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TITLE : EXPERIMENTS ON CELL LOSS RESILIENCE
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Ad-hoc group : ATM, Prediction

1.Introduction

Cell loss is one of annoying problems on the ATM networks. This document discusses two techniques which should be considered to realize cell loss resilience,
i.e., 1) Spatial localization of lost MB(Macro Block)
2) Temporal localization of degraded image
We have implanted these schemes into SM3 and investigated the performance of them.

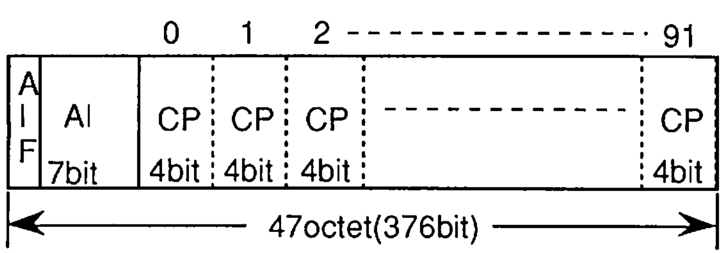
2. Spatial localization of lost MB(Refer to Matsushita proposal: MPEG 91/217, AVC- 154)

In SM3 the unique code words are used in slice, picture, GOP and sequence headers. So if a cell loss occurs, the coded data is lost on slice basis. Basically, localization of lost MB can be achieved by recognizing the position of coded MB data in the bitstream. To inform the position of coded MB data to the decoder, several information bits are added into each SAR-PDU payload of the cell. This operation is done by cell assembler(CLA) located between a source coder and ATM networks.

Even if the decoder knows the position of coded MB in the bitstream, it is impossible to start decoding from that MB, because Motion Vector(MV), DC value of DCT coefficients, and MB Address(MBA) are coded as relative value to adjacent MB's. To avoid it, the source coder should produce some Absolute valued MB(AMB) periodically. In AMB, followings are performed.

-Use absolute MB address instead of relative MB address
-Reset MV predictors to value 0
-Reset DC predictors to value 128
-Transmit Quant value as MQuant

The AMB head position information in the bitstream is informed from an encoder to a CLA, which sets the bitstream into SAR-PDU payload as follows.



CP(Cell Partitions: 4bit*92)

The bitstream in SAR-PDU payload is divided into 92 Cell Partitions(CP). Each partition has a zero origin continuous Cell Partition Number(CPN).

AI(Address Information: 7bit)

The AI is the binary expression of CPN with which CP includes the head of an AMB. The AMB information must start from the head of the CP specified by AI. If the AMB head position is not located in the head of the CP, appropriate number of bits(1 - 3 bits of '1') are stuffed in the CP and the AMB head position is located in the head of the next CP after the AI increased by one.

AIF(Address Information flag: 1bit)

The AIF is set to '1' unless AI does not exist in the payload.

On the other hand, in Cell Disassembler(CLD) located between ATM networks and a decoder, the AMB head position information is decoded from AI. The AMB head position information and the cell loss occurrence information are informed to a decoder. The decoder removes the stuffed bits using AMB head position information. In case of cell loss, the decoder searches the unique code word or AMB position and restart decoding from the position.

3. Simulation results on the spatial localization of lost MB

Basic coding scheme is the SM3(M=1: 4Mbps). The loss of coding efficiency due to AMB is estimated. Average SNRs(Y) of coded image using SM3 and SM3+localization are denoted in Table1. Cell Loss Ratio(CLR) is equal to zero and AMB is used every four coded MB.

-Test sequences -- Flower Garden, Mobile&Calendar, Table Tennis(0 -149 frame: 5 sec).

Table1. Average SNR(Y) of coded image(dB)

(CLR=0)	Flower Garden	Mobile&Calendar	Table Tennis
SM3	28.96	27.45	31.84
SM3 + localization	28.73	27.24	31.70

The worst deterioration of SNR due to AMB is only 0.2 dB in this case, and it is difficult to detect the degradation of the image quality.

Secondly, the numbers of lost MB through 150 frames are showed in Table2. CLR is equal to 1/1000(calculated according to TM2) and AMB is used every four coded MB.

-Test sequences -- Flower Garden, Mobile&Calendar, Table Tennis(0 -149 frame: 5 sec).

Table2. Number of lost Macro Blocks

(CLR=0)	Flower Garden	Mobile&Calendar	Table Tennis
SM3	740	826	691
SM3 + localization	221	292	257

Where SM3 ---------------- Restart decoding from the head of slice

SM3+localization -- Restart decoding from the AMB included in successive cell

The number of lost MB can be reduced to 1/3 by proposed method. Increasing the number of AMB, lesser MB will be lost. But it causes the loss of coding efficiency.

4. Temporal localization of degraded image

The degradation due to cell loss influences the following frames because of inter-frame prediction. To prevent it, the following methods may be considered.

a) Using intra frame -- simple GOP approach
b) Cyclic intra slice -- defined in AVC-323(TM2)
c) Leaky prediction -- defined in AVC-310, AVC-323(TM2)

5. Simulation results on the temporal localization of degraded image

The following methods are adopted to realize temporal localization of a decoded image's degradation.

a) Using intra picture (GOP = 15)
b) Cyclic intra slice (Two slices are coded as intra per a frame)
c) Leaky prediction (Floating point calculation with truncation to 8bit;
Using fixed LF n = 4, i.e., LF = 0.9375;
The LF is NOT transmitted to decoder)

Average SNRs(Y) of coded image using SM3 with a)-c) method are denoted in Table3. Cell Loss Ratio(CLR) is equal to 1/1000, localization of lost MB is adopted (AMB is used every four coded MB). And to reduce the decoded image's degradation, the lost MBs are displaced by the motion-compensated previous frame. A motion vector of the lost MB is presumed using motion vectors of decoded MB surrounding the lost MB. (Refer to AVC-235 ANNEX)

+Test sequences -- Flower Garden, Mobile&Calendar,
Table Tennis, Football(0 -149 frame: 5 sec)

Table3. Average SNR(Y) of coded image(dB)

(CLR=1/1000)	Flower Garden	Mobile&Calendar	Table Tennis	Football
Intra picture	28.06	26.77	31.17	30.18
Intra slice	28.03	26.68	31.22	30.28
Leaky prediction	28.31	26.63	31.43	30.25

Using Intra picture or Intra slice, the degradation is refreshed cyclically.But the degradation propagates for several frames, which gives an unfavorable impression subjectively.

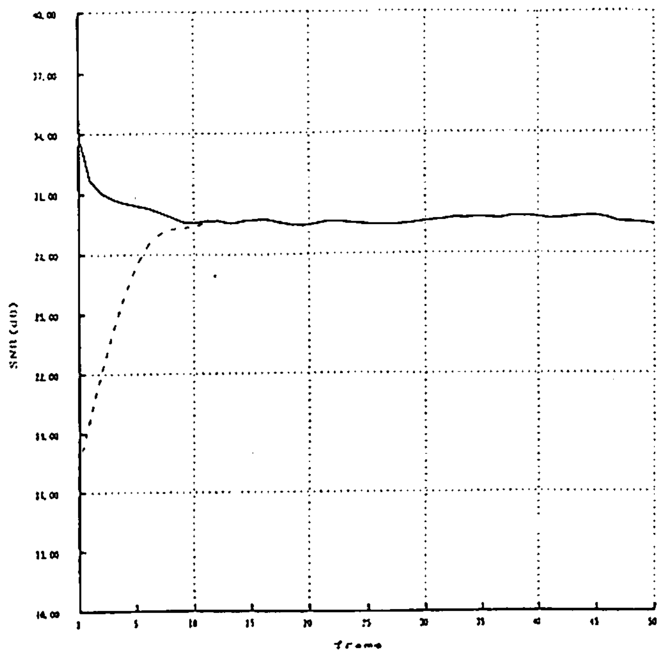
The leaky prediction recuperates the quality of decoded image gradually. It is a desirable characteristic for human visual system. Therefore the leaky prediction is preferable method to realize temporal localization of degraded image.

However, unfortunately the leaky prediction reduces subjective quality at stationary state. It seems to be while the noise due to the leaky prediction mainly consists of the low frequency component. Therefore some improvements are needed on the leaky prediction. An example of improvements on the leaky prediction is showed in ANNEX.

6.Channel hopping and leaky prediction

The leaky prediction can converge the mismatch between coder and decoder due to channel hopping as Fig.1-3. (After the channel hopping,the predicted image is set to 128 at the decoder.)
In case of LF=0.75 and 0.875, the mismatch is converged by 10th and 20th frame respectively.
On the other hand, in case of LF=0.9375, it can not be converged before 40th frame.

The leaky prediction is compared with Intra picture and Intra slice subjectively. In the Intra picture or Intra slice, 15 frames after channel hopping are set to constant level (e.g., blue image). Because the leaky prediction recuperates the quality of decoded image gradually, we can recognize the rough decoded image promptly even in case of LF=0.9375. Therefore the leaky prediction with LF up to 0.9375 gives better impression than Intra picture or Intra slice.

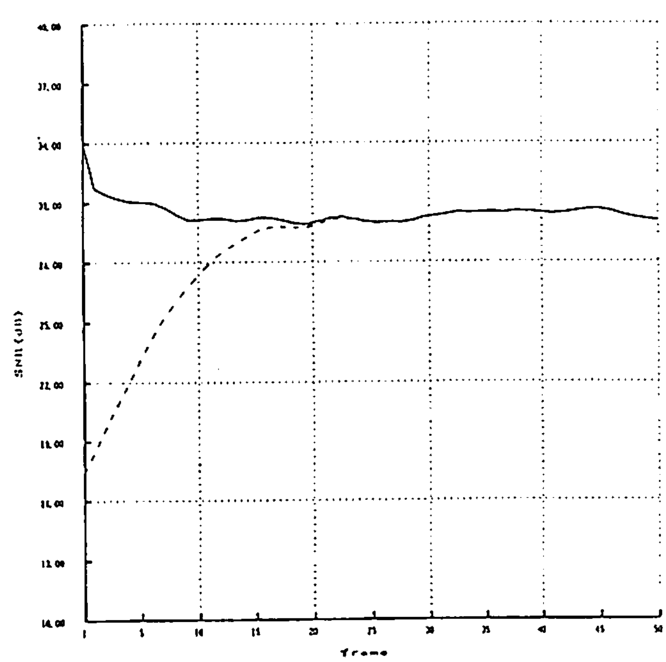


Leak factor=0. 75

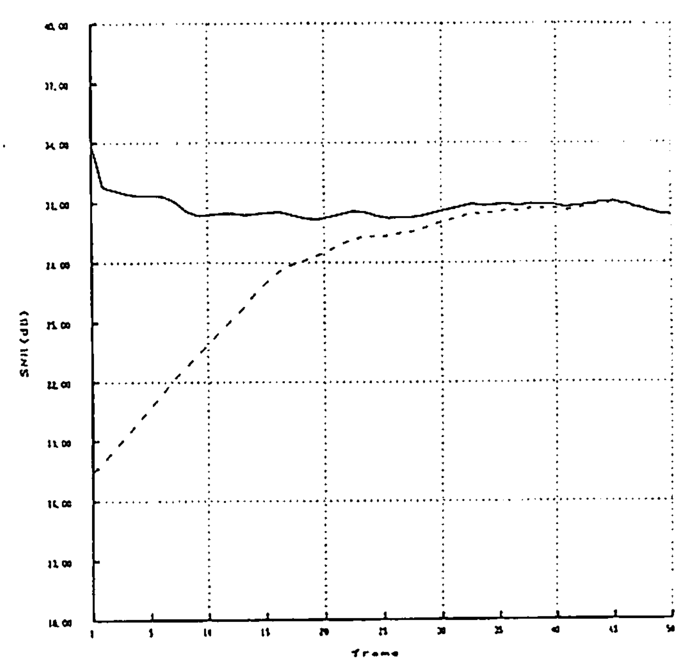
Reference ———
Leaky prediction – – – –

Fig1.

Fig2. Fig3.



Leak factor=0. 875



Leak factor=0. 9375

7.Conclusion

Several techniques to realize cell loss resilience are discussed. Concerning the temporal localization of degraded image and channel hopping, the leaky prediction is favorable in terms of the error recovery. However some improvements should be needed on the leaky prediction to get better image quality at stationary state.

ANNEX to AVC-333

An example of improvements on the leaky prediction

Speaking generally, the leaky prediction increase the prediction error as compared with a "perfect" prediction. Fig.A-1 and A-2 shows the mean absolute value of DCT coefficients of prediction error on the perfect prediction and the leaky prediction respectively. (5th frame of 'Football')

Fig.A-1 Mean absolute value of DCT coefficients of prediction error(perfect prediction)

22.14	13.18	8.23	5.93	4.53	3.43	2.74	1.55
15.43	10.57	7.41	5.29	4.09	3.18	2.39	1.41
11.46	8.65	6.05	4.54	3.42	2.55	2.09	1.23
10.01	6.81	5.16	3.60	2.66	2.08	1.74	1.07
8.51	6.14	4.53	3.23	2.40	1.89	1.59	1.00
10.03	7.06	4.87	3.47	2.61	2.11	1.83	1.15
10.88	7.81	5.90	4.14	3.31	2.59	2.14	1.32
16.30	10.20	6.92	4.82	3.56	2.96	2.52	1.47

Fig.A-2 Mean absolute value of DCT coefficients of prediction error(leaky prediction, LF=0.875)

38.79	13.71	8.47	6.07	4.63	3.44	2.75	1.56
16.16	10.74	7.55	5.39	4.14	3.19	2.38	1.42
11.68	8.71	6.15	4.63	3.47	2.56	2.09	1.24
10.08	6.86	5.17	3.63	2.67	2.09	1.74	1.09
8.95	6.34	4.58	3.23	2.38	1.87	1.58	1.01
9.75	6.87	4.74	3.40	2.56	2.09	1.82	1.16
10.52	7.62	5.78	4.05	3.27	2.57	2.12	1.33
16.14	10.02	6.72	4.71	3.51	2.94	2.50	1.47

Obviously the leaky prediction causes a increase of the prediction error especially in low frequency coefficients. Therefore if the leaky prediction is used, quantization of these DCT coefficients should be performed more carefully.

We have modified the quantization of a DC value of the DCT coefficients on the leaky prediction i.e., the DC coefficient is quantized with a fixed quantize step. We have implanted this modified quantizer into SM3 with the leaky prediction, and evaluated the coding performance. Average SNRs of decoding image are showed in Table.A-1.

-Test sequence	-- Football (0 - 59 frame: 2 sec).
-Coding rate	-- 4Mbps
-Leak factor	-- 0.9375
-Fixed quantize step size	-- 8, 12, 16

Table.A-1 Average SNRs of decoding image (dB)

Fixed Qstep	SNR(dB)
NOT used	30.78
Q = 16	30.24
Q = 12	30.01
Q = 8	29.36

Using the fixed quantize step for DC coefficient reduce the SNR of decoded image compared with using variable quantize step. However using the fixed quantize step, especially at Q = 12, improves subjective quality of decoded image. It will be demonstrated by D1 tape.