EE6427- Video Signal Processing Assignment 1

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（1） Calculate two-dimensional transform

$$\begin{bmatrix} 10,10,10,10,10,10,10,10 \\ 10,10,10,10,10,10,10,10 \\ 20,20,20,20,20,20,20,20 \\ 20,20,20,20,20,20,20,20 \\ 40,40,40,40,40,40,40,40 \\ 40,40,40,40,40,40,40,40 \\ 10,10,10,10,10,10,10,10 \\ 10,10,10,10,10,10,10,10 \end{bmatrix}$$

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

1、 Row transform:

$$\begin{bmatrix} 80,0,0,0,0,0,0,0 \\ 80,0,0,0,0,0,0,0 \\ 160,0,0,0,0,0,0,0 \\ 160,0,0,0,0,0,0,0 \\ 320,0,0,0,0,0,0,0 \\ 320,0,0,0,0,0,0,0 \\ 80,0,0,0,0,0,0,0 \\ 80,0,0,0,0,0,0,0 \end{bmatrix}$$

2、 Column transform：

$$\begin{bmatrix} 1280,0,0,0,0,0,0,0 \\ 0,0,0,0,0,0,0,0 \\ 320,0,0,0,0,0,0,0 \\ 0,0,0,0,0,0,0,0 \\ -320,0,0,0,0,0,0,0 \\ 0,0,0,0,0,0,0,0 \\ -640,0,0,0,0,0,0,0 \\ 0,0,0,0,0,0,0,0 \end{bmatrix}$$

3、 Quantization:

$$
\begin{bmatrix}
80,0,0,0,0,0,0,0 \\
0,0,0,0,0,0,0,0 \\
23,0,0,0,0,0,0,0 \\
0,0,0,0,0,0,0,0 \\
-18,0,0,0,0,0,0,0 \\
0,0,0,0,0,0,0,0 \\
-13,0,0,0,0,0,0,0 \\
0,0,0,0,0,0,0,0
\end{bmatrix}
$$

4、 Zigzag scaning:

[80,0,0,23,0,0,0,0,0,0,-18,0,0,0,0,0,0,0,0,0,0,-13,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]

（2） Arithmetic coding:

Name:WEIZHIFE

Distribution:

Character	Probability	Interval
E	2/8	[0.00 ~0.25)
F	1/8	[0.25 ~0.375)
H	1/8	[0.375 ~0.5)
I	2/8	[0.50 ~0.75)
W	1/8	[0.75 ~0.875)
Z	1/8	[0.875 ~1.0)

Coding:

character	Low	High
W	0.75	0.875
E	0.75	0.78125
I	0.765625	0.7734375
Z	0.77246094	0.7734375
H	0.7728271484	0.7729492188
I	0.7728881836	0.7729187012
F	0.772895813	0.7728996277
E	0.772895813	0.7728967667

The encoding numbers is:

0.772895813

（3） EZW:

Sequence: WEIZHIFENGVIDEOS

23	5	9	26
8	9	6	5
14	7	22	9
4	5	15	19

Max =26 ; T0=16 ; range: 16-32
D1: PZTZ TPTT PTTP
S1: 0100
range: 8-15
D2: ZZPP PTTT PTTT TPPT
S2:1010000101
Range: 4-7
D3: ZPZT TTPP TPPP
S3:111100010101000
Range:2-3
D4: ZTTT
S4:100101101110101
Range:0-1:
D5: ZTTT

（4） PSNR:

1、I use tmn.exe to encode the first 150 frame of football_cif.yuv.

Command: .\tmn.exe -i ..\football_cif.yuv -a 0 -b 149 -x 3 -O 0 -S 0 -I 1 -q 1 -B QP1.bits -o QP1.yuv

The quantization parameter is set from 1 to 21

2、The corresponding bitrate is as follow:

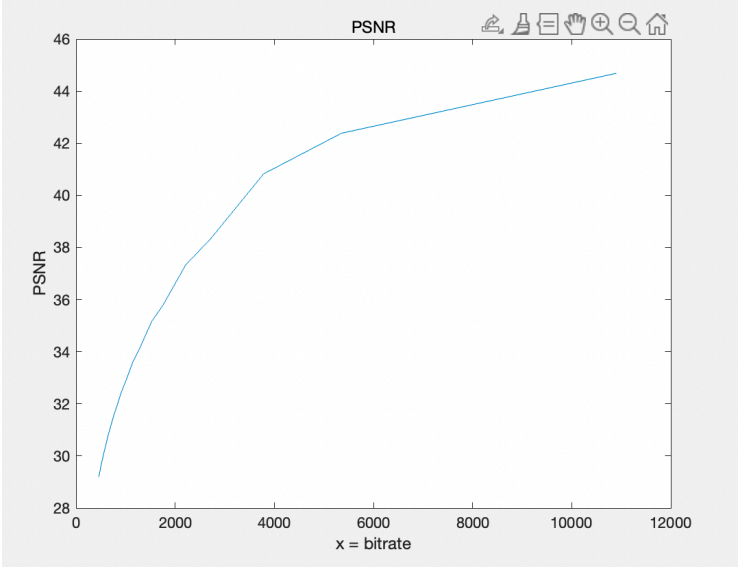
QP	Bitrates
1	10901.63 (10833.82) kbit/sec
2	5355.12 (5302.44) kbit/sec
3	3784.63 (3744.56) kbit/sec
4	2718.93 (2685.28) kbit/sec
5	2211.47 (2183.36) kbit/sec
6	1763.82 (1739.08) kbit/sec
7	1522.87 (1501.34) kbit/sec
8	1283.76 (1264.21) kbit/sec
9	1147.70 (1130.14) kbit/sec
10	1000.27 (984.11) kbit/sec
11	913.09 (898.31) kbit/sec
12	817.12 (803.30) kbit/sec
13	758.08 (745.31) kbit/sec
14	689.69 (677.68) kbit/sec
15	648.08 (636.84) kbit/sec
16	599.02 (588.36) kbit/sec
17	567.63 (557.60) kbit/sec
18	529.91 (520.33) kbit/sec
19	506.87 (497.72) kbit/sec
20	477.66 (468.90) kbit/sec
21	459.59 (451.20) kbit/sec

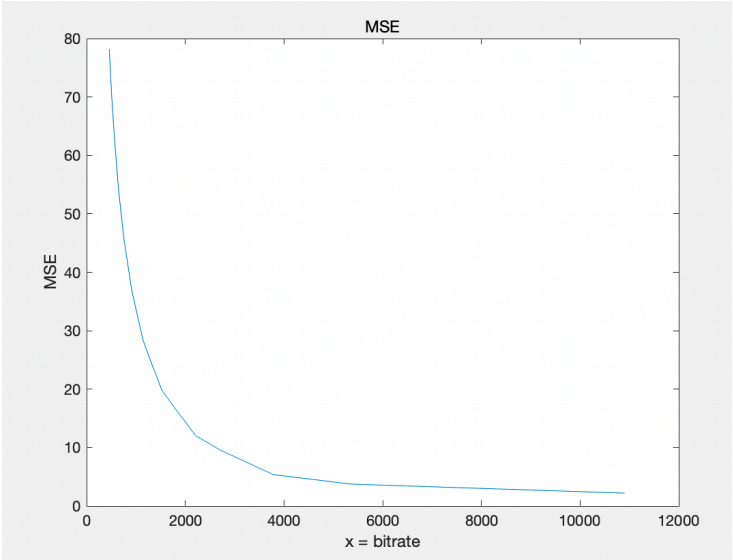
3、I use tmndec.exe to decode the bitstream that I got in step1 and get 21 decoded 'yuv' file.

Command: ./tmndec -o5 -l .\QP1.bits .\decode_qp1.yuv

```
PS Microsoft.PowerShell.Core\FileSystem::\\Mac\Home\Desktop\notebook\6427\assignment\h263>  ./tmndec -o5 -l .\QP1.bits .\decode_qp1.yuv
```

4、Calculate PSNR-Y and MSE-Y against bitrate:





H.263 coding algorithm has coding control in its encoder, from the experiment result, we can find that with the QP increase, the bitrate of the encoding bitstreams will decrease. Meanwhile, the error of the encoded file will increase.

With the QP increase, the coefficients in higher frequency will be eliminated or be quantized more coarsely. Therefore, more details will be lost after we perform encoding. The MATLAB result also prove this. According to the figure, The MSE increase and the PSNR decrease (related to the inverse of the MSE) with the increase of the QP.

The MATLAB Code is shown as follow:

```
diff_MSE=[];
diff_PSNR=[];
MSE=0;
prefix='./decode_qp%d.yuv';
for index=1:21
    addr=sprintf(prefix,index)
    fid=fopen(addr,'rb');
    fid2=fopen('../football_cif.yuv','rb');
    for i=1:Frames
        %Y=fread(fid,[1024,768],'uint8');
        Y=fread(fid,[352,288],'uint8');
        U=fread(fid,[352/2,288/2],'uint8');
        V=fread(fid,[352/2,288/2],'uint8');


       % figure;imshow(uint8(Y));
        Y_orgin=fread(fid2,[352,288],'uint8');
        U_origin=fread(fid2,[352/2,288/2],'uint8');
        V_orin=fread(fid2,[352/2,288/2],'uint8');

        MSE =MSE + sum((Y_orgin-Y).^2,'all')/(352*288);
    end
    MSE=MSE/Frames
    PSNR =10*log10(255^2 / MSE)
    diff_MSE=[diff_MSE,MSE];
    diff_PSNR=[diff_PSNR,PSNR];
    fclose  all;
end
```

5、I Fix the bitrate to different values and then plot the MSE-Y against frame number.

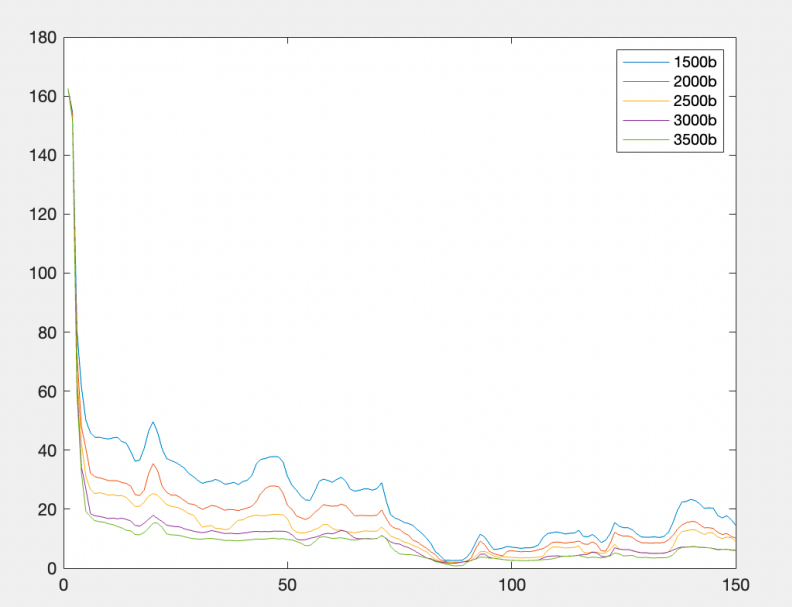
The encode command is :

.\tmn.exe -i ..\football_cif.yuv -x 3 -S 0 -O 0 -b 149 -I 30 -r 1500000 -R 30 -o dec_bit_1500k.yuv -B dec_bit_1500k.bits

The chosen bitrate is:

1500k	2000k	2500k	3000k	3500k

The MSE-Y against frame number is shown as below:



From the result, we could find that the MSE increase with the decrease of the bitrate. In other words, the higher the bitrate is, the more details will be encoded into the video, so that there will be less error.
However, due to the complexity of each video frame, the MSE will vary through the frame numbers.

The MATLAB Code is shown as follow:

```
diff_MSE_2=[];
diff_PSNR_2=[];
MSE=0;

prefix='./decode_qp%d.yuv';
fix=["./decode_fix_1500k.yuv" ,"./decode_fix_2000k.yuv","./decode_fix_2500k.yuv","./decode_fix_3000k.yuv","

MSE_fix=[];
for i=1:5
    fix(i)
    fid1=fopen(fix(i),'rb');
    fid2=fopen('../football_cif.yuv','rb');
    mse_fix=[]
    for j=1:150
        Y=fread(fid1,[352,288],'uint8');
        U=fread(fid1,[352/2,288/2],'uint8');
        V=fread(fid1,[352/2,288/2],'uint8');

        Y_orgin=fread(fid2,[352,288],'uint8');
        U_origin=fread(fid2,[352/2,288/2],'uint8');
        V_orin=fread(fid2,[352/2,288/2],'uint8');

        mse_fix =[mse_fix,sum((Y_orgin-Y).^2,'all')/(352*288)];
    end
     MSE_fix=[ MSE_fix;mse_fix];
     fclose  all;

end
x=linspace(0,1,150);
```

```
y1 = MSE_fix(1,:)
plot(x,y1);
hold on;
y2 = MSE_fix(2,:)
plot(x,y2);
y3 = MSE_fix(3,:)
plot(x,y3);
y4 = MSE_fix(4,:)
plot(x,y4);
y5 = MSE_fix(5,:)
plot(x,y5);
legend('1500b','2000b','2500b','3000b','3500b')
hold off;
```

（5） Appendix:
Bitrate of different QP:

```
Total   : 361127

Mean quantizer   : 1.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 10901.63 (10833.82) kbit/sec
```

```
Total   : 176747

Mean quantizer   : 2.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 5355.12 (5302.44) kbit/sec
```

```
Total   : 124818

Mean quantizer   : 3.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 3784.63 (3744.56) kbit/sec
```

```
Total   : 89509

Mean quantizer   : 4.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 2718.93 (2685.28) kbit/sec
```

```
Total   : 72778

Mean quantizer   : 5.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 2211.47 (2183.36) kbit/sec
```

```
Total   : 57969

Mean quantizer   : 6.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 1763.82 (1739.08) kbit/sec
```

```
==============
Total   : 50044

Mean quantizer   : 7.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 1522.87 (1501.34) kbit/sec
==========================================
```

```
==============
Total   : 42140

Mean quantizer   : 8.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 1283.76 (1264.21) kbit/sec
==========================================
```

```
==============
Total   : 37671

Mean quantizer   : 9.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 1147.70 (1130.14) kbit/sec
==========================================
```

```
==============
Total   : 32803

Mean quantizer   : 10.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 1000.27 (984.11) kbit/sec
==========================================
```

```
==============
Total   : 29943

Mean quantizer   : 11.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 913.09 (898.31) kbit/sec
==========================================
```

```
==============
Total   : 26776

Mean quantizer   : 12.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 817.12 (803.30) kbit/sec
==========================================
```

```
==============
Total   : 24843

Mean quantizer   : 13.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 758.08 (745.31) kbit/sec
==========================================
```

```
==============
Total   : 22589

Mean quantizer   : 14.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 689.69 (677.68) kbit/sec
==========================================
```

```
==============
Total   : 21227

Mean quantizer   : 15.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 648.08 (636.84) kbit/sec
==========================================
```

```
==============
Total   : 19611

Mean quantizer   : 16.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 599.02 (588.36) kbit/sec
==========================================
```

```
==============
Total   : 18586

Mean quantizer   : 17.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 567.63 (557.60) kbit/sec
==========================================
```

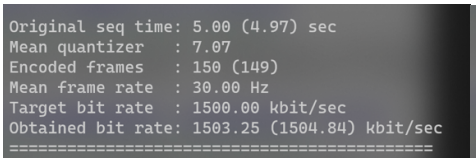
```
==============
Total   : 17344

Mean quantizer   : 18.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 529.91 (520.33) kbit/sec
==========================================
```

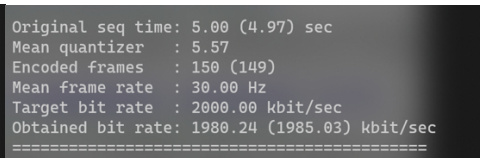
```
==============
Total   : 16590

Mean quantizer   : 19.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 506.87 (497.72) kbit/sec
==========================================
```

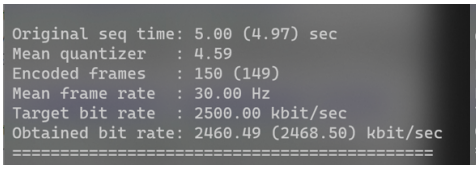
```
==============
Total   : 15630

Mean quantizer   : 20.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 477.66 (468.90) kbit/sec
==========================================
```

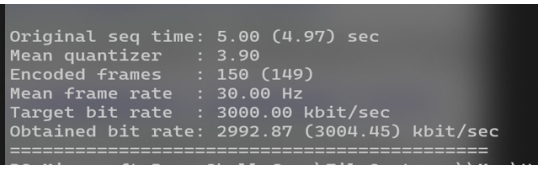
```
Mean quantizer   : 21.00
Encoded frames   : 150 (149)
Mean frame rate  : 30.00 Hz
Obtained bit rate: 459.59 (451.20) kbit/sec
==========================================
```

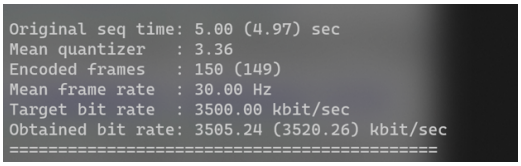
Fix bitrate:


Original seq time: 5.00 (4.97) sec
Mean quantizer : 7.07
Encoded frames : 150 (149)
Mean frame rate : 30.00 Hz
Target bit rate : 1500.00 kbit/sec
Obtained bit rate: 1503.25 (1504.84) kbit/sec


Original seq time: 5.00 (4.97) sec
Mean quantizer : 5.57
Encoded frames : 150 (149)
Mean frame rate : 30.00 Hz
Target bit rate : 2000.00 kbit/sec
Obtained bit rate: 1980.24 (1985.03) kbit/sec


Original seq time: 5.00 (4.97) sec
Mean quantizer : 4.59
Encoded frames : 150 (149)
Mean frame rate : 30.00 Hz
Target bit rate : 2500.00 kbit/sec
Obtained bit rate: 2460.49 (2468.50) kbit/sec


Original seq time: 5.00 (4.97) sec
Mean quantizer : 3.90
Encoded frames : 150 (149)
Mean frame rate : 30.00 Hz
Target bit rate : 3000.00 kbit/sec
Obtained bit rate: 2992.87 (3004.45) kbit/sec


Original seq time: 5.00 (4.97) sec
Mean quantizer : 3.36
Encoded frames : 150 (149)
Mean frame rate : 30.00 Hz
Target bit rate : 3500.00 kbit/sec
Obtained bit rate: 3505.24 (3520.26) kbit/sec