TECHNISCHE UNIVERSITÄT BERLIN
Fakultät IV – Elektrotechnik und Informatik
Fachgebiet Internet Network Architectures

IP Multimedia Lab WS 2018/19
Homework 1
Due: 11.12.2018, 11.55 PM

You can upload your submission to the ISIS online course (`https://isis.tu-berlin.de/mod/folder/view.php?id=628432`). Please submit your results as an archive, including your code and any scripts that you wrote to solve the assignments. Prepare a PDF file, in which you write down your findings and answers to the questions. For your submission, please consider the following points:

- Please name your archive *worksheet_⟨ws_number⟩_group_⟨group_number⟩*
- Add a cover page to the PDF including your group number and all group members
- Describe all relevant steps you performed
- Make your plots easily understandable, this is supported by
  - labeling your x-axis and y-axis
  - using informative captions
  - setting an appropriate font size
  - adding legends when needed
- Write down which libraries/tools you used
- Describe your results and denote to which (sub-)task they belong
- All code must be properly documented using inline comments
- All files that belong to a specific question must have the question/subquestion in their filenames
- When you are asked to visualize results, you are expected to provide a plot, i.e. visualizing using a table is not sufficient!
- When using ffmpeg, please shortly refer to all flags used, what they do, and why you use them (it is sufficient to do so once for a flag, i.e. when you apply a certain paramter a second time, you do not again need to describe it)

For this task, you need ffmpeg [1]. Please use, whenever you apply an ffmpeg command, the flag *-threads 1*. For question 3,4, and 5, you need the video *Big Buck Bunny* from the Blender Foundation [2]. The video is provided to you here: `https://service.inet.tu-berlin.de/owncloud/index.php/s/oVnj8eoJdL8ySGU`.

Question 1: (20 Points) *Introduction to Videos and ffmpeg*

(a) Describe in your own words and on a basic level the following terms:

1. Resolution
2. Frames per second
3. Bitrate
4. Codec

[1] https://www.ffmpeg.org/
[2] https://www.blender.org/foundation/

5. Compression
6. Raw video
7. Motion vector

(b) How dose the bitrate change if the resolution increases? Give a short explanation!

(c) How does the bitrate change if the frames per second decreases? Give a short explanation!

(d) Use ffmpeg to find out (1)-(3) from sub task (a) for the Big Buck Bunny clip.

Question 2: (30 Points) *Moving Pictures and Motion Vectors* Download all images from `https://service.inet.tu-berlin.de/owncloud/index.php/s/fGGIKX24ZOpqTdV`. Transform them to YUV and only consider the Y-channels in the following.

(a) Compute the entropies for all of the images.

(b) Compute the entropies of the subsequent images' differences and visualize your results.

(c) Compute the entropies of the difference of all images to the first one and visualize your results.

(d) Implement a function called *EstMotion*. For all macro blocks in the next image (00005901.png), it finds the best hit in the current image (00005900.png). The best hit is the minimum value of a cost function. Your function returns for each macro block the distance to the best hit as (x,y)-vector. Consider the following two cost functions:

- CF1: Mean difference
- CF2: Absolute mean difference

(e) Compare CF1 and CF2 for blocks of a size of 16x16. For which of the cost functions is the prediction error, i.e. the entropy between predicted image and actual image, larger?

(f) Vary the block size and compare the efforts to transmit the motion blocks and compare the entropy of the error pattern. Which block size minimizes the data to be transmitted?

Question 3: (20 Points) *Variable Bitrate Encoding (VBR)*

(a) Encode the video using the encoder *libx264* and constant rate factors of $crf = \{18, 24, 30, 36, 42, 48\}$. Use a .mp4 as ouputfile.

(b) Watch (partly) each of the resulting videos. Let each team member rate the quality on a scale from 1 (bad) to 5 (excellent).

(c) Describe your satisfaction with the video resulting from $crf = 48$. Which effects in terms of quality degradation do you notice?

(d) Plot the average bitrate for all videos resulting from subtask (a). What can you see?

Question 4: (30 Points) *Constant Bitrate Encoding (CBR).* When encoding videos with a constant bitrate, this is usually done in two passes. Hereby, the first pass analyzes the video and the second pass actually encodes the video.

(a) Use a two pass encoding to encode the source video with CBR. Again, use the encoder *libx264*. As target bitrates, use the average bitrate obtained from question 2(c).

(b) Take a look on one of the output files from the first pass (per default, it is named ffmpeg2pass-0). Which information can you easily (without the need to google) gather? What is especially interesting considering the lines containing „type:I“? How do you interpret this?

(c) The command $ffprobe$ together with the $show\_frames$ flag allows to analyze in detail your videos' frames. For the following tasks consider, once again, your video from subtask (a) with the lowest target bitrate and the one with the highest target bitrate. Visualize the fraction of I-frames, P-frames, and B-frames on the total number of frames of the two videos and describe your observations. Visualize the amount of bytes that I-frames, P-frames, and B-frames contribute to the total file size.

Question 5: (35 Points) *CBR versus VBR.* For the following task, consider the VBR videos with $crf = \{18, 30, 48\}$ and the three corresponding CBR videos.

(a) Investigate and visualize the average quality of the six videos, using the structural similarity (SSIM) and PSNR. For this task, you can use ffmpeg built-in functionalities.

(b) Visualize the bitrate for each video on a per-second scale.

(c) Visualize the SSIM for each video on a per-second scale.

(d) Compare CBR and VBR based on the results from subtask (b) and (c). Additionally, use box plots to visualize median and quartiles of SSIM and bitrate. Interpret your results!

(e) You are the team leader of Netflix's video compression team and responsible for encoding videos. Netflix delivers its content on two ways: rental of DVDs, which are delivered via post, and providing the content on their servers, so that clients can stream the videos via the Internet. How would you encode videos...

- for the DVD and
- for the online streaming service?

Explain your choices!