EE6427-VIDEO SIGNAL PROCESSING Assignment

Msc CCA Yongqian Huang
Matric No. G1801127L

(1) Calculate two-dimensional transform by using row column decomposition method

$$\begin{bmatrix} 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 \\ 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 \\ 20 & 20 & 20 & 20 & 20 & 20 & 20 & 20 \\ 20 & 20 & 20 & 20 & 20 & 20 & 20 & 20 \\ 40 & 40 & 40 & 40 & 40 & 40 & 40 & 40 \\ 40 & 40 & 40 & 40 & 40 & 40 & 40 & 40 \\ 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 \\ 100 & 100 & 100 & 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$

First, the 1-D DCT of each row can be computed as:

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 100 \\ 100 \\ 100 \\ 100 \\ 100 \\ 100 \\ 100 \\ 100 \end{bmatrix} = \begin{bmatrix} 800 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Then we have: Transpose

$$\begin{bmatrix} 800 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 800 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 160 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 160 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 800 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 800 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Second, the 1-D DCT of each column can be computed as::

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 800 \\ 800 \\ 160 \\ 160 \\ 320 \\ 320 \\ 800 \\ 800 \end{bmatrix} = \begin{bmatrix} 4160 \\ 0 \\ 320 \\ 0 \\ -320 \\ 0 \\ 2240 \\ 0 \end{bmatrix}$$

Then we have the 2-D DCT :

$$\begin{bmatrix} 4160 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2240 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

After quantization, the 2-D DCT is tranformed as

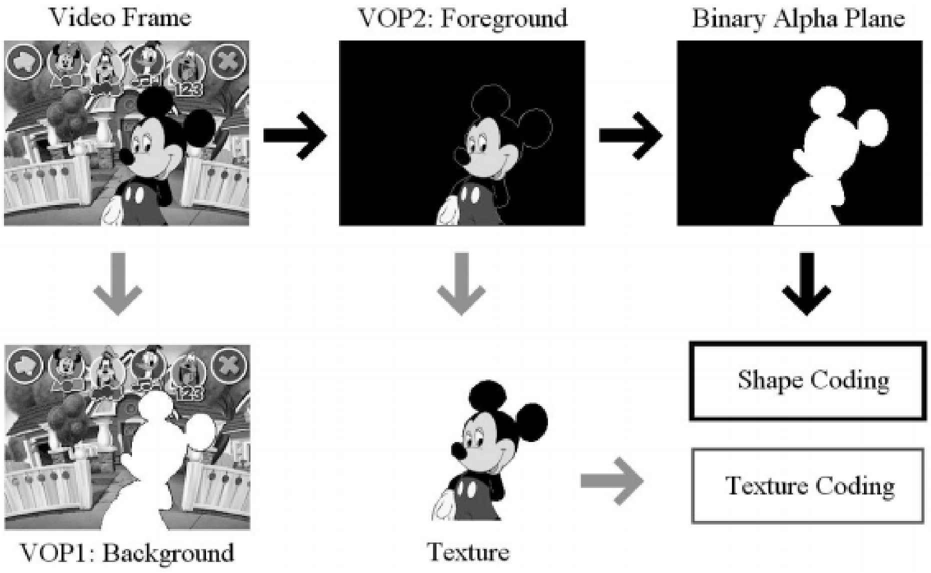
$$\begin{bmatrix} 260 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 22.8571 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -17.7778 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 45.7143 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

After zig-zag scanning, the one-dimensional outputis:

$$260,0,0,22.8571,0,0,0,0,0,0,-17.7778,0,0,0,0,0,0,0,0,0,0,45.7143,0,0,0,$$
$$0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0$$

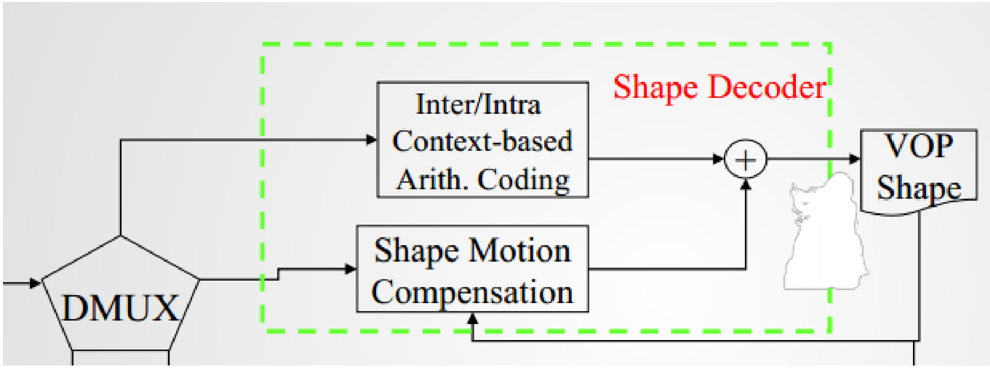
(2) Describe the shape decoding implementation with some simple diagrams and examples

MEPG-4 emphasizes the concept of visual objects (VO). Evey frame of the visual objects, called as the video object plane (VOP), consists of shape and texture information along with the optional motion information. As shown in the following figure, each video frame is decomposed into several VOs along with their composition information so that the decoder can put them together into a video scene.

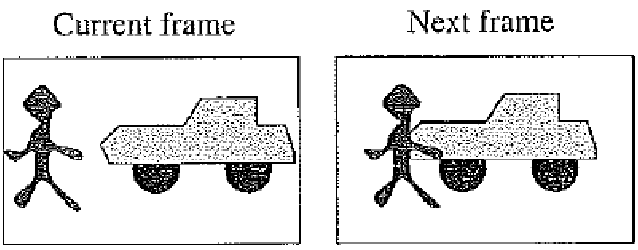


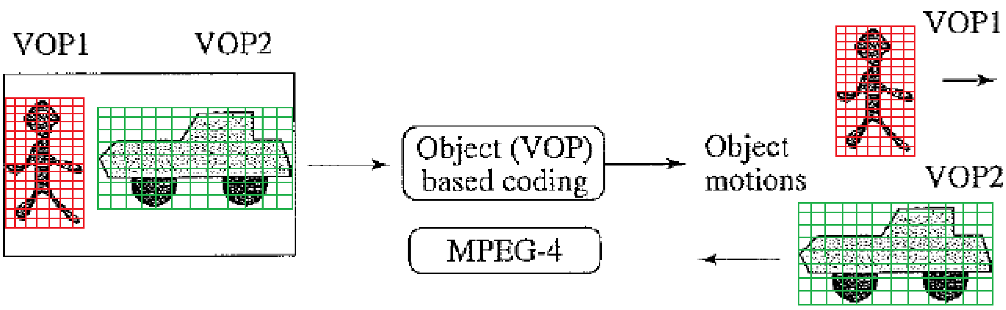
For the coding process of shape coding, the encoder divide the intra frames and inter frames into 16×16 binary alpha blocks (BABs) and applies the context-based arithmetic encoder (CAE) to encode.

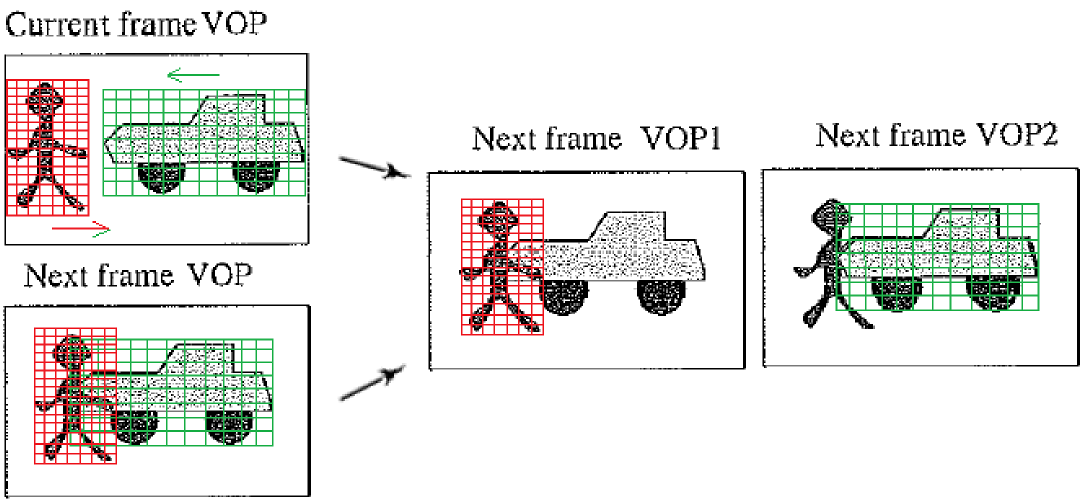
For the decoding process, as shown in the following flow diagram, the decoder decodes the CAE of the first received intra frame and combine all the BABs to obtain the shape of the target VOP. When the following inter frames come, apart from decoding the new shape from the CAE, the previous reference frame and the received moton vector are also employed to implement shape motion compensation, which is added with the decoded shape to gain the final shape of the VOP.



Take the following figures as an example. The current frame is referred as the reference frame, divided into the BABs and encoded with the CAE. The decoder then decodes the CAE to obtiain the shapes of the VOPs. For the next frame, apart from the same operation with the BABs and the CAE, previous reference frame and shape motion compensation are also applied to ontain the new shapes of the VOPs.

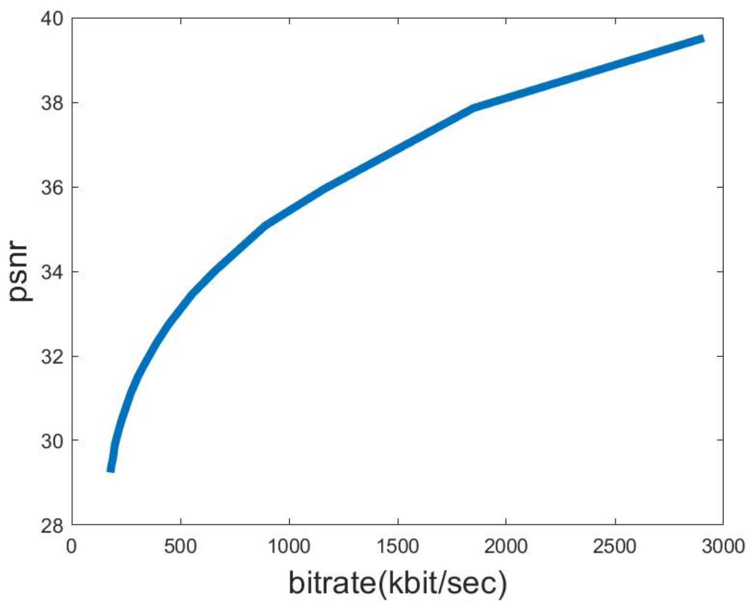




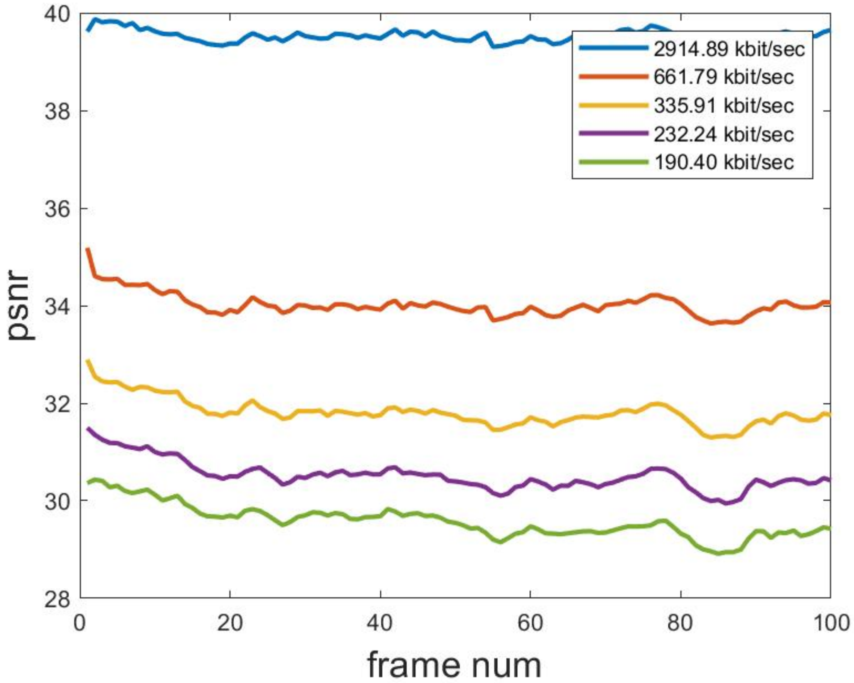


(3) Plot the PSNR curve by changing the quantization value at an H.263 encoder.

Q	Bitrate	PSNR
2	2914.89	39.5191
3	1852.97	37.8591
4	1162.16	35.9412
5	895.61	35.0823
6	661.79	34.0143
7	554.96	33.4517
8	446.19	32.7435
9	394.05	32.3311
10	335.91	31.8111
11	305.30	31.5080
12	272.05	31.1000
13	252.51	30.8320
14	232.24	30.5154
15	221.16	30.3105
16	206.66	30.0433
17	199.56	29.8744
18	190.40	29.5780
19	183.48	29.4290
20	177.55	29.2418



From the figure above, it can be obvious that the psnr is positive correlated with the bitrate. As the quantization parameter increases, the original video was deeper compressed and less bitrate is required to represent the data. Meanwhile, the loss of information will bring noise into the decoded video and give rise to the smaller psnr.



In accord with previous conclusion, higher bitrate always obtain higher PSNR performance in all the frames.

(4) Arithmetic Coding: 'HUANG YON'

Character	Probability	Interval (Range)
SPACE	1/9	[0.00-0.11)
A	1/9	[0.11-0.22)
G	1/9	[0.22-0.33)
H	1/9	[0.33-0.44)
N	2/9	[0.44-0.66)
O	1/9	[0.66-0.77)
U	1/9	[0.77-0.88)
Y	1/9	[0.88-0.99)

New Character	Low Value	High Value
	0.0	1.0
H	0.33	0.44
U	0.4147	0.4268
A	0.416031	0.417362
N	0.41661664	0.41690946
G	0.4166810604	0.4167132706
SPACE	0.4166810604	0.416684603522
Y	0.41668417834736	0.41668456809078
O	0.416684435578017	0.416684478449793
N	0.416684454441599	0.416684463873390

The final low value 0.416684454441599 represents the message "HUANG YON" .

(5) Two-stage Haar Wavelet Transform

"HUANG YONGQIAN G1801127L" the corresponding ASCII codes for the first 16 values are "72 85 65 78 71 32 89 79 78 71 81 73 65 78 32 71".

72	85	65	78
71	32	89	79
78	71	81	73
65	78	32	71

Stage1

Apply 1D row Haar Wavelet Transform for 4 rows (Decomposition on rows).

78.5	71.5	-6.5	-6.5
51.5	84.0	19.5	5.0
74.5	77.0	3.5	4.0
71.5	51.5	-6.5	-19.5

Apply 1D column Haar Wavelet Transform for 4 columns (Decomposition on columns).

65.0	77.75	6.5	-0.75
73.0	64.25	-1.5	-7.75
13.5	-6.25	-13.0	-5.75
1.5	12.75	5.0	11.75

Stage2

Apply 1D row Haar Wavelet Transform for 4 rows (Decomposition on rows).

71.3750	2.8750	-6.3750	3.6250
68.6250	-4.6250	4.3750	3.1250
3.6250	-9.3750	9.8750	-3.6250
7.1250	8.3750	-5.6250	-3.3750

Apply 1D column Haar Wavelet Transform for 4 columns (Decomposition on columns).

70	-0.8750	-1	3.3750
5.3750	-0.5000	2.1250	-3.500
1.3750	3.7500	-5.3750	0.2500
-1.7500	-8.8750	7.7500	-0.1250