5C1 Video Processing : Compression Laboratory

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1 Introduction

1. What is transcoding?

   Transcoding is a technique that converts a media file from one format to another, such as converting from an MPEG2 video to H.264 video, in order to make media files compatible for different devices.

2. Why is transcoding necessary?

   1. Change the bitrate to adapt to different network environments. Bandwidth is always a limiting factor for video streaming, and mobile devices and crowded locations will limit the download bandwidth. Transcoding can generate video stream with different bitrates and transmit to end devices when the download bandwidth changes.
   2. Adapt to the format requirements of different websites. When uploading video files onto video websites, the user need to transcode the video data into the formats that are supported by the particular site.
   3. Reduce storage requirements. Sources files are generated by many kinds of tools and devices. Professional devices tend to use the lossless codec that has high-quality preserving capabilities, but it not suits mobile devices storage. Transcoding can reduce the file size, making it suitable for storage and playback on a variety of devices.

3. Define PSNR and explain how it is used to measure the quality of a transcoded video file. Give a range of values for PSNR that are acceptable for transcoded video quality.

Peak Signal-to-Noise Ratio (PSNR) is a quantitative measure to compare the effects of image algorithms on image or video quality. A higher PSNR indicates better image quality. Given a $m \times n$ lossy image I and its ground truth image I‘, PSNR is defined as follow:

$$MSE = \frac{1}{m \times n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \|I(i,j) - I'(i,j)\|^2$$

$$PSNR = 10log_{10} \left[\frac{max(I')}{MSE} \right]$$

Video quality can be measured by averaging PSNRs of every frame. Typically, PSNR values in lossy video compression are between $30dB$ and $50dB$, Acceptable values for transcoded video PSNR are considered to be about $20dB$ to $25dB$. The higher the better.

4. Give a range of bitrates acceptable for 720p video at 25fps. Explain why a specific 720p file may require more or less bitrate to achieve an acceptable quality.

The acceptable range for 720p video at 25fps is from $2Mbps$ to $4Mbps$. Theoretically, A higher bitrate can retain more video details and reduce compression loss. Meanwhile, the increase of the frame rate will also increase the bitrate, resulting in smoother playback.

2 The Test Sequence

1. What codec is used for the video and audio elementary streams? H.264
2. How long is the sequence? 00:00:16.90
3. What is the framerate of the sequence? 29.97
4. What is the average bitrate of the coded sequence? 6378 kb/s
5. Which of these pixel formats is used for the video data : YUV444, YUV422, YUV420? YUV420

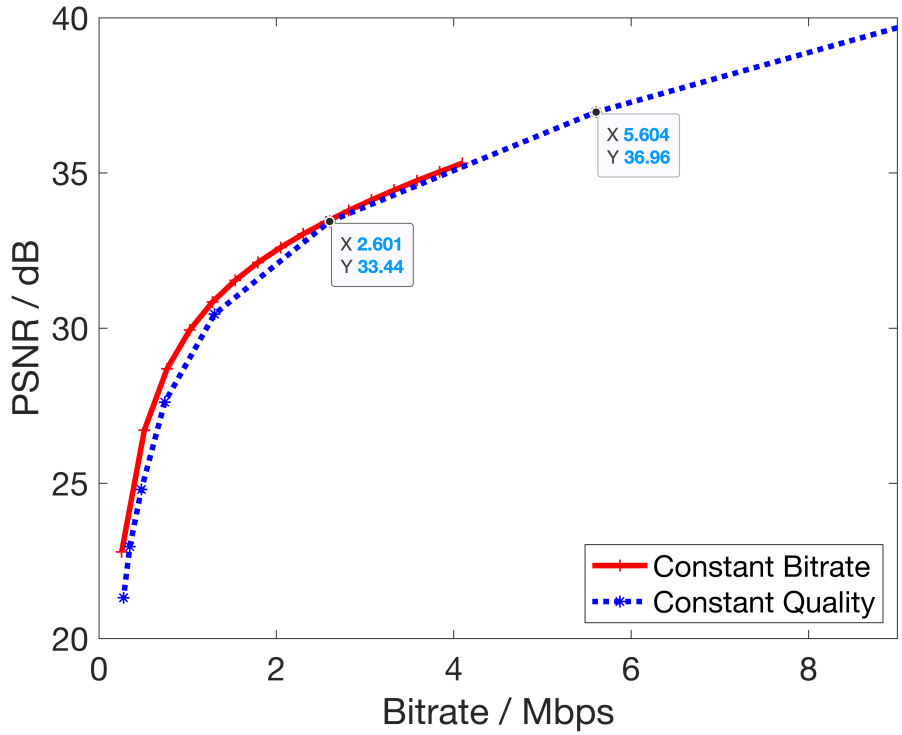

Figure 1: *Two RD curves are shown. In red is the Constant Quality (CQ) encoder, while in blue is shown the Constant Bitrate (CBR) Encoder. As can be seen, the CBR encoder performs better compared to the CQ encoder when using the same bitrate.*

3 Rate Distortion Analysis

Figure 1 shows R-D curves for constant bitrate and constant quality encoding. The table below shows a selection of the data measured using ffmpeg under the different rate control strategies.

CBR		CQ		
Bitrate (kbps)	PSNR	QP	Bitrate (kbps)	PSNR
256	22.787	2	82005.8	60.148
512	26.714	4	71576.4	57.259
768	28.691	10	43809.0	51.855
1024	29.939	15	28104.3	48.182
1280	30.842	20	17480.9	44.500
1536	31.538	25	10433.8	40.828
1792	32.112	30	5604.0	36.963
2048	32.599	35	2601.4	33.437
2304	33.035	40	1302.8	30.451
2560	33.423	45	741.9	27.613
2816	33.789	50	478.3	24.802
3072	34.129	55	348.1	22.960
3328	34.446	60	276.6	21.312
3584	34.752			
3840	35.036			
4096	35.314			

1. Discuss in your write-up any differences or similarities between the two curves.

When the bitrate increases from $0Mbps$ to around $3Mbps$, we can observe that the PSNRs increase sharply using Constant Quality (CQ) encoder and Constant Bitrate (CBR) encoder. After that, two curves still show an upward trend but slowdown. On the other hand, the PSNRs of CBR encoder are always higher than those of CQ encoder when using the same bitrate, and it demonstrates that the CBR encoder can achieve better transcoding effect.

2. Comment on the visual quality of the outputs at similar bitrates especially at the low end of the scale.

The output video with $256Kbps$ bitrates shows poor visual quality and massive blocking artifacts no matter what encoder is used. The $1Mbps$ bitrate provides acceptable visual quality. As the bitrate increases, the artifacts become not obvious until the bitrate reaches around $5Mbps$, at which point it is difficult to tell the difference between the original video and re-encoded videos.

3. State the bitrate above which the quality of the transcoded file does not change substantially. Explain your criterion for selecting this bitrate. State whether this is the same for both types of rate control or not.

By observing Figure 1, the growth rate of R-D curve is relatively slow after the bitrate reaches $5Mbps$. This shows that increasing the bitrate does not significantly improve the video quality. Meanwhile, according to Q2, the change of visual quality after $5Mbps$ is difficult to perceive for human eyes.
Therefore, according to the user's bandwidth, the bitrate range of 720p video transcoding using CR encoder should be selected between $1 - 5Mbps$. The higher the bandwidth, the higher the bitrate can be used. The quantisation scale factor of CQ should be selected as a $30 - 45Mpbs$ interval. The higher the bandwidth, the smaller the quantisation parameter should be.