ELEC S347F Multimedia Technologies,
Spring Term, 2021
Tutorial 05 Solution

Question 1: Given the following display order of a group of frames in MPEG-1 video:

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Type	I	B	B	P	B	B	B	P	I	B	B	B	P	B	P	P

(a) Determine the transmission (decoding) order of the frames.

(b) Find the minimum playback delay of the frames if this is a stored video.

(c) Find the minimum playback delay of the frames if this is a real-time video.

(d) Find the no. of groups of pictures (GOPs)

(e) Determine which of them are closed GOPs and open GOPs.

(f) Determine which frame(s) are sufficiently required to decode frame x?

  (i)   x = 2

  (ii) x = 6

  (iii) x = 8

  (iv) x = 9

(g) Suppose there is an error in decoding frame x, determine which of the other frames may possibly suffered from error directly and indirectly?

  (i)   x = 2

  (ii) x = 1

  (iii) x = 8

(h) Suppose the following frames are removed from the video, explain whether it would any cause problem in decoding the remaining frames or not? If yes, suggest how to solve it by a minimal modification to the frame structure.

  (i)   Frames [5, 8]

  (ii) Frames [9, 13]

(a) The transmission (decoding) order is

No.	1	4	2	3	8	5	6	7	9	13	10	11	12	15	14	16
Type	I	P	B	B	P	B	B	B	I	P	B	B	B	P	B	P

(b) Playback delay = 1 frame

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
No.	1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Type	I	-	B	B	P	B	B	B	P	I	B	B	B	P	B	P	P

(c) The encode and display orders are respectively:

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No.	1			4	2	3		8	5	6	7	9	13	10	11	12	15	14	16	
Encode	I	-	-	P	B	B	-	P	B	B	B	I	P	B	B	B	P	B	P	
Display	I	-	-	-	B	B	P	-	B	B	B	P	I	B	B	B	P	B	P	P

  Playback delay = 3 + 1 = 4 frames

(d) 2 GOPs: [1, 8], [9, 16]

(e) Both are closed GOPs.

(f) (i) 1 and 4, (ii) 4 and 8, (iii) 4, (iv) none

(g) (i) directly: no; indirectly: no, (ii) directly: 2, 3, 4; indirectly: 5, 6, 7, 8 (iii) directly: 5, 6, 7; indirectly: no

(h) (i) no problem since no other frames reference [5, 8]

(ii) yes since frames 14 and 15 reference frame 13 directly. Solution change frame 14 from B-frame to I-frame, and change frame 15 (P-frame) to reference from frame 14 (I-frame).

Question 2: If the following sequence of MPEG-1 video frames are read from a disc:

1, 4, 2, 3, 7, 5, 6, 10, 8, 9 *(The numbers represent the frame ID in display order)*

(a) Which of the frames are B-Frames?

(b) Can you identify which of the frames are P frames?

(a) 2, 3, 5, 6, 8, 9

(b) No. It is not possible.

Question 3: A multimedia presentation must be delivered over a channel at a rate of 1.5 Mbps. The presentation consists of digitized audio and video to be compressed using the MPEG-1 standard. Given that the audio has an average bit rate of 300 kbps. The video is in PAL format (spatial resolution of 352x288, 4:2:0 Chroma subsampling and frame rate of 25 fps). The average compression ratios of I-Frame and P-Frame are 10:1 and 20:1 respectively. There are 15% overheads for packetization of the video. Assuming the video frame has a fixed sequence of 12 frames:

$I\ B\ B\ P\ B\ B\ P\ B\ B\ P\ B\ B\ I\ .\ .$

What is the compression ratio required for the B-frame to ensure the desired delivery rate?

Desired data rate = 1.5 Mbps

Desired video rate = desired data rate - audio rate = 1.5 – 0.3 = 1.2 Mbps

Targeted video rate = desired video Rate / overhead = 1.2 / 1.15 = 1.044 Mbps

Raw frame size (after Chroma subsampling) = 352x288x8 + (352x288/4)x8 + (352x288/4)x8 = 1,216,512 bits

Each GOP has 12 Frame: 1x I-Frame, 3xP-Frames and 8xB-Frames

Average frame rate = (1x0.1 + 3x0.05 + 8xR)/12 = (0.25+8R)/12

We require: 1,216,512 x 25 x (0.25+8R)/12 = 1,044,000

$\Rightarrow$ (0.25 + 8R) = 0.412

$\Rightarrow$ 8R = 0.16

$\Rightarrow$ R = 0.02

Therefore, the required compression ratio for B-Frame is 50:1.