5C1 Video Processing : ANSWERS Assignment II

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1 Part I : Introduction

1. What is *adaptive video streaming* and why is it necessary?
   Adaptive streaming is a technique that delivers video in the highest usable quality for each specific user and device. It adjusts the quality of media streaming according to user's bandwidth and CPU capacity. The source content is encoded by an encoder at multiple bit rates. The player client switches between different encodings based on available resources. It is necessary because the bandwidth is time varying and the large diversity of devices.

2. Why are multiple resolutions used in Adaptive streaming? Give examples of the resolutions used in a typical bitrate ladder for a file at 1080p.
   Because the purpose of adaptive streaming is to create different videos for each device (different resolution) with the best quality. In the RD curve, as the bitrate increase to a certain level, switching to a higher resolution helps to gain better quality than staying at the same resolution while continually increasing bitrates. In Per-title Bitrate ladder, the resolutions used for a file at 1080p would be 1920×1080.

3. What is the purpose of a video compression standard? Give examples of video compression standards in common use today. Discuss the importance of industrial standards to the video streaming industry. Give examples of new standards under development and explain why new standards are needed.
   The purpose of a video compression standard is to define the syntax of a bitstream, which indicates how to decode a compressed bitstream. Popular video compression standards being used nowadays are H.264 and MPEG-4 Part 2. The compression standards indicate how to decode a compressed bitstream. That allows more large raw video data to be compressed and transmitted on the internet which encourages the media companies to grow. Moreover, those companies require unified standards to do video compression for collaboration. AV1 is the new standard under development. New standards are needed because we need to keep reducing the cost of video streaming. With the increasing size of the video file, we need new standards to compress a larger video file in order to be able to transmit and distribute them through networks. In the meantime, we need to make our networks available to new sources of data as well as the evolution of each domain.

4. (From the invited BBC talk) Does BBC use in practise Deep Neural Networks (DNNs) for video compression? What are the main issues when using DNNs for video compression?
   It is not in practice yet. The main issue with using DNNs for video compression is that those neural networks are not specifically designed for signal processing. Hence applying them to video compression need a lot of effort for tuning and re-engineering, for example, the padding and sampling, to make them work properly. Otherwise, it would fail easily.

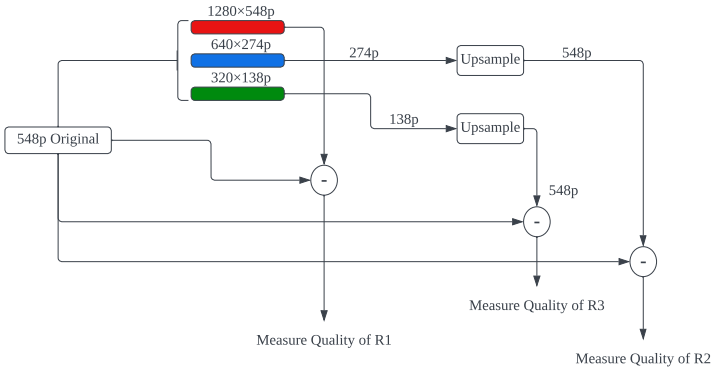

Figure 1: *The description of the algorithm.*

2 Part II

1. Describe, explain and justify the algorithm you use to create the representations. Explain how you generate the PSNR that is used to compare representations and make decisions.
   To create the representations for these three yuv raw data files, I first use the FFmpeg command to convert the yuv file to an mp4 file with H.264 codec and several bitrates of the output file. I use bitrates in the table provided for each resolution.
   I then upsample those mp4 files with 640 $\times$ 274p and 320 $\times$ 138p resolution to 1280 $\times$ 548p by FFmpeg using the Lanczos method to interpolate the value.
   I compare the quality of the original 548p yuv file with the mp4 files of 548p resolution and upsampled mp4 files of 274p and 138p resolutions by calculating PSNR values. Then, an R/D plot with 3 R/D curves is generated based on these PSNR values.
   The PSNR of comparing the original yuv file and 548p mp4 files generates the R1 curve in red. The PSNR of comparing the original yuv file and 274p mp4 files generates the R2 curve in blue. And the PSNR of comparing the original yuv file and 138p mp4 files generates the R3 curve in green. Two crossovers B_{c1} and B_{c2} are marked in the plot which is approximately 1200kbps with 41.1 dB and 100kbps with 30dB. For 548p resolution, the estimated maximum bitrate B_{max} is 5120kbps with 49.2 dB video quality. Hence, the representation bitrate is calculated by Equ.1 below.
   $$B_{target1} = \frac{(B_{max} + B_{c1})}{2}. \tag{1}$$
   The representation bitrates of 274p and 138p are $k_1 B_{c1}$ and $k_2 B_{c2}$ which are the sites where R2 and R3 have the highest slope. Those sites represent a balance between file size and quality. Figure 1 shows the description of the algorithm.
2. Show on a single R/D plot in Figure 2, the RD curves for each of your representations. Place appropriate legends and label your axes appropriately. Show on the plot your estimate for the crossover bitrates i.e. the maximum bitrate where the quality of representations at 138p and 274p are greater than 274p and 548p respectively.
3. Write here the quality and rate for your chosen representation at 274p. $\sim$ 435Kbps, 37.5dB
4. Write here the quality and rate for your chosen representation at 720p. $\sim$ 3.1MBps, 47.1dB
5. The Jambolassie representation at 274p has bitrate and PSNR = 0.65 Mbps, 39 dB
6. Comment on any differences between the Jambolassie representation at 274p and your chosen representation.

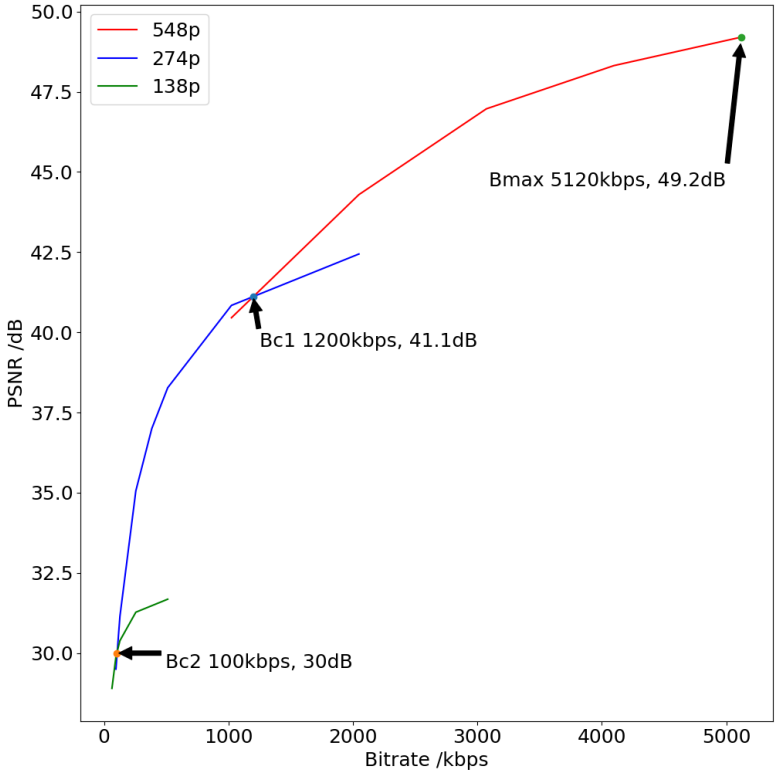

Figure 2: *The RD Curves for three representations are shown as well as crossover bitrates.*

The Jambolassie representation at 274p has higher PSNR with a higher bitrate than the representation I chose which means better video quality with a bigger file size. The representation I chose is the site on the curve where it has the highest slope which means the video has good quality and an acceptable size. It is a optimal choice, however, both representations get good video quality. The decision on choosing representation and which to sacrifice depends on the needs and the bandwidth which varies a lot over a period of time.