AVC 344

INTERNATIONAL ORGANISATION FOR STANDARDISATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO-IEC/JTC1/SC29/WG11
CODED REPRESENTATION OF PICTURE AND AUDIO INFORMATION

ISO-IEC/JTC1/SG29/WG11
MPEG 92/
September 1992

Title: A Frequency Pyramid Architecture with Improved Coding Efficiency

Source: T.K.Tan (Monash University, Melbourne, Australia)
T.Sikora (Monash University, Melbourne, Australia)
A.Johnson (Telecom Research Labs, Melbourne, Australia)

On behalf of Australian "Universal Video Codec" project (Monash University Video Lab, AOTC, Siemens Ltd. and University of New South Wales)

Purpose: Information and Proposal

Introduction

Our investigation have shown that a frequency scalability coding structure with a single-loop encoder and single-loop decoder has good bit rate efficiency when compared to the single layer coder but suffers from drift effects in the lower resolution scales. This drift can be eliminated by employing a multi-loop encoder / single-loop decoder structure, see figure 1. However, this basic scalable coder suffers in its coding efficiency. Differences in the prediction error between scales have to be corrected in the higher resolution scales.

Similar problems have been encountered in subband approaches which only have a single-loop decoder [1,2]. The drift appears in some or all scales depending on the structure used. It can only be removed by using a multi-loop decoder.

In this contribution we would like to introduce a new coding structure. This structure makes use of the prediction from the lower scales to improve the coding efficiency. The main coding structure remains the same as the basic scalable coder except that a new path which we shall call path_Y is introduced. This path is duplicated in the decoder which makes it a multi-loop decoder. A block diagram of this basic scalable coder with path_Y is shown in figure 2.

Path_Y

Figure 3. shows and example of the path_Y coefficient substitution. The same action can be performed by the decoder since it can retrieve the quantised coefficients from the bitstream. Therefore there is no need for more side information except signalling at the sequence or picture level to indicate the use of this mode.

The coefficients in the prediction is selected in the following manner. If the corresponding DCT coefficient in the inverse-quantised coefficient of the scale_2 (X2) is zero, then the prediction in scale_4 is selected from the motion compensated prediction of that scale. If the inverse-quantised coefficient of scale_2 is not zero, then the prediction is chosen from the motion compensated prediction of scale_2 (Y2). The same thing is then done for the prediction of scale_8 based on scale_4 (using X4 and Y4).

Test Conditions

In this experiment, we compare the performances of the basic scalable coder against the basic scalable coder with path_Y. The single layer is also provided as a reference. The experiments were performed on 94 frames of the sequences *Flower Garden, Mobile & Calendar, Ballet and Fountain & Rainbow*. The following test conditions were chosen.

- chroma sub-sampling 4:2:0
- bit rate 1.5, 2.5 and 4.0 Mbps
- independent rate control on all layers - Slice Granularity as in Core Experiment I.6
- N = 12, M = 3.
- frame prediction and coding only.
- 1/2 pixel motion vector resolution in all scale.
- other aspects as in TM2

Results

The test results, in tables 2 - 5, show that in all sequences the basic scalable coder with path_Y produced the higher average signal to noise ratio when compared to the basic scalable coder. The improvement for scale_8 range from 0.52 dB with *Ballet* to 1.12 dB with *Mobile & Calendar*. On scale_4 the improvement range from 0.44 dB with *Ballet* to 0.91 dB with *Fountain & Rainbow*. The signal to noise ratio of the base layer should remain roughly the same as it is not directly affected by the additional path. The improvement seen in *Ballet* is smaller compared to the rest since the efficiency of the scalable coder is already very close to the single layer coder.

The improvement in the average signal to noise ratio is also reflected in the frame by frame signal to noise ratio plots depicted in graphs 1 - 6. Test sequences will also be shown on D1 for subjective evaluation.

Conclusions and Proposal

From our result we conclude that using the additional prediction improves the coding efficiency of the scalable coder. The only drawback is the complexity of the decoder. But if good quality on all layers is desired, then this may be an appropriate solution.

We would like to propose that this encoder/decoder structure be investigated as a follow-up experiment for Core Experiment I.2 and I.3 as defined in TM2. We have also found that rate control and bit rate distribution among the different scales can affect the performance of the encoder. Therefore we recommend that different bit rate distributions be investigated.

We realise that many different decoder structures have been proposed in the MPEG forum recently. These include combinations of pyramid, subband, single-loop and multi-loop scalable schemes. We propose that an 8 bit word be transmitted in the sequence header to indicate the structure of the decoder which is necessary in decoding the bitstream. An example is given below.

```
if (fscalable) {
        do {
                fscale_code                               8       uimsbf
        } while (nextbits != '0000 0111')
        end_of_fscales_code                               8       '0000 0111'
        fscale_decoder_structure                          8       uimsbf
}
```

fscale_decoder_structure -- This is an 8-bit integer defined in the following table which indicates the frequency scalable decoder structure used.

value	decoder structure
0	reserved
1	decoder structure 1
2	decoder structure 2
3	decoder structure 3
etc.	etc.

Table 1.

Acknowledgement

The work described in this paper is part of a joint research project being carried out by Monash University, the University College, University of New South Wales, together with partners Siemens Ltd. and AOTC. Support was provided under the Generic Technology component of the Industry Research and Development Act 1986.

References

[1] MPEG 92/288 C. Herpel, "Multiple loop decoder for TM1 scalable mode"
[2] MPEG 92/287 B. Hammer and A.Reingruber, "Experiment 1 of the scalability annex of TM1"

Appendix A. Block Diagrams.

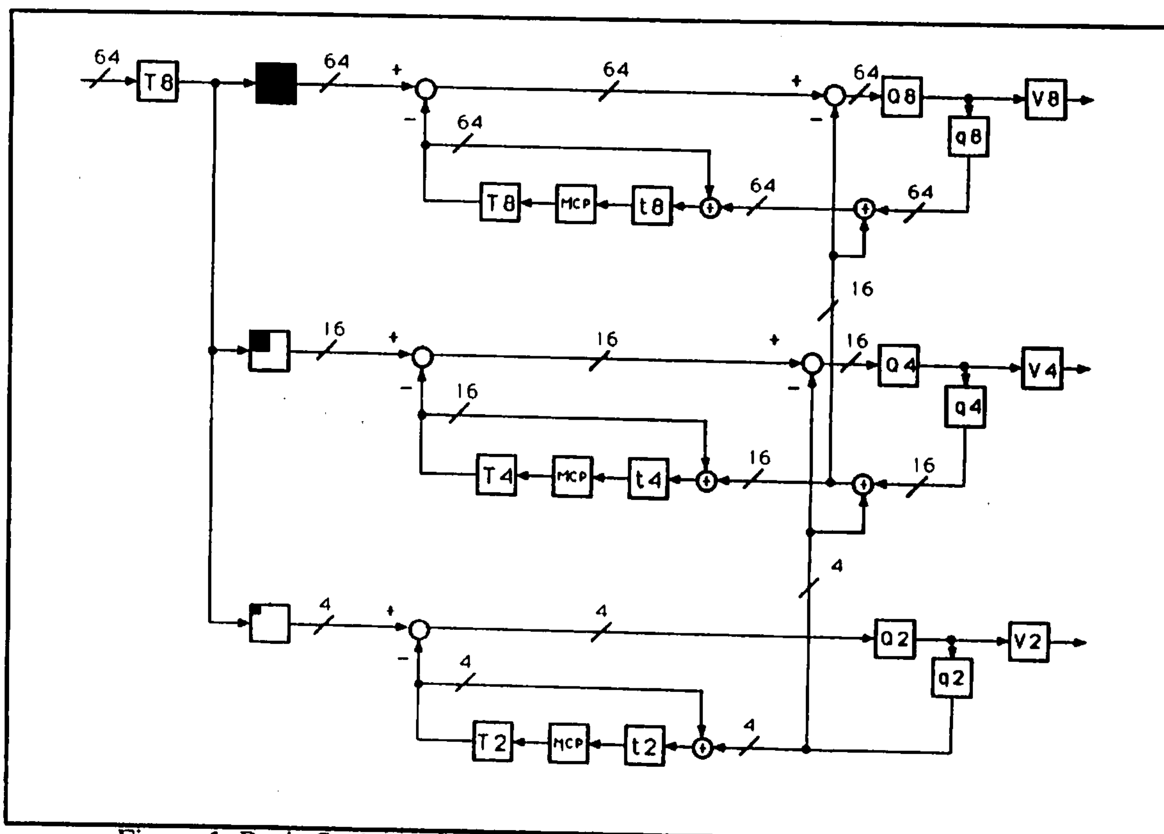


Figure 1. Basic Scalable Coder (Multi-loop encoder / Single-loop decoder).

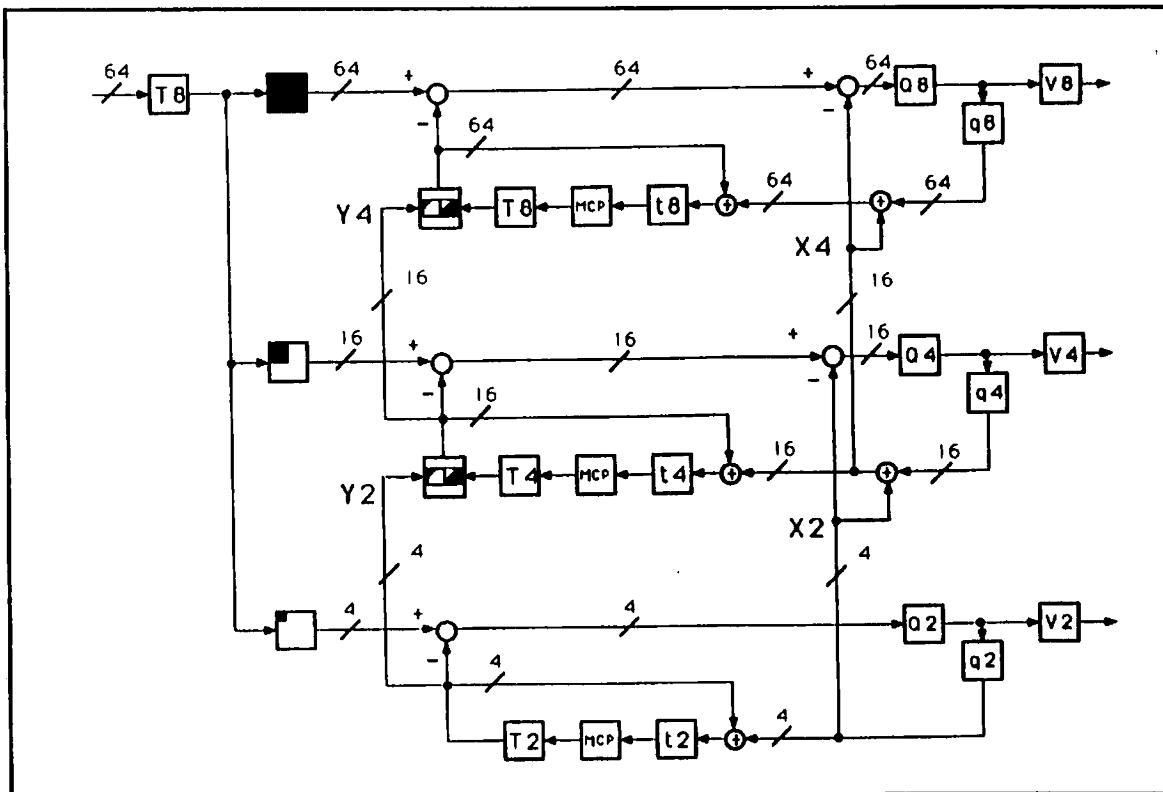


Figure 2. Basic Scalable Coder + Path_Y (Multi-loop encoder / Multi-loop decoder).

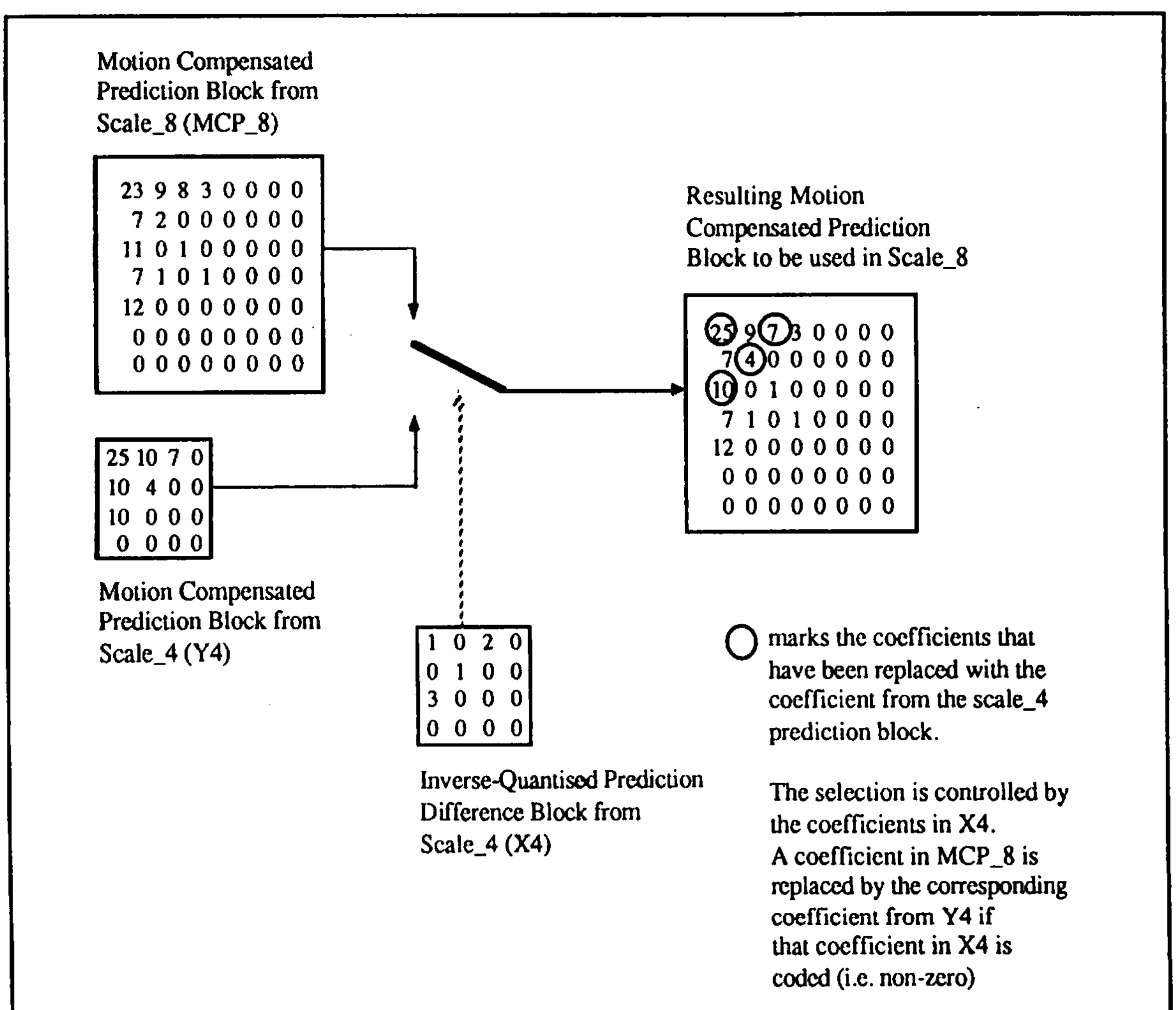


Figure 3. An example of the path_Y substitution for scale_8.

Appendix B. Table of results averaged over 94 frames.

		I. Single Layer	II. Basic Scalable Coder	III. Basic Scalable Coder + Path_Y	Improvement (III - II)
PSNR [dB]	Scale_8	28.92	26.81	27.81	1.00
	Scale_4		28.94	29.77	0.83
	Scale_2		33.56	33.50	-0.06
Bit rate [kbps]	Scale_8	3907	1470	1467	
	Scale_4		988	982	
	Scale_2		1495	1489	
	Total	3907	3953	3938	

Table 2. Flower Garden

		I. Single Layer	II. Basic Scalable Coder	III. Basic Scalable Coder + Path_Y	Improvement (III - II)
PSNR [dB]	Scale_8	28.56	26.32	27.44	1.12
	Scale_4		28.16	28.96	0.80
	Scale_2		33.32	33.24	-0.08
Bit rate [kbps]	Scale_8	3905	1460	1461	
	Scale_4		973	974	
	Scale_2		1460	1458	
	Total	3905	3893	3893	

Table 3. Mobile & Calendar

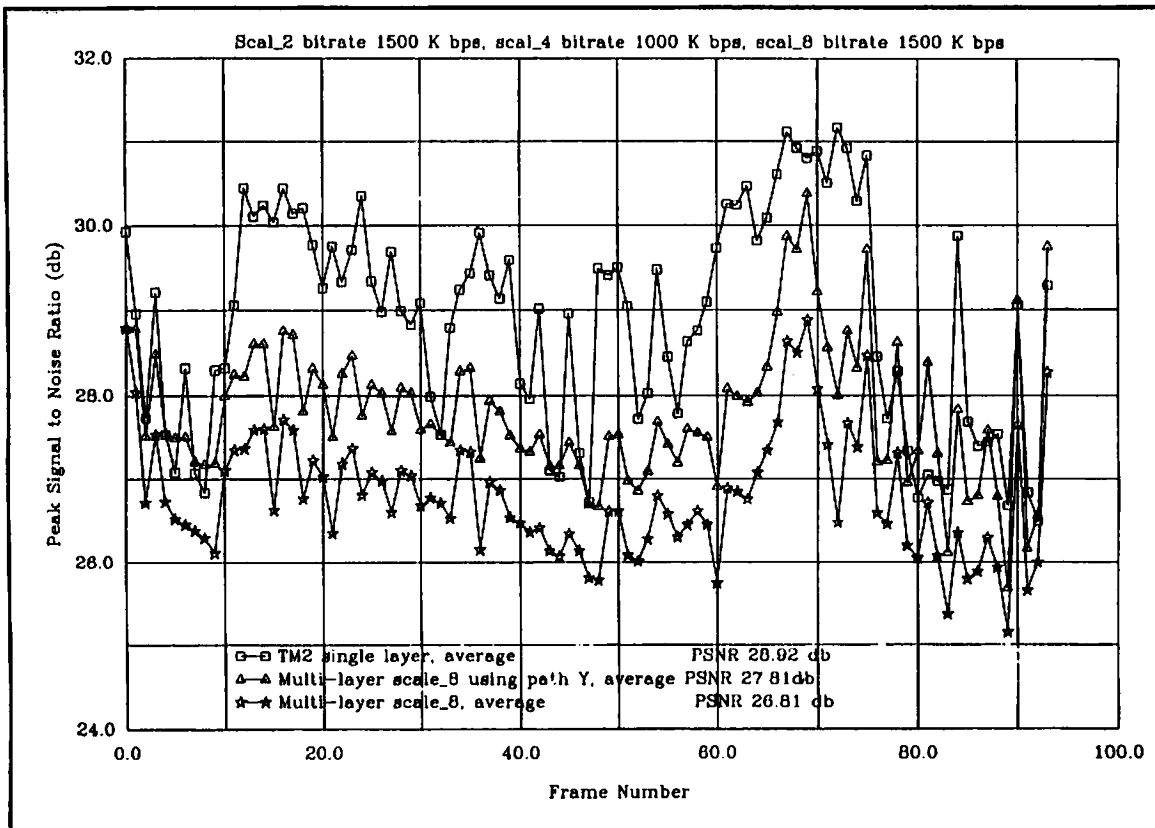
		I. Single Layer	II. Basic Scalable Coder	III. Basic Scalable Coder + Path_Y	Improvement (III - II)
PSNR [dB]	Scale_8	41.42	40.61	41.13	0.52
	Scale_4		42.20	42.64	0.44
	Scale_2		44.05	43.62	-0.43
Bit rate [kbps]	Scale_8	3914	1473	1473	
	Scale_4		980	980	
	Scale_2		1488	1488	
	Total	3914	3941	3941	

Table 4. Ballet

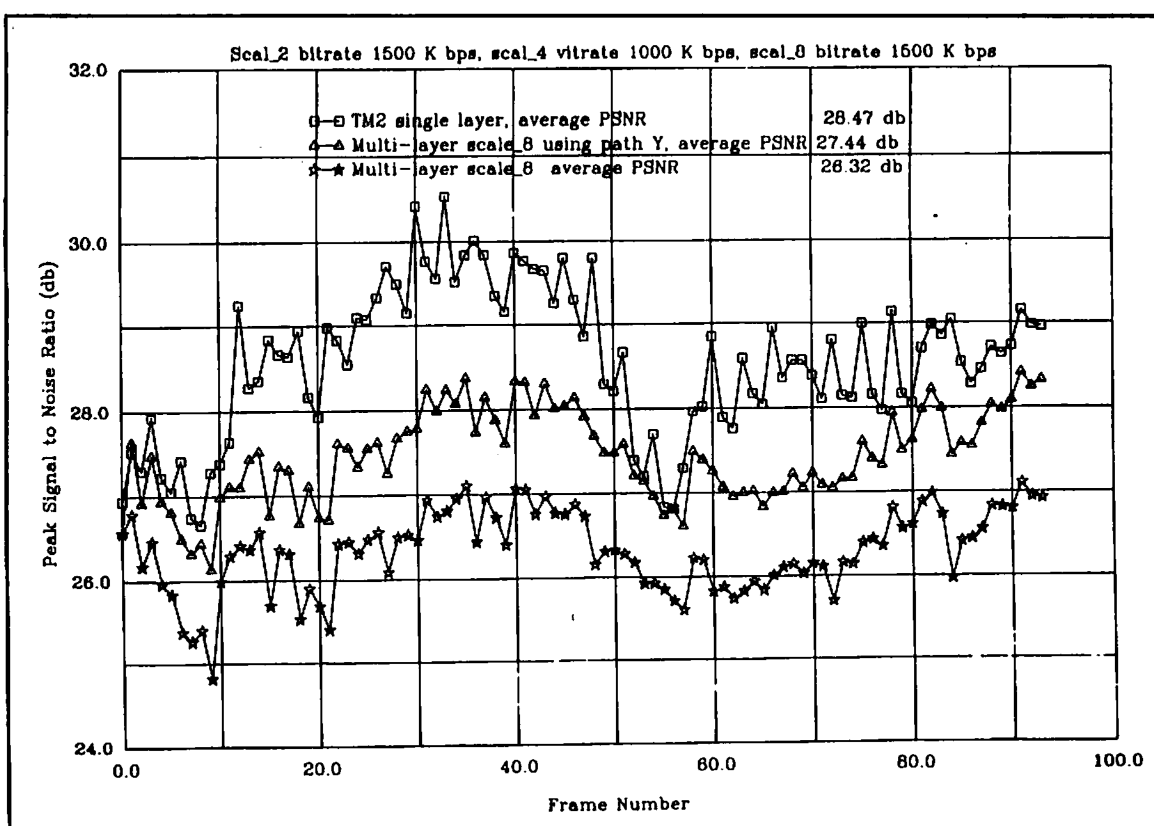
		I. Single Layer	II. Basic Scalable Coder	III. Basic Scalable Coder + Path_Y	Improvement (III - II)
PSNR [dB]	Scale_8	34.61	32.10	33.07	0.97
	Scale_4		34.50	35.41	0.91
	Scale_2		42.17	42.06	-0.11
Bit rate [kbps]	Scale_8	3912	1467	1470	
	Scale_4		979	979	
	Scale_2		1470	1464	
	Total	3912	3916	3913	

Table 5. Fountain & Rainbow

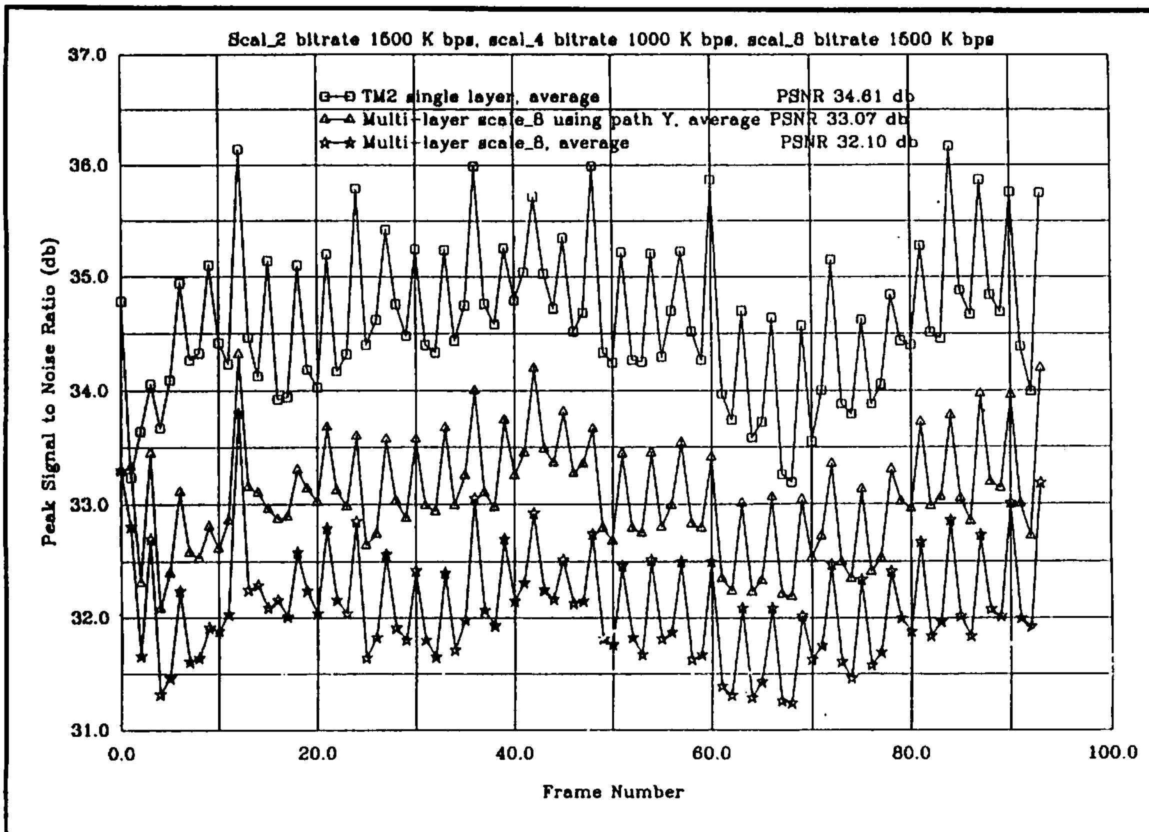
Appendix C. Plots of frame by frame PSNR.



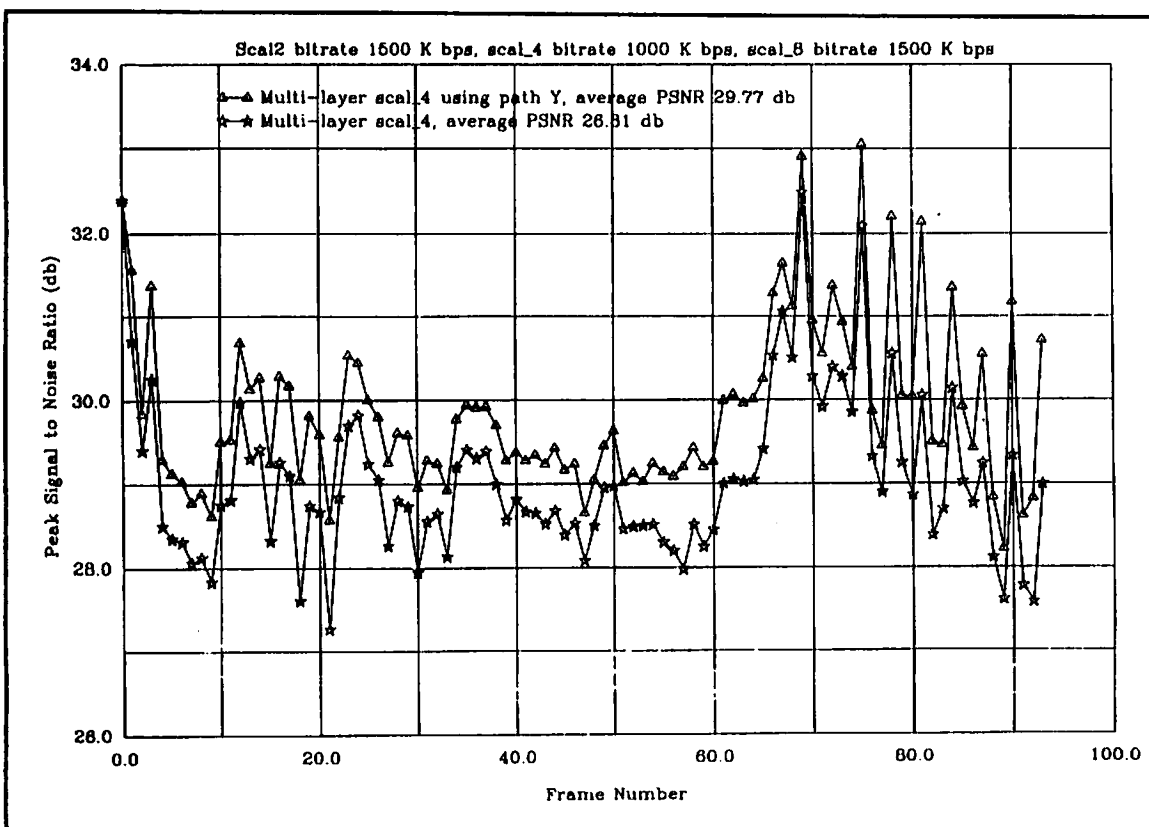
Graph 1. Flower Garden Scale_8



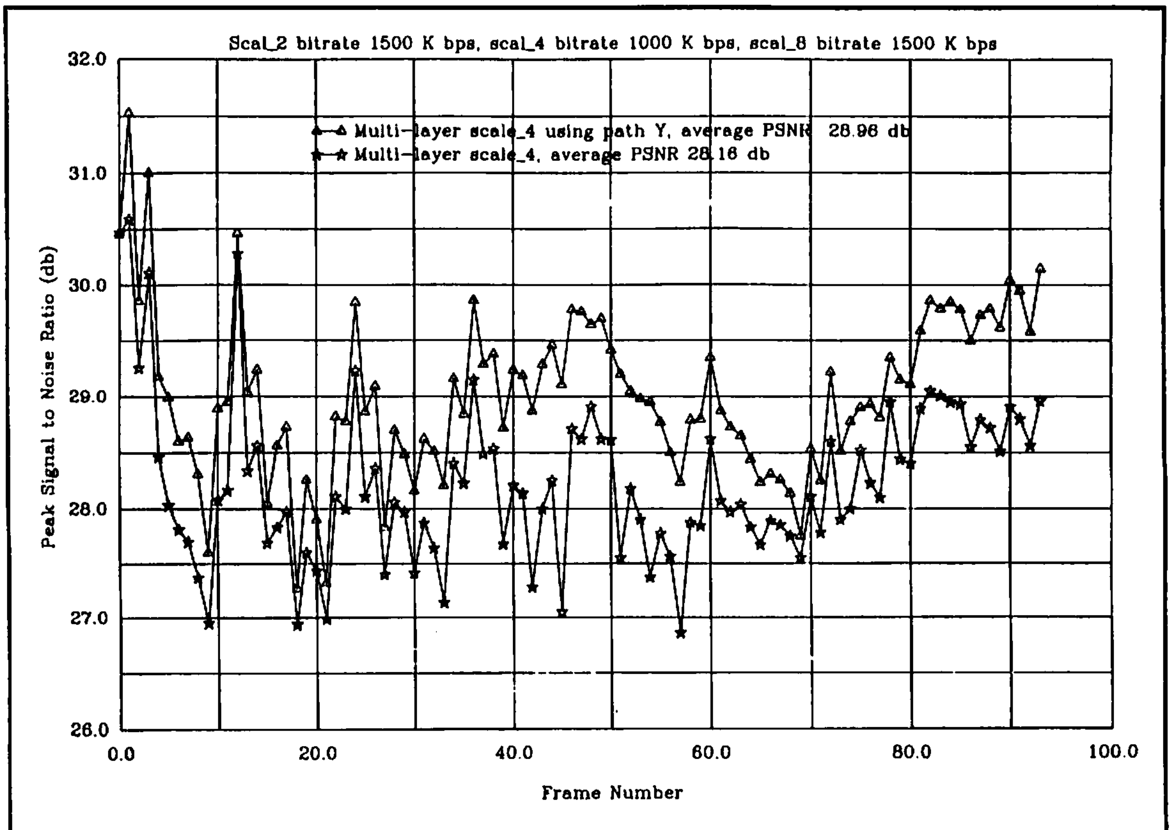
Graph 2. Mobile & Calendar Scale_8



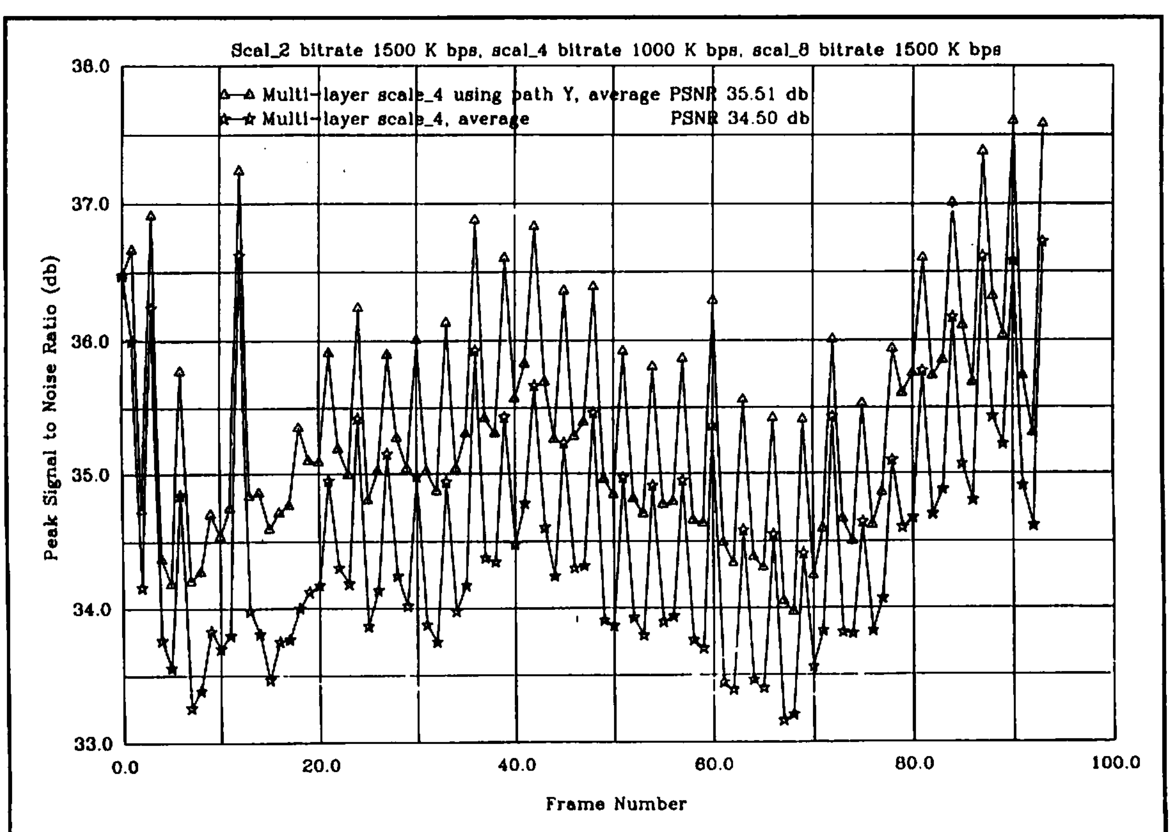
Graph 3. Fountain & Rainbow Scale_8



Graph 4. Flower Garden Scale_4



Graph 5. Mobile & Calendar Scale_4



Graph 6. Fountain & Rainbow Scale_4