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Experts Group for ATM Video Coding

SOURCE : Japan
TITLE : Cell-loss compensation scheme
PURPOSE : Proposal/Discussion

1. Introduction

A cell-loss compensation scheme, which consists of structured packing, concealment at the decoder and leaky prediction, was introduced at this past meetings (AVC-235, AVC-279). In this document, the proposed scheme was installed into a TM2 based coding argorithm, and each element of the scheme, especially leaky prediction, is evaluated in detail through computer simulation.

2. Cell-loss compensation scheme

Cell-loss compensation can be divided into two aspects with respect to their effects.

- Spatial domain compensation
  To minimize the degraded area in a picture at the point of cell loss.
- Temporal domain compensation
  To make complete recovery from degradation after a cell loss.

Both of the two aspects should be properly treated in considering cell-loss compensation scenarios. In the proposed scheme, structured packing and concealment belong to the spatial domain compensation, and leaky prediction can be regarded as a temporal domain compensation.

We propose that the standard error resilience scheme should include such mechanisms that enable both of the two compensation functions when required.

3. Computer simulation

The effect of each element in the proposed scheme was evaluated, considering the two aspects of cell loss discussed above, through computer simulation using a TM2 based coding algorithm. As for the temporal domain compensation, leaky prediction and intra slice method were compared. The simulation conditions were as follows.

- Picture format : 4:2:0
- GOP structure : M=1, N=150 (IPPPP....)
- Picture structure : Frame picture
- Prediction method : Adaptive frame/field
- Leak factor : 0.9375($1-1/2^4$)
- Precision in leakage culculation : 8 bit (truncation)
- Mean cell-loss ratio : 10^{-3}
- Mean burst of cell loss : 2
- Overhead for cell assembly : 20 bits (MSP and ABA)

It has been pointed out in discussions in Japan that the numerical precision in leak factor calculation affects on the recovery process. Some considerations are discussed in the Annex, but further study is required.

Table 1 shows the simulation results of each method. Figure 1,2 and 3 show the SNR fluctuation by each method at 9 Mb/s for Flower Garden, and each figure includes the cases "without cell loss and compensation" and "with cell loss and no compensation" as references.

(1)Spatial domain compensation

Degradation in average SNR is small owing to the concealment. However, the frame by frame SNR decreases with time. This is caused by the accumulation of the concealment error, which means further compensation is necessary.

(2)Temporal domain compensation

Leaky prediction gives better average SNR of the reproduced picture in Flower Garden when compared to intra slice method, but not in Mobile and Calendar. As for temporal behavior of SNR, degradation due to cell loss propagates several frames in intra slice method, but gradually recovers in leaky prediction. Leaky prediction also gives better results in subjective picture quality.

(3)Combination of spatial and temporal domain compensation

Almost same results are obtained in average SNR by "spatial domain compensation + leaky prediction" and "spatial domain compensation + intra slice method". Both methods give better results than the cases when either of the spatial or time domain compensation is used. However, the former method gives better subjective picture quality for the same reason as described in (2).

Some of the reproduced pictures will be demonstrated by VCR at the meeting.

4. Conclusion

The each element in the proposed cell-loss concealment method was installed into a TM2 based coding algorithm and evaluated through computer simulation. The results indicate that the both of the spatial and temporal domain compensation are necessary to realize sufficient cell loss compensation and that leaky prediction is preferable to intra slice method as a time domain compensation.

Therefore, we propose that the standard error resilience scheme should provide both the spatial and temporal domain compensation mechanisms.

Table 1: Average SNR(dB) in each scheme

	Intra slice	Leaky prediction	SP & Conc	Flower Garden		Mobile & Calendar	
				4 Mb/s	9 Mb/s	4 Mb/s	9 Mb/s
Without cell loss	–	–	–	28.60	33.76	26.69	31.07
	○	–	–	28.03	32.82	26.25	30.58
	–	○	–	27.89	32.82	25.87	30.38
	–	–	○	28.24	32.95	26.38	30.68
With cell loss	–	–	–	25.16	22.13	25.09	25.31
	○	–	–	25.97	25.59	25.60	27.75
	–	○	–	26.62	27.78	25.34	27.94
	–	–	○	27.71	30.50	26.14	29.72
	○	–	○	27.43	31.78	25.89	29.91
	–	○	○	27.29	31.98	25.49	29.78

○: Item(s) applied

SP: Structured Packing

Conc: Concealment

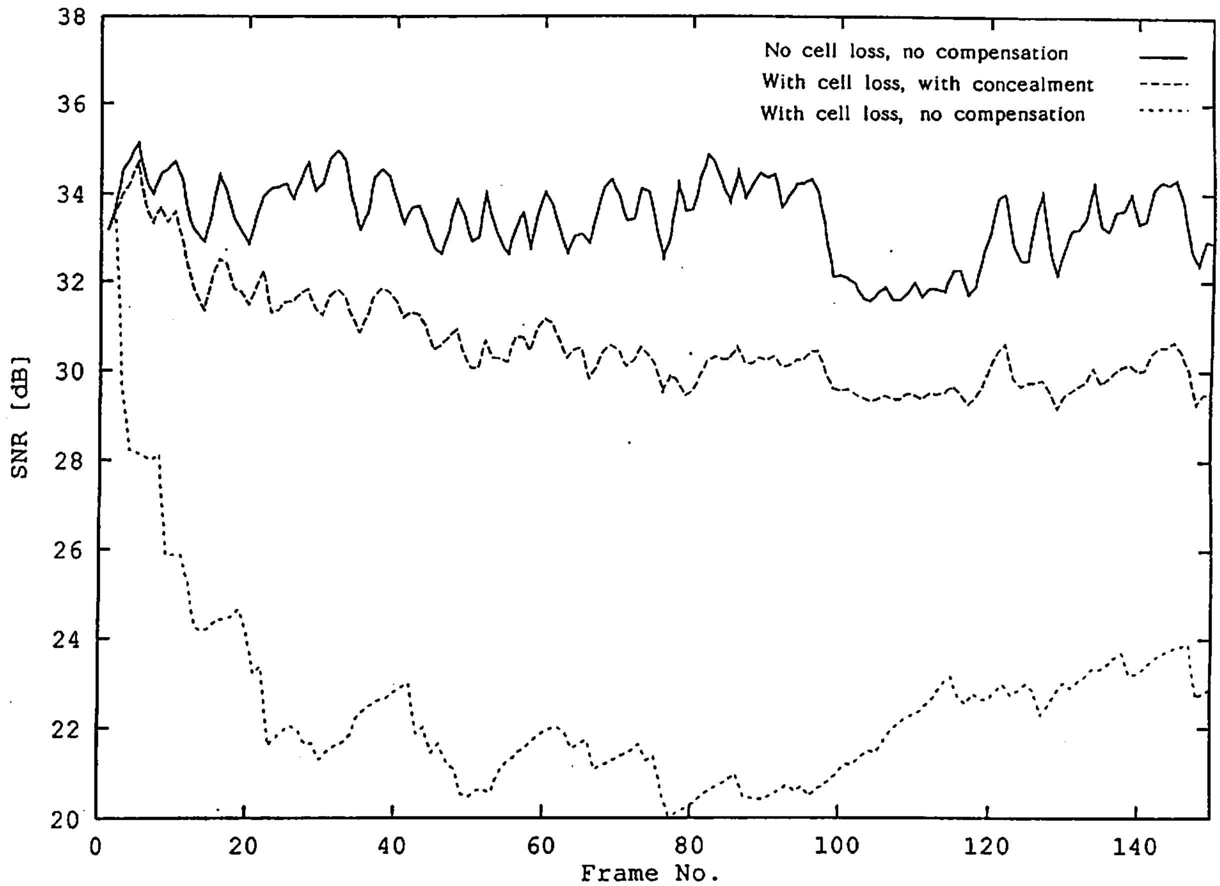

Figure 1: Spatial domain compensation

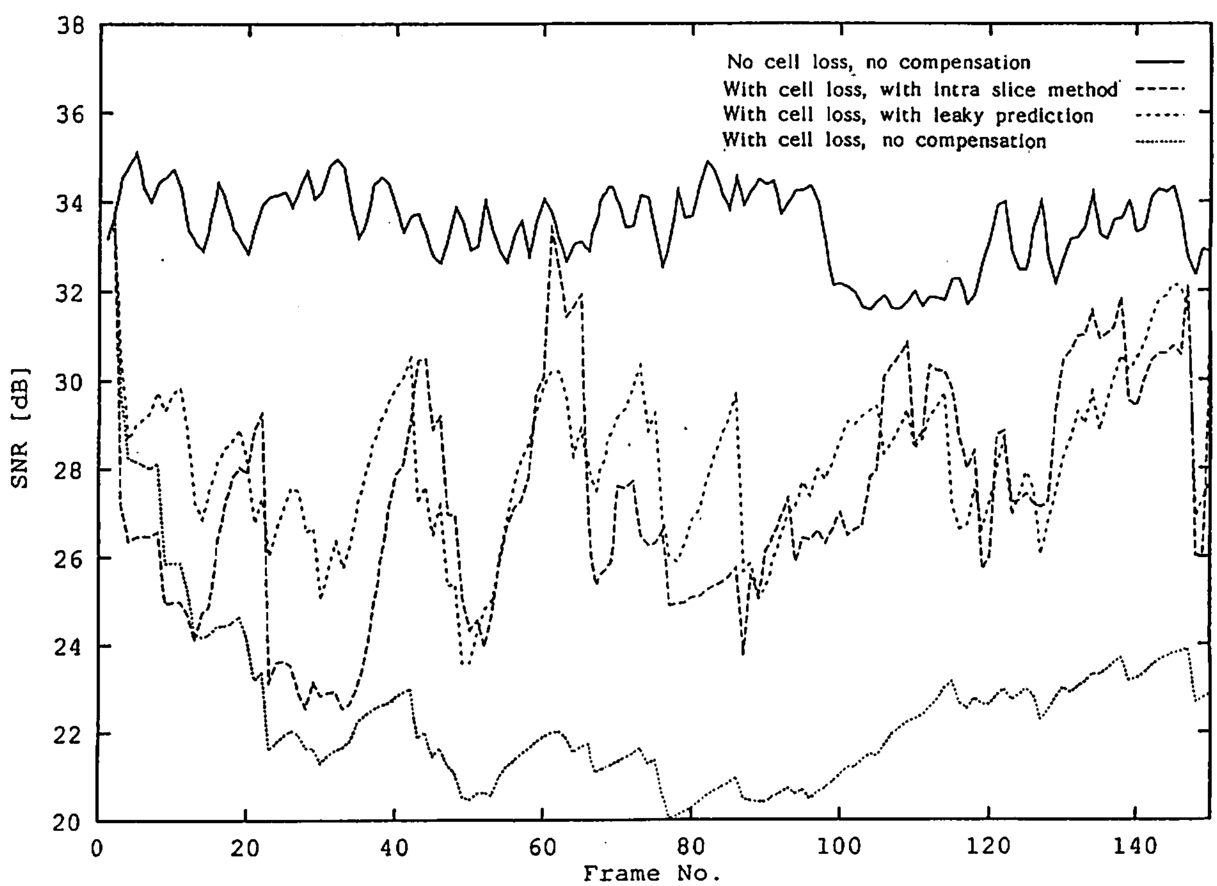

Figure 2: Temporal domain compensation

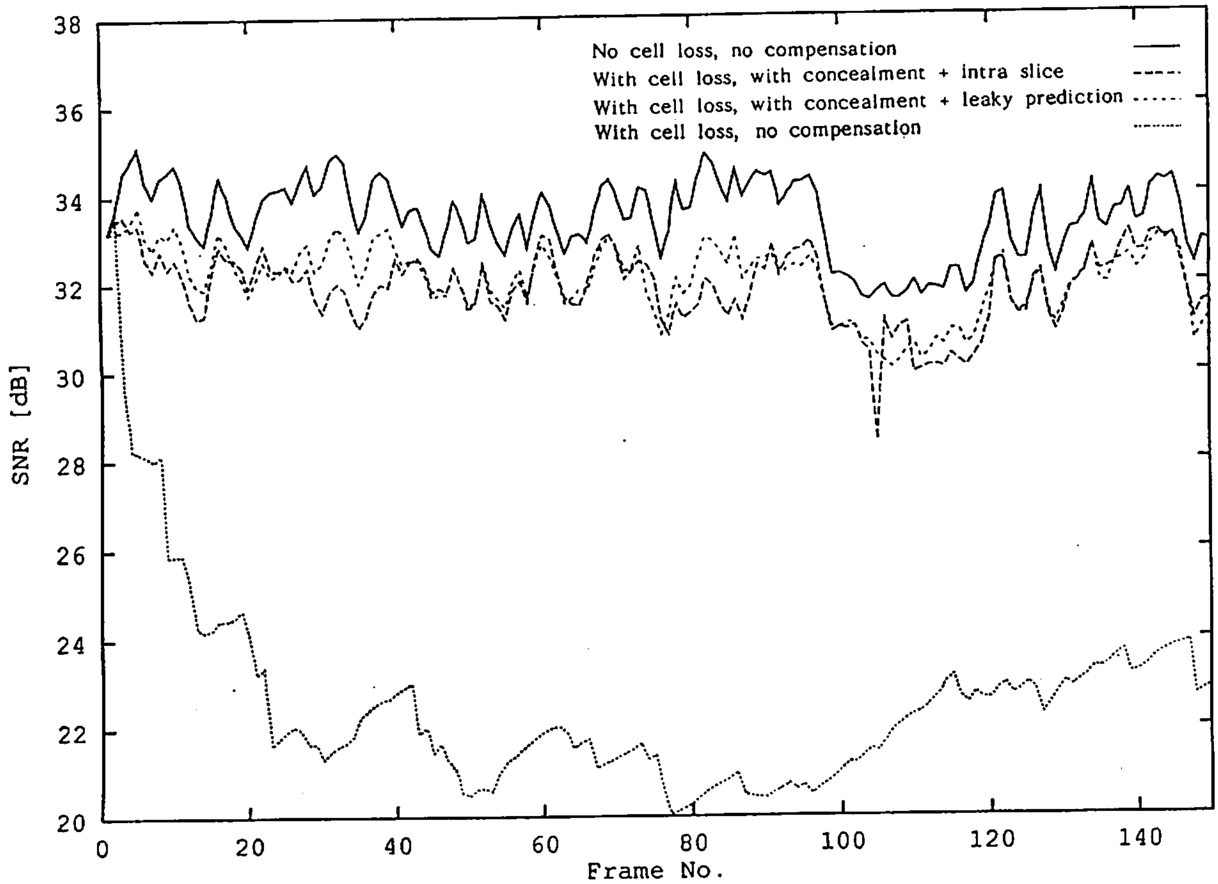

Figure 3: Combined spatial and temporal compensation

Numerical precision in the leak factor calculation

1. Introduction

Leaky prediction is known as one of the methods to resume mismatcth between encoder and decoder caused by transmission error etc. However, insufficient precision in the coding loop generates residual error which may keep the decoder from complete recovery. In this doccument, influence of the numerical precision in leaky prediction is discussed in detail.

2. Operation precision vs. residual error

The maximum residual error was calculated using an encoder and decoder model depicted in figure 1. The assumed conditions are as follows.

- Leak factor LF = $1-1/2^n$ (n = 1,2,3,4,5,6)
- Operational precision 8+k bits

Figure 2 shows LF input vs. LF output after truncation to 8 bits in case of k=0. These characteristics indicate the maximum residual error for k=0 are as follows.

n	LF	Maximum residual error
1	1 - 1/2	+- 1
2	1 - 1/4	+- 3
3	1 - 1/8	+- 7
4	1 - 1/16	+- 15
5	1 - 1/32	+- 31
6	1 - 1/64	+- 64

It was clarified through these results that the maximum residual error for each leak factor value is 2^{n-k} +-1 for n>=k, 1 for n<k in the case of truncation, and 0 for n<k in the case of rounding. Therefore, it can be concluded that it is necessary to have a numerical precision of 8+n+1 bits with rounding to get rid of residual error.

3. Experiments using TM2

Influence of the residual error on actual coding process was evaluated through computer simulation using the TM2 low delay mode. The simulation conditions are as follows.

- Leak factor LF = $1-1/2^4$
- Bit rate 4 and 9 Mb/s

In the simulations, initial value of the frame memory (reference picture) at the decoder were set to gray level (128).

[Experiment 1] Input: Flat DC picture (DC value of 160)

Figure 3 shows the SNR fluctuation of the reproduced picture at the decoder when the operation precision is 8,9,...,14 bits respectively. These curves show that the insuficient precision keep the decoder from convergence due to residual error.

[Experiment 2] Input: Motion picture

This experiment can be regarded not only as an influence of operational precision, but also a channel hopping compensation. Figure 4 shows the SNR fluctuations for Flower Garden and Mobile and Calendar at 9 Mb/s when 8 and 14 bits are used for the leak factor culculation. The results show that there is no significant difference between the case with different operation precision. Subjective evaluation of the reproduced picture shows that the leaky prediction works good also as a channel hopping compensation.

4. Conclusion

Influence of the numerical precision in leaky prediction was evaluated. The results show that in the case of still DC picture input, the mismatch between encoder and decoder is not converge into zero when the precision is insufficient. In the case of actual picture input, however, there seemed to be very little influence on picture quality. Further study may be required to clarify this item by using various sequences.

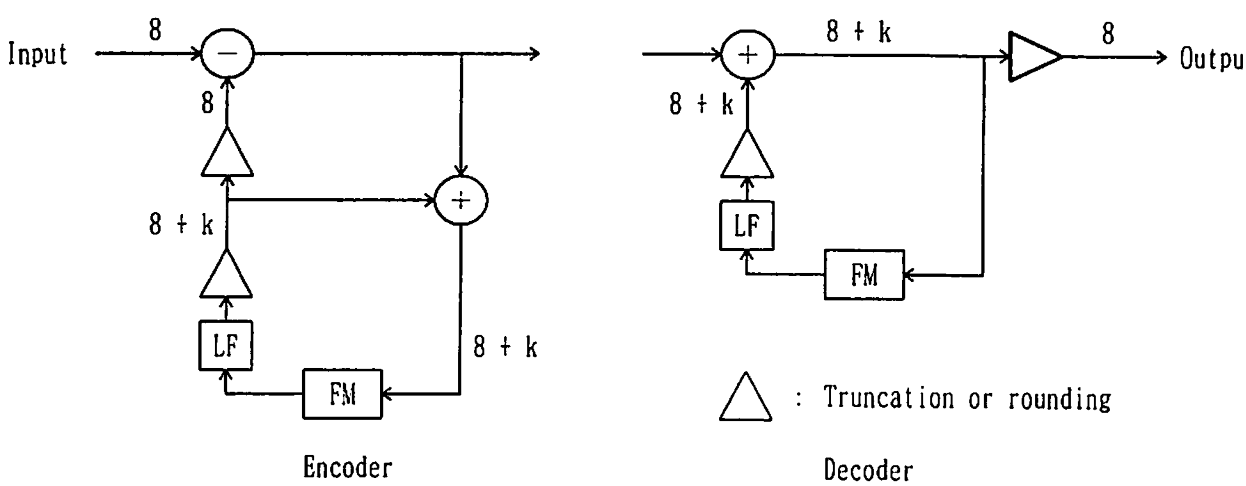

Figure 1: Encoder and decoder model with leaky prediction

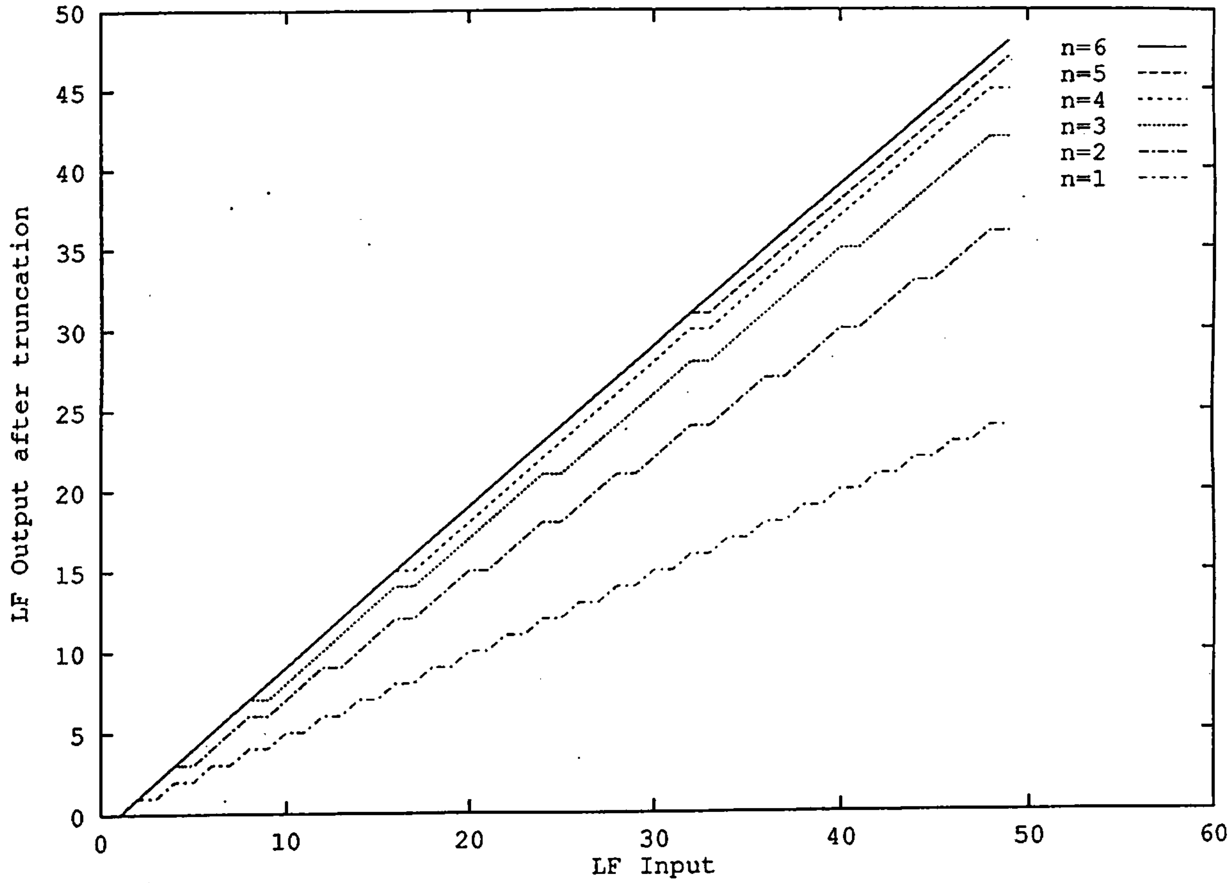

Figure 2: LF input vs. LF output after truncation

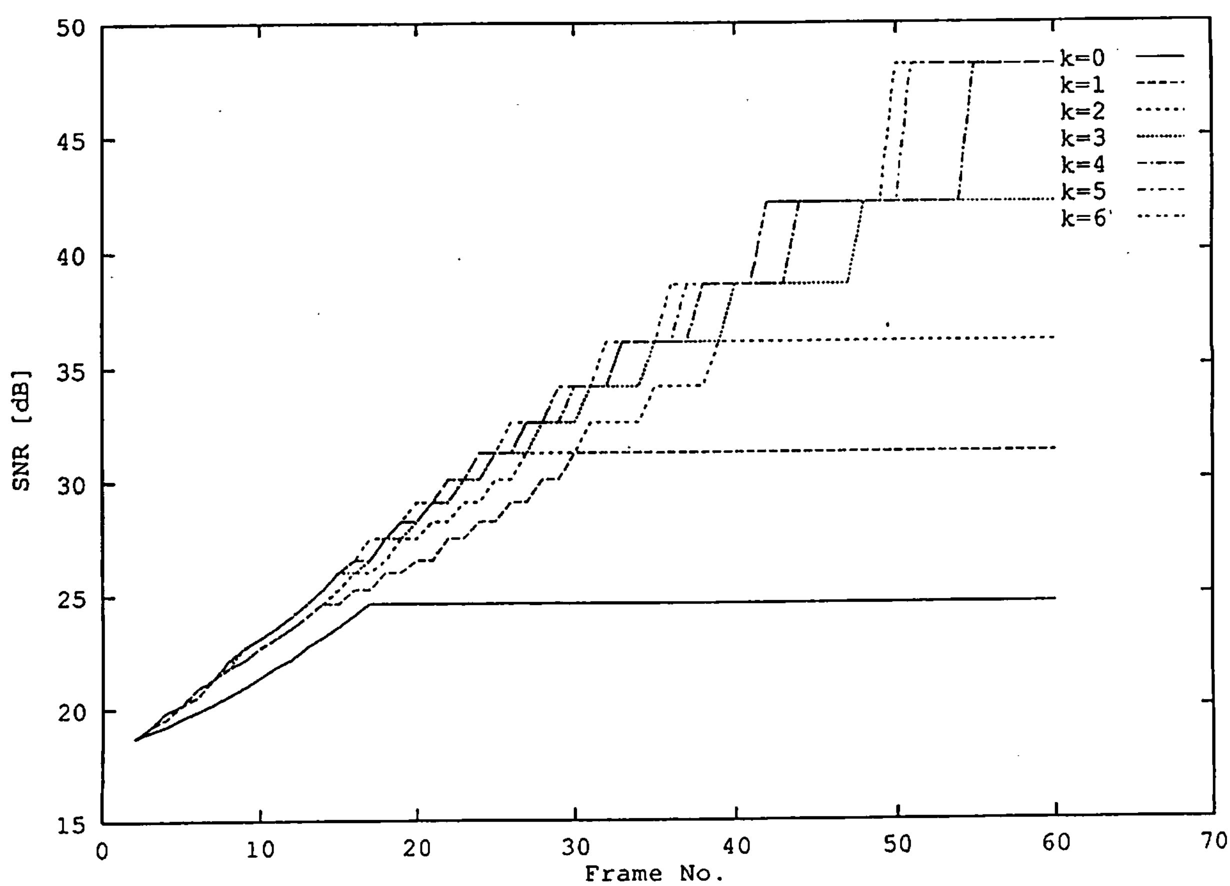

Figure 3: Results of experiment 1

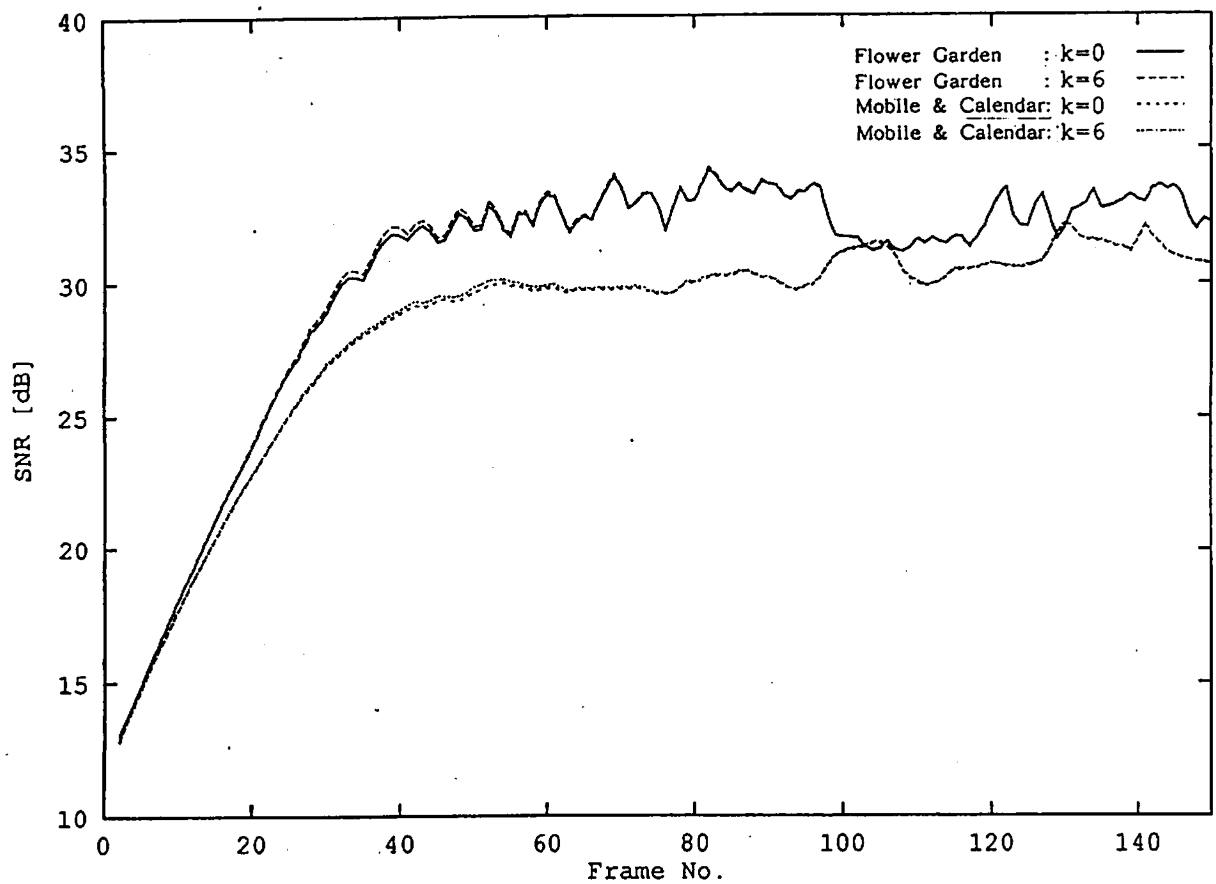

Figure 4: Results of experiment 2