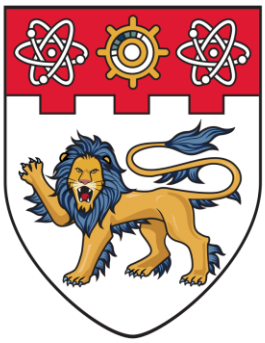

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EE6427 VIDEO SIGNAL PROCESSING

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(1) Calculate two-dimensional transform of figure 1 by using row-column decomposition method with the basis function in figure 2, please show all the intermediate steps to obtain the final result.

$$\begin{pmatrix} 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 20 & 20 & 20 & 20 & 20 & 20 & 20 & 20 \\ 20 & 20 & 20 & 20 & 20 & 20 & 20 & 20 \\ 40 & 40 & 40 & 40 & 40 & 40 & 40 & 40 \\ 40 & 40 & 40 & 40 & 40 & 40 & 40 & 40 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \end{pmatrix}$$

Figure 1

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{pmatrix}$$

Figure 2

if the quantization matrix on page 6 of the lecture note "JPEG" is used, calculate the quantization output. What is the one-dimensional output after zig-zag scanning?

(20 marks)

1. Figure 1 matrix which is multiplied to Figure 2 as taken as column which gives

The first row of figure 1 is multiplied with figure 2 which gives the first-row output and transforms as column to get an output

$$A = \begin{pmatrix} 80 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 80 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 160 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 160 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 80 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 80 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

2. for row multiplication figure 1 is multiplied to A

$$B = \begin{pmatrix} 1280 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -320 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -640 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Quantization Output

The B output matrix after row column decomposition it is divided by element wise

$$\text{By } Z(u,v) = \begin{pmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{pmatrix}$$

F(u,v) = B / (QF * Z (u,v))

QF = 1

$$F(u,v) = \begin{pmatrix} 80 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 23 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -18 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -13 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

After Zigzag coding

$$[80 \;\; 0 \;\; 0 \; 23 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \; -18 \;\; 0 \;\; 0 \;\; 0 \; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \; -13 \; 0 \cdots 0]_{1x64}$$

(2) Define a character string using YOUR FULL NAME as appearing in Matriculation Card (all in capital letters and remove all spaces in your name) and follow by “VIDEOSIGNALP”. Use arithmetic coding method in the lecture note “compression fundamental” to encode the first 8 letters of the character string. Show the steps of the divisions of the interval during arithmetic encoding the character string, and show the codeword produced by the encoding procedure. For example, "CHA TAI" should encode "CHATAIVI". You need to use YOUR FULL NAME as appearing in Matriculation Card (all in capital letters and remove all spaces in your name). And assign the interval (range) in alphabetical order. E.g. "A" should be assigned as the first letter in the interval. (please refer to the example in the lecture note). (Zero mark will be given if you don’t follow the rule.) (20 marks)

Answer;

Name: **NARAYANA**

LETTER	NO OF REPETITION	PROBABILITY	LOWER LIMIT	UPPER LIMIT
A	4	0.5	0.0	0.5
N	2	0.25	0.5	0.75
R	1	0.125	0.75	0.875
Y	1	0.125	0.875	1.0

Formula

Difference = upper limit of previous letter – lower limit previous letter

Range = (Lower limit of previous letter, Upper limit + difference * Probability of the Letter)

Name: NARAYANA

FIRST LETTER N

Letter	Lower Limit	Upper Limit
N	0.5	0.75

Second Letter A

Difference = 0.75 – 0.25 = 0.25

Range = (0.5,0.5 + (0.25 *0.5))

= (0.5,0.625)

Letter	Lower Limit	Upper Limit
A	0.5	0.625

Third letter R

Difference = 0.625 – 0.5

A -> Range = (0.5,0.5+(0.125*0.5)) = (0.5,0.5625)

N -> Range = (0.5625,0.5625 + (0.125*0.25)) = (0.5625, 0.59375)

R -> Range = (0.59375,0.59375 +(0.125*0.125)) = (0.59375,0.609375)

Letter	Lower Limit	Upper Limit
R	0.59375	0.609375

Fourth letter A

Difference = 0.609375 - 0.59375 = 0.015625

A-> Range = (0.59375, 0.59375 + (0.015625 * 0.5)) = (0.59375,0.6015625)

Letter	Lower Limit	Upper Limit
A	0.59375	0.6015625

Fifth Letter Y

Difference = 0.6015625 – 0.59375 = $7.8125 * 10^{-3}$

A -> Range = (0.59375, 0.59375+ ($7.8125 * 10^{-3} * 0.5$)) = (0.59375, 0.59765625)

N -> Range = (0.59765625, 0.59765625 + ($7.8125 * 10^{-3}$*0.25))

= (0.59765625, 0.599609375)

R -> Range = (0.599609375, 0.599609375 + ($7.8125 * 10^{-3}$*0.125))

= (0.599609375, 0.6005859375)

Y -> Range = (0.6005859375, 0.6005859375 + ($7.8125 * 10^{-3}$ *0.125))

= (0.6005859375, 0.6015625)

Letter	Lower Limit	Upper Limit
Y	0.6005859375	0.6015625

Sixth letter A

Difference = 0.6015625 - 0.6005859375 = $9.765625 * 10^{-4}$

A -> Range = (0.6005859375, 0.6005859375 + ($9.765625 * 10^{-4}$*0.5))

= (0.6005859375, 0.6010742188)

Letter	Lower Limit	Upper Limit
A	0.6005859375	0.6010742188

Seventh letter N

Difference = 0.6010742188 - 0.6005859375 = $4.882813 * 10^{-4}$

A -> Range = (0.6005859375, 0.6005859375 + ($4.882813 * 10^{-4}$*0.5))

= (0.6005859375, 0.6008300782)

N -> Range = (0.6008300782, 0.6008300782 + ($4.882813 * 10^{-4}$*0.25))

= (0.6008300782, 0.6009521485)

Letter	Lower Limit	Upper Limit
N	0.6008300782	0.6009521485

Eighth letter A

Difference = 0.6009521485 - 0.6008300782 = $1.220703 * 10^{-4}$

A -> Range = (0.6009521485, 0.6009521485 + ($1.220703 * 10^{-4}$*0.5))

= (0.6009521485, 0.6008911134)

Letter	Lower Limit	Upper Limit
A	0.6009521485	0.6008911134

Letter	Lower Limit	Upper Limit
N	**0.5**	**0.75**
A	**0.5**	**0.625**
R	**0.59375**	**0.609375**
A	**0.59375**	**0.6015625**
Y	**0.6005859375**	**0.6015625**
A	**0.6005859375**	**0.6010742188**
N	**0.6008300782**	**0.6009521485**
A	**0.6009521485**	**0.6008911134**

The final low value, **0.6009521485** representing the message "**NARAYANA**" using this encoding scheme

decoding

(0.6009521485 – 0.5) -> **N**

0.1009521485/0.25 = 0.403808594

(0.403808594 – 0.0) -> **A**

0.403808594/0.5 = 0.807617188

(0.807617188 – 0.75) -> **R**

= 0.057617188 / 0.125 = 0.460937504

(0.460937504 – 0.0) -> **A**

0.460937504/0.5 = 0.921875008
0.921875008 – 0.875 = 0.046875008 -> **Y**
0.046875008/0.125 = 0.375000064
0.375000064 – 0.0 -> **A**
0.375000064/0.5 = 0.750000128
0.750000128 – 0.5 -> **N**
$1.28 * 10^{-7}/0.25 = 2.56 * 10^{-7}$
$2.56 * 10^{-7} – 0$ -> **A**

(3) Define a character string using YOUR FULL NAME as appearing in Matriculation Card (all in capital letters and remove all spaces in your name) and follow by "VIDEOSIGNALP". Please remove all spaces in the string and let "A"=1, "B"=2, …, "Y"=25, "Z"=26 as an input to fill up the following 4x4 matrix. (Zero mark will be given if you don't follow the rule.)
For example : If YOUR FULL NAME as appearing in Matriculation Card, e.g. "CHA TAI", the 16 letters are "CHATAIVIDEOSIGNA" the corresponding numbers for the first 16 letters are " 3 8 1 20 1 9 22 9 4 5 15 19 9 7 14 1"

3	8	1	20
1	9	22	9
4	5	15	19
9	7	14	1

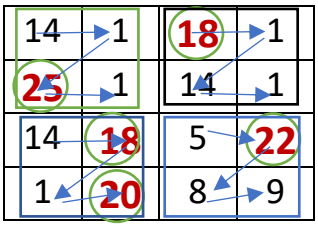
Let the 4x4 matrix (obtained from above) be a two-level discrete wavelet transform decomposition result. Applying the EZW coding scheme to the wavelet coefficients and show the encoding result. Note that four symbols in dominant pass for EZW are T (zerotree root), Z (isolated zero), P (positive) and N (negative) respectively.

(20 marks)

Answer:
Name: NARAYANANREVATHI
[14 1 18 1 25 1 1 14 1 14 18 5 22 1 20 8 9]

14	1	18	1
25	1	14	1
14	18	5	22
1	20	8	9

FIRST LIMIT 16 – 32

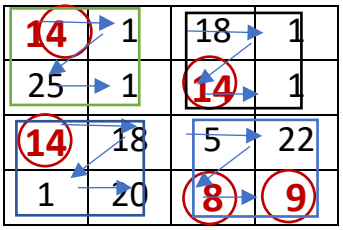


D1: TZPZ PTTT TPTP TPTT

18	25	18	22	20
1	1	1	1	1
0	1	0	0	0
1	0	1	1	1
0	0	1	1	0
0	1	0	0	0

S1 : 01000

SECOND LIMT 8 – 15

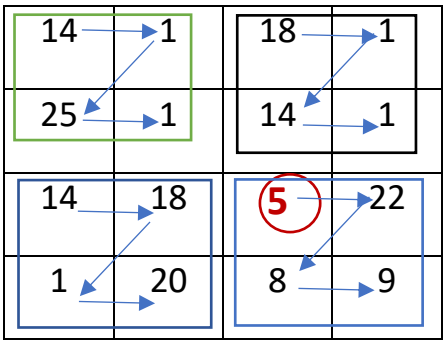


D2: PZZZ ITPT PTTT TTPP

18	25	18	22	20	14	14	14	8	9
1	1	1	1	1	0	0	0	0	0
0	1	0	0	0	1	1	1	1	1
1	0	1	1	1	1	1	1	0	0
0	0	1	1	0	1	1	1	0	0
0	1	0	0	0	0	0	0	0	1

S2: 1011111100

Third Limit 4 – 7



D3: TTTZ ITTT TTTT ZTTT

18	25	18	22	20	14	14	14	8	9	5
1	1	1	1	1	0	0	0	0	0	0
0	1	0	0	0	1	1	1	1	1	0
1	0	1	1	1	1	1	1	0	0	1
0	0	1	1	0	1	1	1	0	0	0

0	1	0	0	0	0	0	0	0	1	1

S3: 0011 0111 000

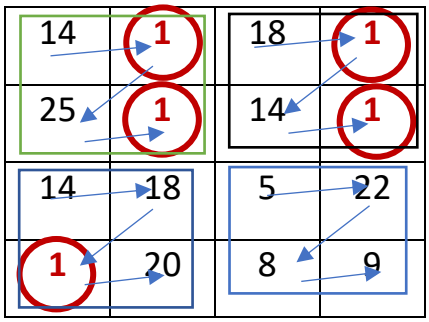
FIFTH LIMIT 2-3

14	1	18	1
25	1	14	1
14	18	5	22
1	20	8	9

D4 : ZTTT

Nothing is in the range of 2-3 so it is ZTTT

SIXTH LIMIT 0 -1



D5: TPZP TPTP TTPT TTTT

(4) Plot the rate distoration curve by changing the parameters at an H.263 encoder. To do this question, you need to **explore the option of the tmn software by yourself.**

- Use the "football_cif.yuv" (can be obtained from ntulearn site) sequence of first 150 frames.
- Use tmn.exe (Unzip from h263.zip. It is a DOS program which requires to execute on command prompt) to generate the result.
- Perform experiments with different quantization parameters, try at least 20 different QPs to obtain meaning results.

Discuss your results based on the reconstructed video quality and the MSE obtained. You may need to write a program to calculate the overall PSNR and MSE, where x_i are the original pixels and $\hat{x}_i$ are the reconstructed pixels obtained from tmndec. Please show all the steps to obtain the results.

Plot the PSNR-Y against various bitrate as shown in figure 3.

Figure 3

Plot the MSE-Y against various bitrate as shown in figure 4.

Figure 4

Fix the bitrate to different values (at least 5 different bitrates), plot the MSE-Y against frame number as shown in the following figure 5.

Figure 5

Please comment on your results.

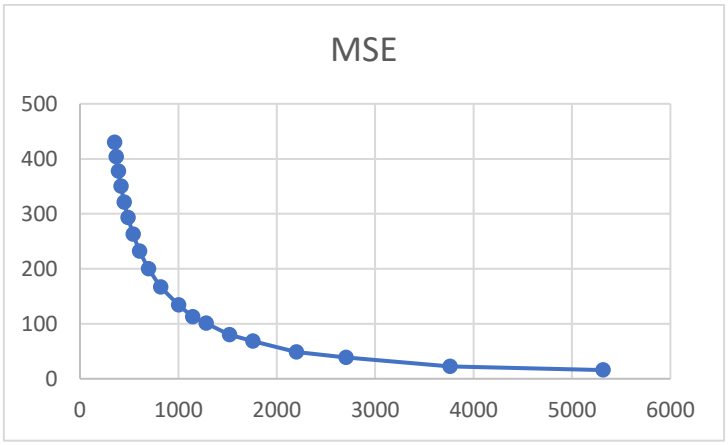
(40 marks)

Answer

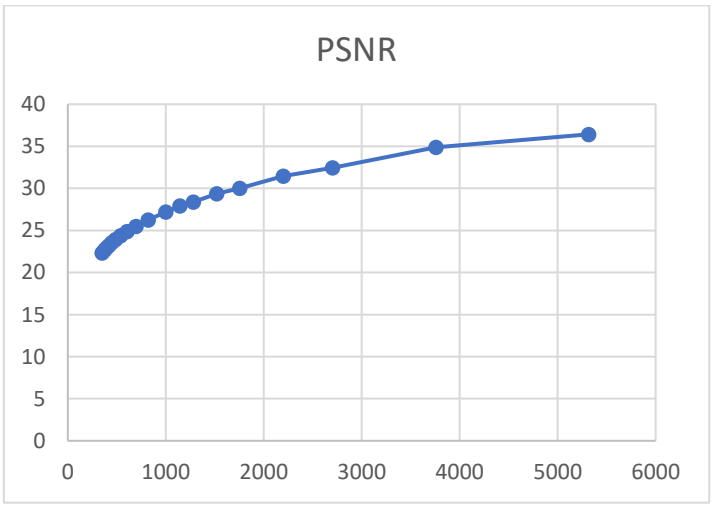
encoding				
QP	Bitrate	MSE	PSNR	
2	5315.07	15.8399	36.4233	tmn -i football_cif.yuv -B f_qp_2.263 -a 0 -b 149 -x 3 -q 2 -S 0
3	3759	22.2542	34.8972	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_3.263 -q 3
4	2701.97	39.0088	32.4441	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_4.263 -q 4
5	2199.28	48.7436	31.4775	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_5.263 -q 5
6	1755.88	68.505	30.0231	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_6.263 -q 6
7	1518.24	79.9667	29.3597	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_7.263 -q 7
8	1281.07	100.8244	28.3854	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_8.263 -q 8
9	1144.64	112.9422	27.9036	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_9.263 -q 9
10	1000.27	134.0587	27.1814	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_10.263 -q 10
12	820.46	166.9903	26.2581	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_12.263 -q 12
14	695.72	200.0246	25.5027	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_14.263 -q 14
16	605.78	231.8404	24.8928	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_16.263 -q 16
18	539.12	262.9487	24.369	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_18.263 -q 18
20	488.66	293.1213	23.9215	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_20.263 -q 20
22	448.11	321.2475	23.5473	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_22.263 -q 22
24	416.07	350.2566	23.1836	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_24.263 -q 24
26	390.34	377.5918	22.8685	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_26.263 -q 26
28	368.39	403.5221	22.6077	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_28.263 -q 28
30	351.11	430.0369	22.3374	tmn -i football_cif.yuv -a 0 -b 149 -x 3 -S 0 -B f_qp_30.263 -q 30

decoding
tmndec -o5 -l f_qp_2.263 qp2.yuv
tmndec -o5 -l f_qp_3.263 qp3.yuv
tmndec -o5 -l f_qp_4.263 qp4.yuv
tmndec -o5 -l f_qp_5.263 qp5.yuv
tmndec -o5 -l f_qp_6.263 qp6.yuv
tmndec -o5 -l f_qp_7.263 qp7.yuv
tmndec -o5 -l f_qp_8.263 qp8.yuv
tmndec -o5 -l f_qp_9.263 qp9.yuv
tmndec -o5 -l f_qp_10.263 qp10.yuv
tmndec -o5 -l f_qp_12.263 qp12.yuv
tmndec -o5 -l f_qp_14.263 qp14.yuv
tmndec -o5 -l f_qp_16.263 qp16.yuv
tmndec -o5 -l f_qp_18.263 qp18.yuv
tmndec -o5 -l f_qp_20.263 qp20.yuv
tmndec -o5 -l f_qp_22.263 qp22.yuv
tmndec -o5 -l f_qp_24.263 qp24.yuv
tmndec -o5 -l f_qp_26.263 qp26.yuv
tmndec -o5 -l f_qp_28.263 qp28.yuv
tmndec -o5 -l f_qp_30.263 qp30.yuv

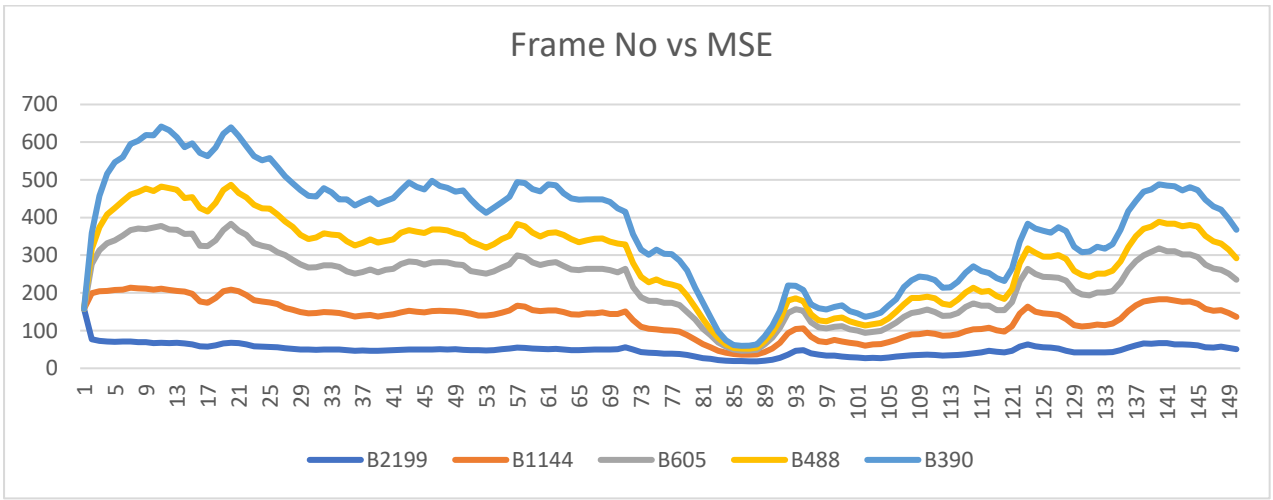
Using the matlab to read the yuv file looping over 150 frames calculating mean mse and PSNR for Y



Bitrate inversely proportional to MSE



Bit rate is Directly proportional to PSNR



As the Bitrate increases the quality of the video increases by having low MSE values