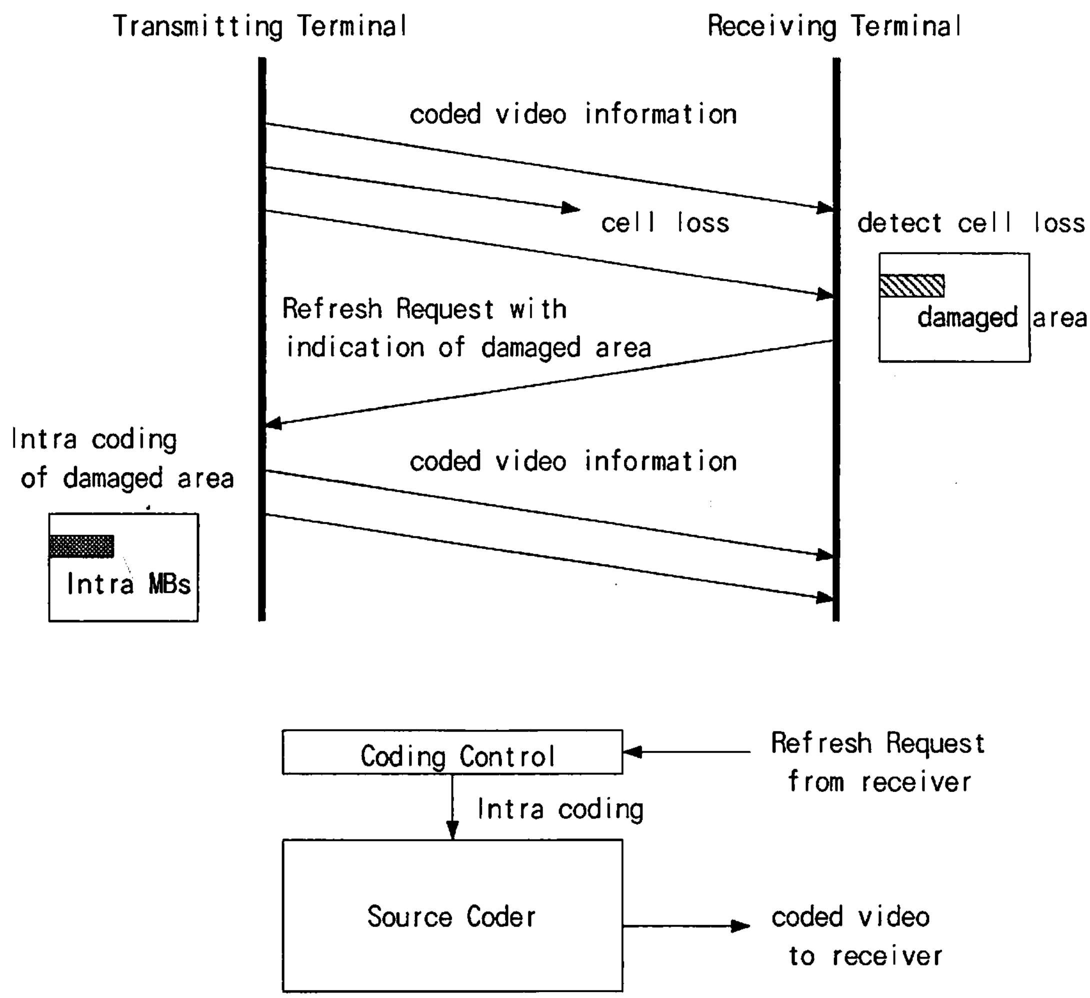


Fig.2 Demand refresh.

4. Error Concealment

Error concealment technique interpolates errored region using previous frame and/or surrounding pixels to reduce the degradation of reconstructed picture quality as shown in Fig.3. Error concealment is basically a decoder option and non-standardization matter. However, that may be more effective accompanied with encoder. Examples are shown below.

(1) Inter frame/field coding

The errored region is replaced using previous decoded picture of the frame memory in decoder. Combination with MC is expected to be more effective, if motion vector of errored MB is protected against cell loss or the motion vector is estimated from surrounding MBs.

(2) Intra coding

It is difficult for intra coding to take picture motion into consideration. Encoder can additionaly transmit motion vector to improve the efficiency of error concealment. The method of motion vector estimation by decoder referring to surrouding region is described in Annex 1.

When cell loss occured in the initial or scene change frame, picture quality degradation by cell loss cannot be sufficiently compensated by error concealment.

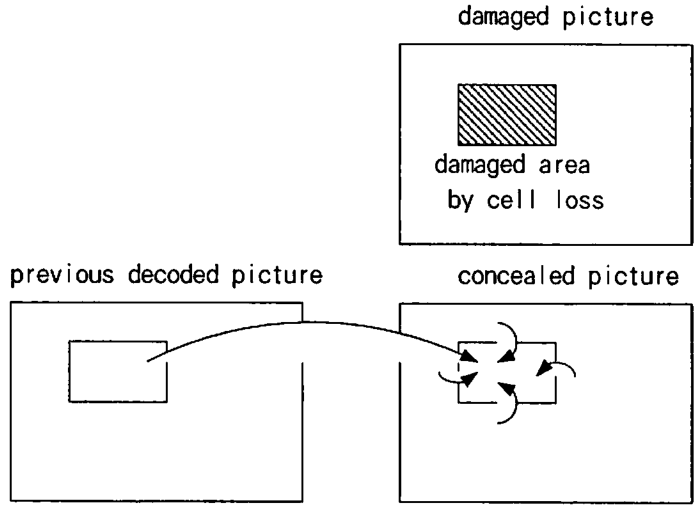


Fig.3 Error Concealment.

5. Video Multiplex Structure

H.261 defines the coding of relative values between MBs such as MBA and MVD. If cell loss occurs and the MB cannot be decoded, the relative values of the consecutive MBs in the GOB(Slice) might not be reconstructed either.

Furthermore AVC-146(MPEG91/206)(NTA) introduces INTRA prediction which uses the pixels of surrounding blocks. Especially the definition of INTRA MB is very important considering its use for cyclic refresh and demand refresh as cell loss recovery.

The propagation of error caused by these structure should be taken into account.

The important informations such as headers, quantization parameters, motion vectors, etc. should be protected, because loss of these informations impacts considerably. High priority cell can be used for this purpose as in AVC-139(MPEG91/311)(DSR,TCE), if CLP is defined. Another method by transmission of more than once was described in AVC-117(MPEG91/324)(UK).

6. Packetization

Fig.4 shows the relations between coded MBs and the video information field of SAR--PDU. In case 2, the loss of previous cell causes synchronization loss of variable length codeword and makes impossiblie to decode the following cells.

If video transmission data unit which is divided into cells consists of smaller number of MBs, the affect of cell loss can be localized. However, transmission efficiency may decrease due to stuffing bits for remainder of cell shown as case 4. The transmission efficiency is discussed in Annex 2.

Case 3 is an example using adaptation header described in the document AVC-139 (MPEG91/311)(DSR,TCE), and the influence caused by the previous cells is relatively small.

7. Conclusions

In this document, we have discussed the possible techniques for cell loss resilient source coding. We have pointed out the necessary matters to be included in the standard and that some items are left for further studies to adopt each technique.

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SAR-PDU (cell)

Header	..... Video Information Field	Trailer

Case 1: Start of MB is synchronized with SAR-PDU.

Header	MB 1	MB 2	. . . . .	MB x1	Trailer

Case 2: Video information field starts from the middle of MB.

Header	MB x2	MB x+1	MB x+2	. . . . .	Trailer

Case 3: Head address of the second MB is added in Case 2.

Header	HA	MB x2	MB x+1	MB x+2	. . . . .	Trailer

HA: Head address of MB x+1

Case 4: Stuffing is used in Case 2.

Header	MB x2	STUFFING etc.	Trailer

Fig.4 MB position inside SAR-PDU.

Note: This figure shows the example of cell multiplex for multimedia multiplex.

The same consideration can be applicable, if video information field is isolated from multiplexed data and the start of that is identified.

In other multiplex methods, cell loss may be more critical, because it will cause the data framing synchronization loss (refer to AVC-129(JAPAN)).

ANNEX 1 to AVC-190

Application of Error Concealment in Intraframe Coding

1. Introduction

Error concealment is a technique wherein deterioration of reproduced image quality is alleviated by interpolating data from the previous frame or surrounding area of the image into parts of an image that have deteriorated due to cell loss. This is basically performed only in the decoder, but good results can be expected if it is carried out in conjunction with the encoder.

We shall describe here an example where error concealment was applied to intraframe coding.

2. Experimental method

(1) Coding system

7 sub-band coding (Figure 1 (a)(b))

LLLL : Intraframe DCT coding

LLLU-UU : Interframe prediction + DCT coding

(2) Cell loss

Regarding the effect of cell loss, it is assumed that the image is recovered in 1 macroblock (16×16 pels). For LLLL, tests are performed by introducing a random cell loss of 1.0 % and applying intraframe coding with error concealment.

(3) Error concealment method

An interpolative frame memory is set up outside the LLLL decoder, and the previous frame is memorized.

Method A : Data is interpolated from the interpolative frame memory into a deteriorated part.

Method B : The decoder is provided with block matching functions. Blocks one size larger than a macroblock (18×18 pels) are cut out from a deteriorated image and the previous frame respectively, matching is performed only on the unaffected area surrounding the deterioration, and the block which gives the minimum error is interpolated into the deteriorated image. (search range : ±15 × ±15, full search)

Method C : The encoder is provided with motion estimating functions. Motion vectors are calculated. These vectors are sent separately to the decoder, and if the corresponding macroblocks are deteriorated due to cell loss, interpolation is performed from the interpolative frame memory using these motion vectors.
(search range : ±15 × ±15, full search)

3. Simulation results

The results given are for experiments carried out on 75 frames taken from the CCIR Rec. 601 test pictures "Table Tennis" and "Flower Garden". Table 1 shows the average coding rate and average SNR; Figure 2(a)(b) show the time variation of SNR. SNR and visual perception quality improved in the order A, B, C (there was very little difference between B and C).

4.Conclusions

We carried out tests concerning the effect of intraframe coding and error concealment. It was shown that an improvement of SNR and visual perception quality can be expected by suitably combining matching vectors.

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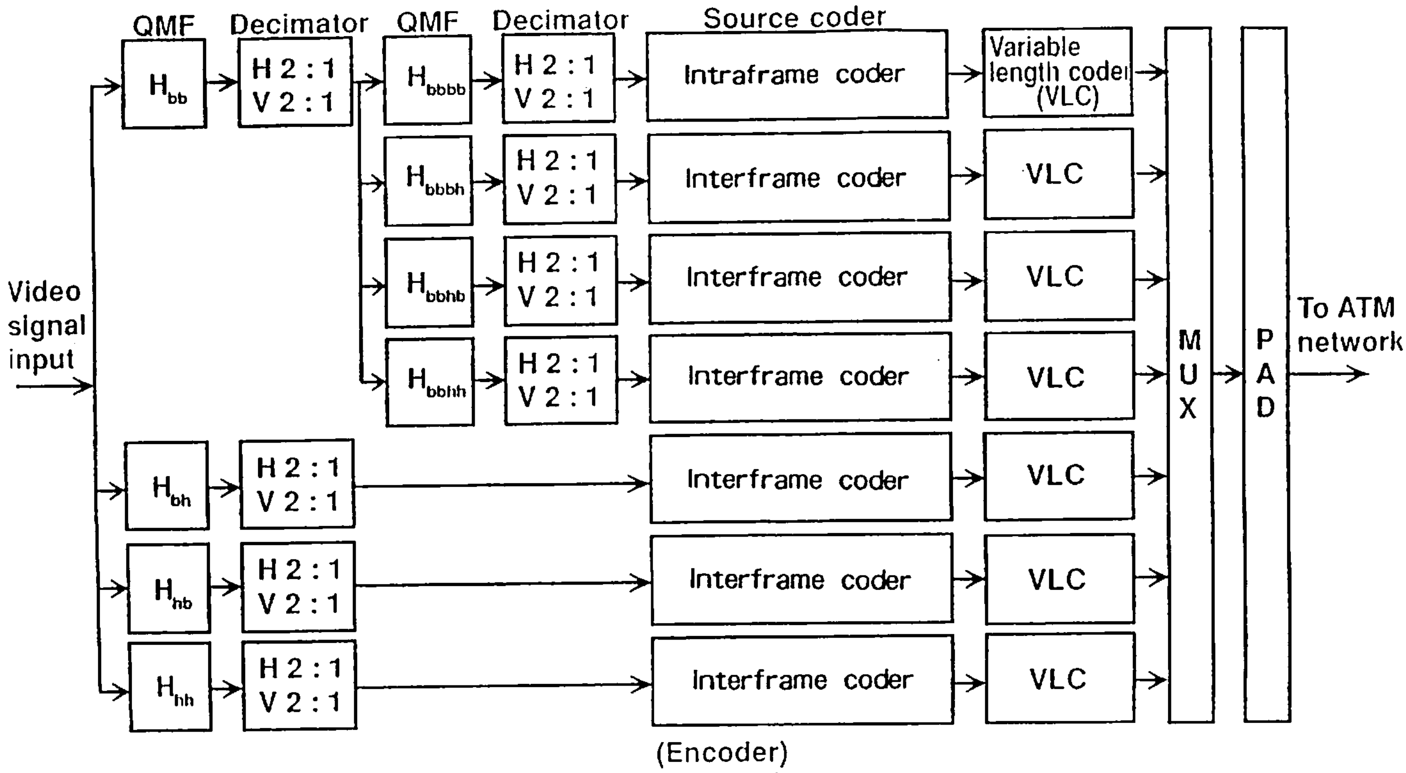

Figure 1(a) Encoder block diagram of variable rate video codec

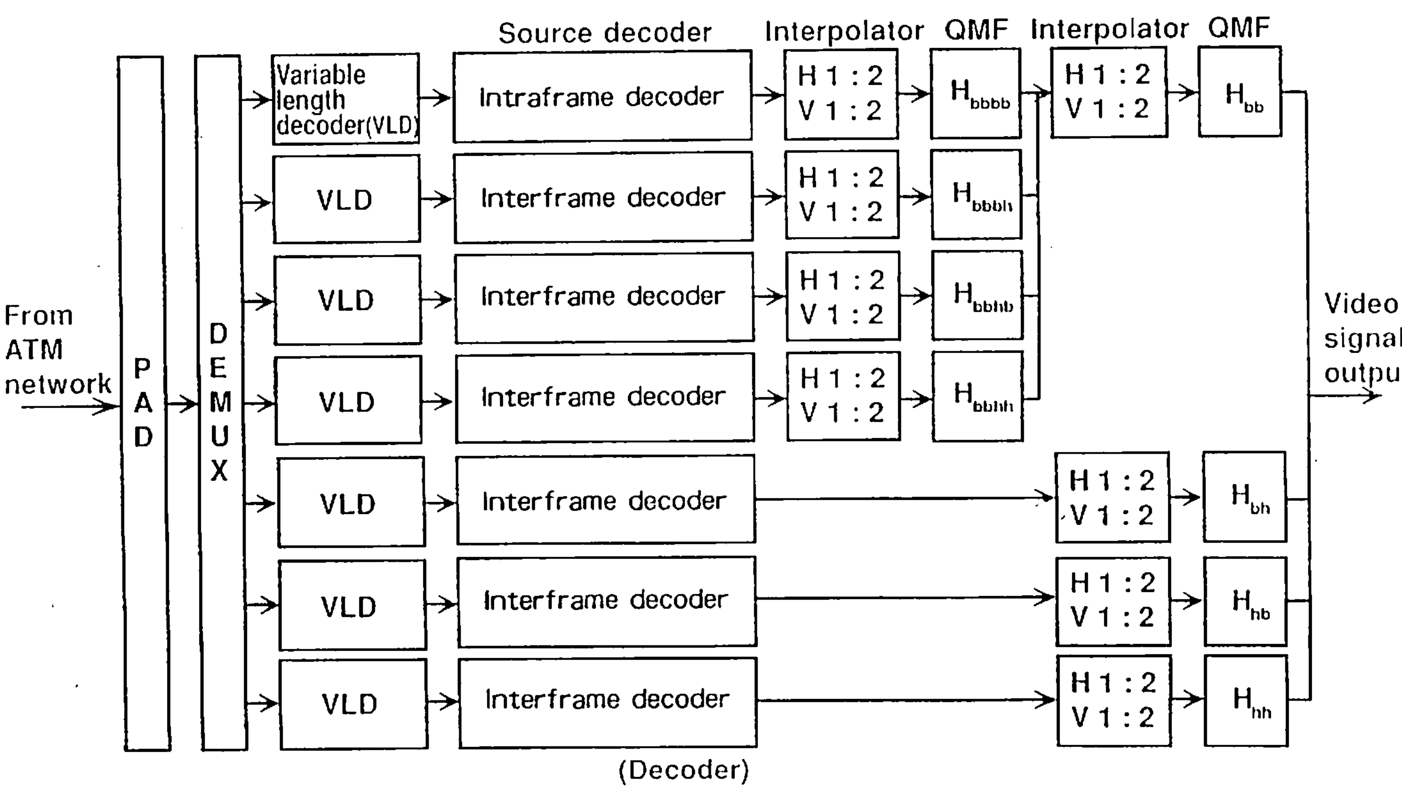

Figure 1(b) Decoder block diagram of variable rate video codec

	Table Tennis		Flower Garden	
	Average coding rate (Mbps)	Average Y-SNR (dB)	Average coding rate (Mbps)	Average Y-SNR (dB)
No cell loss	19.138	37.53	28.717	39.06
No error concealment	19.138	34.44	28.717	33.21
Error concealment A	19.138	37.00	28.717	36.51
Error concealment B	19.138	37.19	28.717	38.03
Error concealment C	19.173	37.20	28.752	38.08

Table 1 Average coding rate and SNR

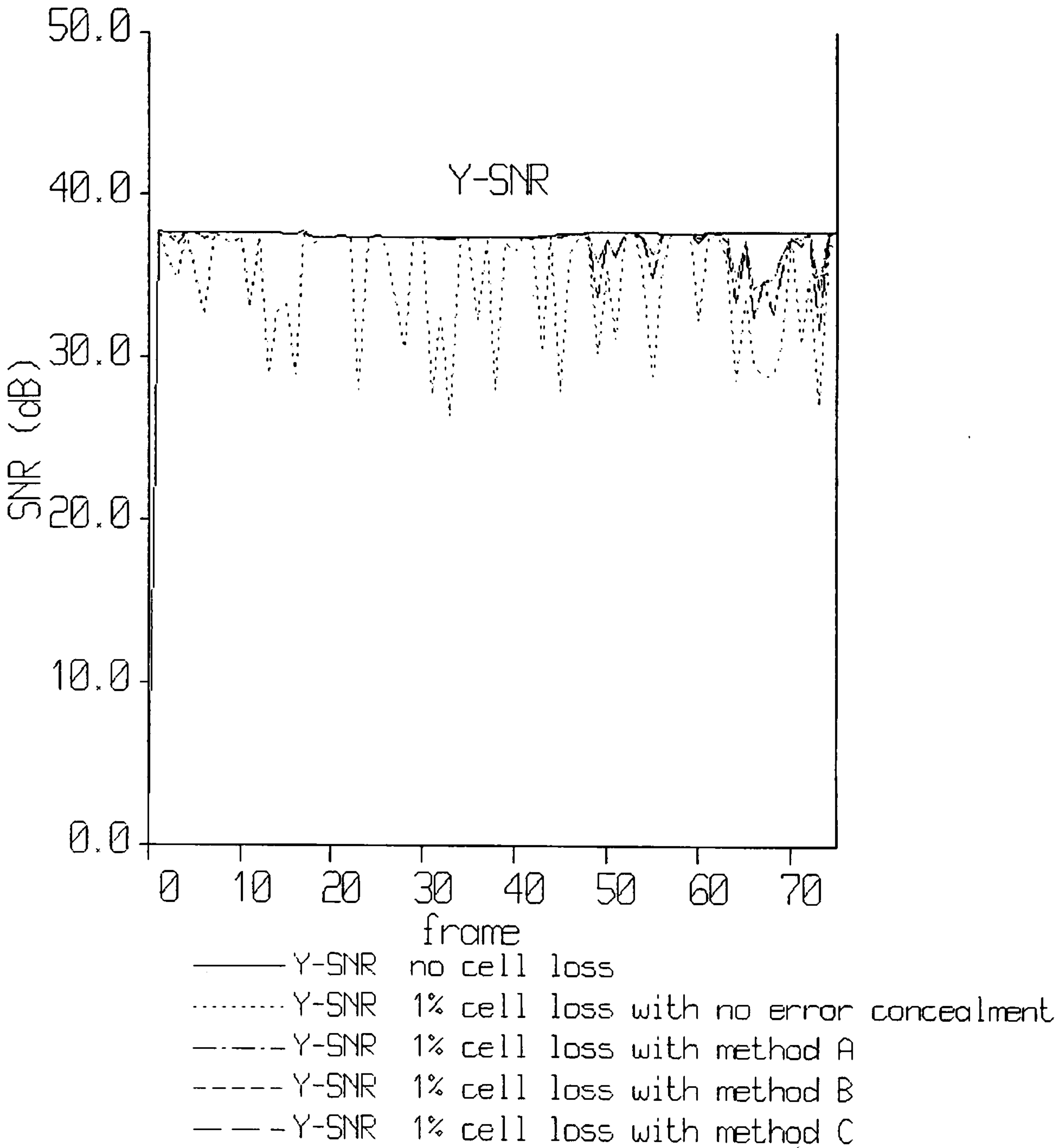

Figure 2(a) Time dependent variation of SNR and coding rate (Table Tennis)

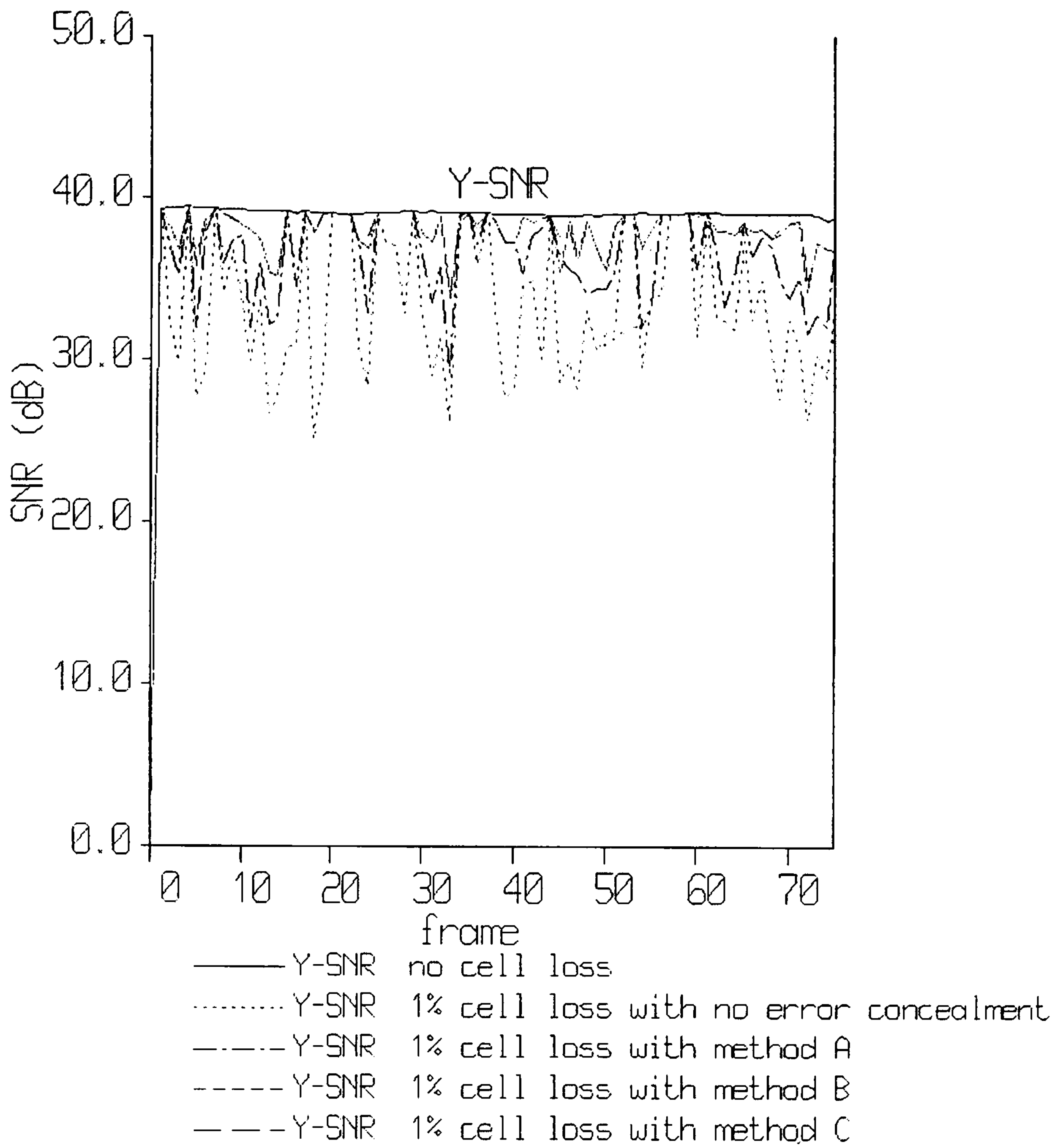

Figure 2(b) Time dependent variation of SNR and coding rate (Flower Garden)

Structured Packing of Coded Video signals into Cells

1 Introduction

Packing method of coded video signals into cells is presented for reducing the damage of received pictures caused by cell loss, which takes the structure of coded video signals into account. this method achieves quick recovery of synchronization loss in the coded video bit stream, based on the scheme that cell synchronization is used as video data synchronization where cell boundary and video data boundary are aligned periodically at the specific intervals. This method will also fit to the base layer transmission of a two layer coding scheme.

2 Packing Structure

Figure 1 shows the packing structure of the method (AA : Absolute Address, RA : Relative Address, CI : Continuation Indicator, EOI : End Of Information). In this structure, one transmission unit consists of p successive cells. Several coded data units (such as Macro Block in H.261) can be packed into one transmission unit as far as they do not penetrate into the next unit. However, when a single coded data unit is longer than a transmission unit, fewest cells that can cover the data become a transmission unit and when a long data is generated during a packing operation, the transmission unit becomes shorter than p cells.

When cell loss occurs in a transmission unit, the following data in the same unit becomes invalid, but the influence is limited within the unit.

3 Transmission Efficiency

The transmission efficiency of the method has been investigated by the computer simulations using a H.261-based coding algorithm with constant quantizer step sizes. Table 1 shows the characteristics of the coded data and figure 2 shows the simulation results of transmission efficiency.

In this method, the picture area size damaged by a cell loss and the transmission efficiency are in trade-off relations. Figure 3 shows the relations between the efficiency and the average number of coded data contained in one transmission unit. The average number of coded data damaged by a cell loss becomes half of the vertical axis when a cell loss occurs at random.

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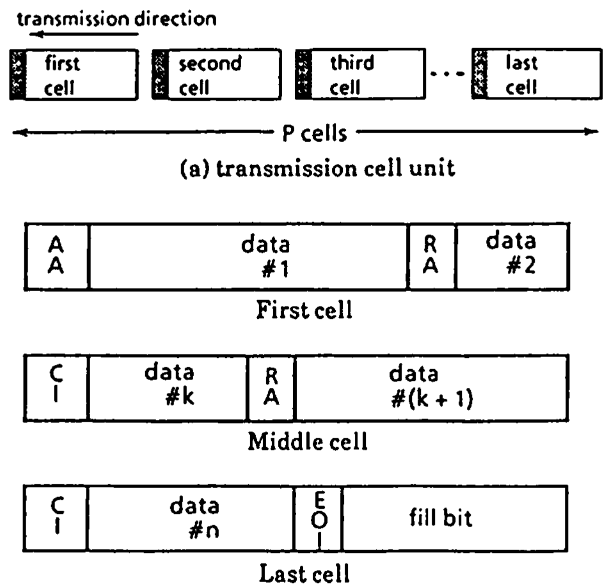

(b) data packing structure

Figure 1 Cell packing structure

Table 1 Coding results

Step Size		Open-ing	Ending	Car	Fish
2	B (kbit/s)	2706	3575	5747	8188
	SNR	46.7	47.0	47.0	47.1
	M (bit)	565	565	647	693
	σ (bit)	501	416	452	322
	σ/M	0.89	0.74	0.70	0.46
	ρ	0.40	0.53	0.75	0.995
4	B (kbit/s)	1487	1892	2894	3899
	SNR	42.5	42.6	42.7	42.5
	M (bit)	244	263	307	330
	σ (bit)	304	252	278	193
	σ/M	1.25	0.96	0.91	0.58
	ρ	0.51	0.60	0.79	0.996
6	B (kbit/s)	975	1230	1887	2435
	SNR	40.0	40.1	40.4	40.1
	M (bit)	192	187	210	206
	σ (bit)	225	177	199	136
	σ/M	1.17	0.95	0.95	0.66
	ρ	0.43	0.55	0.76	0.994
8	B (kbit/s)	740	913	1378	1727
	SNR	38.0	38.2	38.7	38.4
	M (bit)	161	147	160	147
	σ (bit)	183	139	155	103
	σ/M	1.14	0.95	0.97	0.70
	ρ	0.39	0.52	0.72	0.991

B : Bit rate
M : Mean data length
σ : Standard deviation of M
ρ : Active picture block ratio

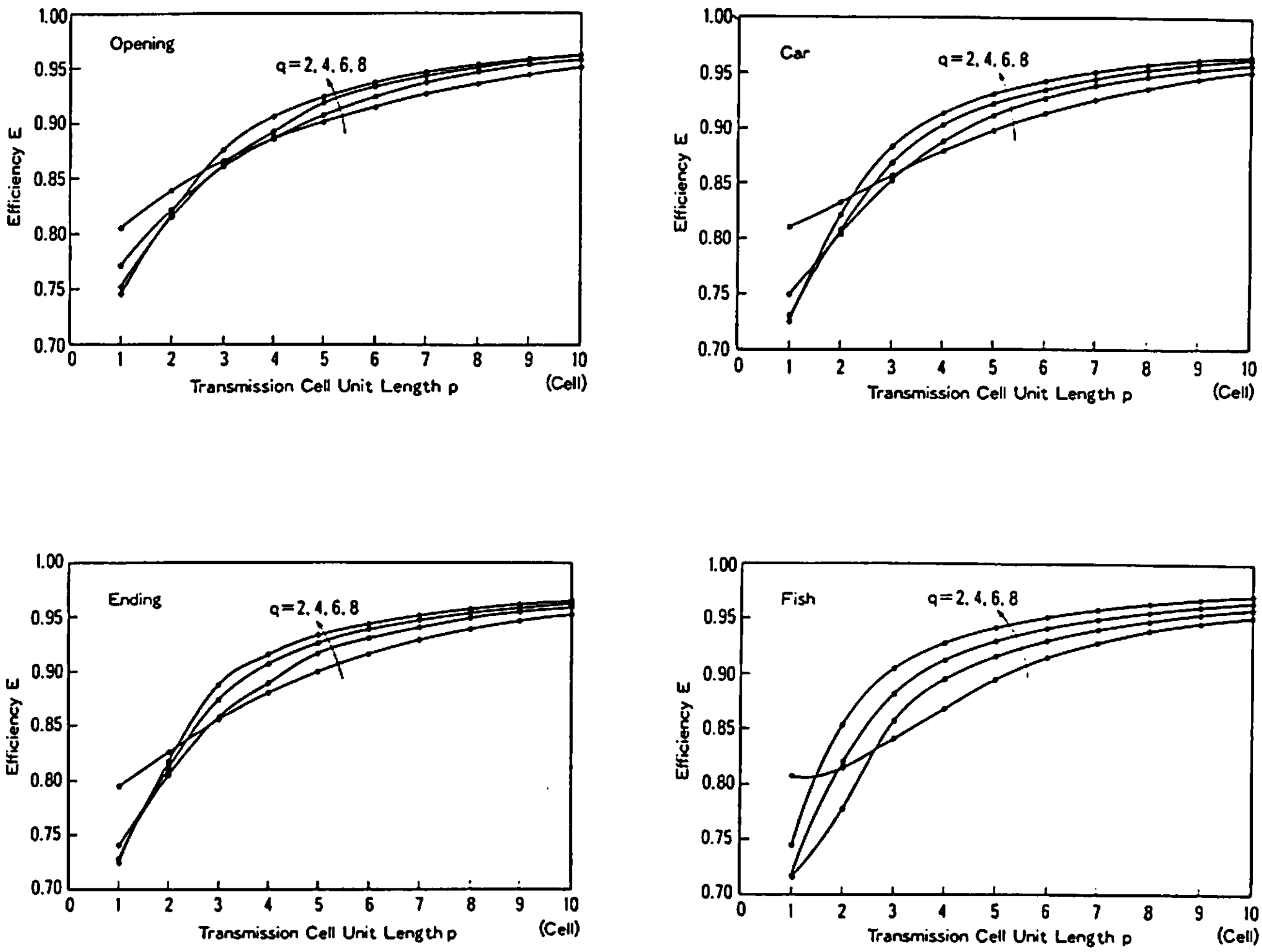

Figure 2 Transmission efficiency for four picture sequences

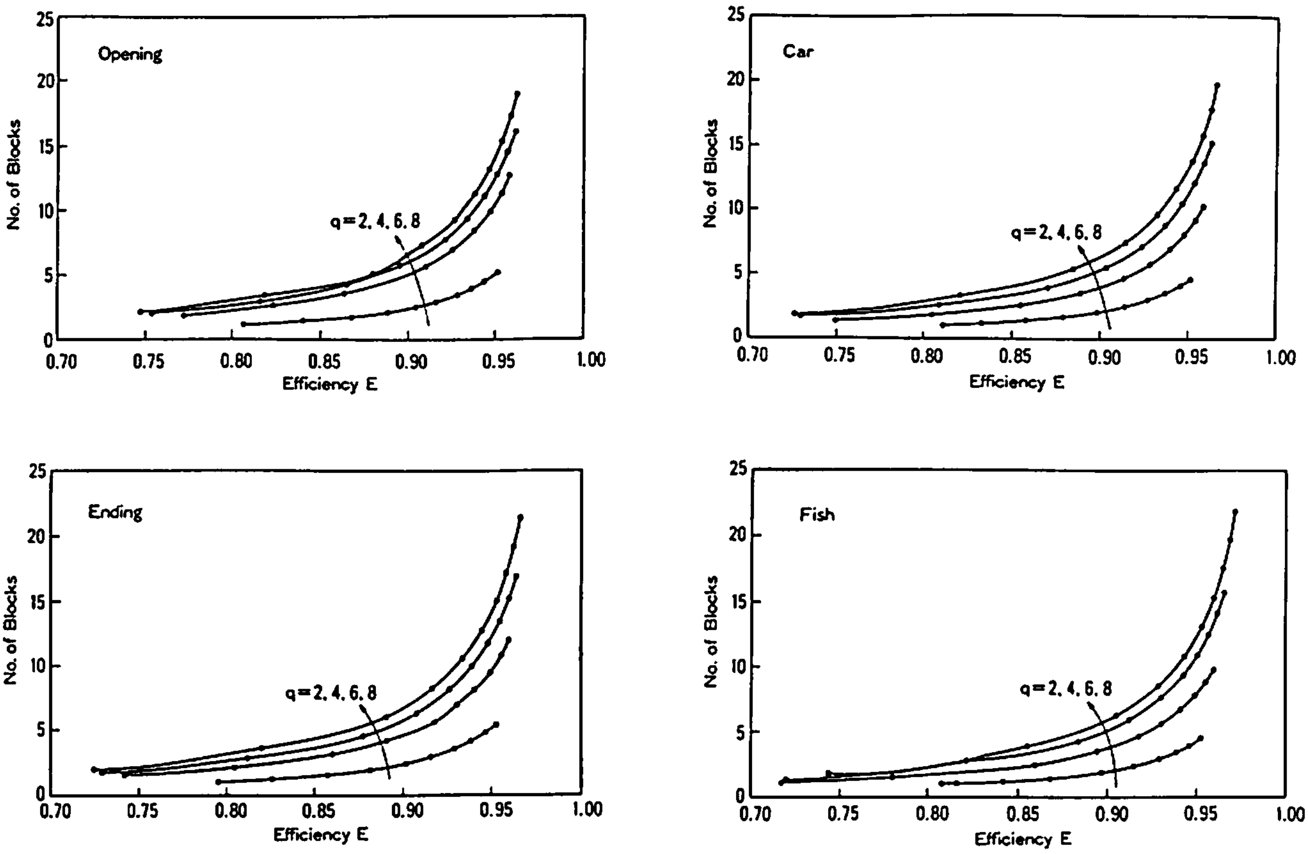

Figure 3 Average number of picture blocks in one transmission unit vs. transmission efficiency