Information and Coding (2021/22)

Manipulating text, audio and image/video

- All the programs should be implemented in C++.
- Document all the code using the Doxygen tool.
- Create a Github project to manage the several versions of your software.
- Each program should be demonstrated during the classes

Part A

1. Deeply explore the C++ Tutorial at https://www.tutorialspoint.com/cplusplus/index.htm, mainly the section "C++ Basics". During the projects, you will need also to use the Standard Template Library, so you should also explore the C++ STL Tutorial at https://www.tutorialspoint.com/cplusplus/cpp_stl_tutorial.htm. The official documentation of C++ is available at https://en.cppreference.com/w/.

Part B

2. Implement a program to copy a text file, character by character. Both file names should be passed as command line arguments to the program.

3. Implement a program to copy an audio file in wav format, sample by sample. Both file names should be passed as command line arguments to the program. You can use the following libraries to manipulate sound files in wav format:
   `libsndfile` (https://github.com/libsndfile/libsndfile
   `AudioFile` (https://github.com/adamstark/AudioFile)
   `wave` (https://github.com/audionamix/wave
   Take as reference the audio samples available on e-learning.

4. Implement a program to copy an image, pixel by pixel. Both file names should be passed as command line arguments to the program. Take into consideration the images and videos referred at the end of this project. Explore the use of OpenCV library (https://opencv.org/). Extend the program to work with video.

Part C

5. Implement a program to calculate the histogram of the letters that exist in a text file and and the corresponding entropy. You can use the available free books in plain text UTF-8 at Project Gutenberg (https://www.gutenberg.org/) (for example "Os Lusíadas" by Luís de Camões https://www.gutenberg.org/ebooks/3333.
   Note: For visualizing graphically the histograms, you can either save the histogram data as a text file and use an external application to visualize it, or you can extend the functionality of the program in order to graphically display the histogram.

6. Implement a program to calculate the histogram of an audio sample and corresponding entropy. You should visualize the histogram of the left and right channels, as well as the histogram of the average of the channels (the mono version).
   Note: For visualizing graphically the histograms, you can either save the histogram data as a text file and use an external application to visualize it, or you can extend the functionality of the program in order to graphically display the histogram.

7. Following the same suggestions of the previous exercise regarding the visualization, implement a program to calculate the histogram of an image file and the corresponding entropy. Consider the histogram of each channel in color images, as well as the histogram of the corresponding grayscale version. Extend the program to work with video.

8. Based on the OpenCV library, implement a program to display the content of an image or a video on the screen. You should handle the correct color transformation for display since the color space used on those videos is YUV (in three different subsampling modes 4:4:4, 4:2:2 and 4:2:0).

Part D

9. Implement a program to reduce the number of bits used to represent each audio sample (uniform scalar quantization).

10. Implement a program to reduce the number of bits used to represent each pixel of an image. In this case, you are free to explore several approaches to quantize the images. Extend the program to work with video.

11. Implement a program that prints the signal-to-noise ratio (SNR) of a certain audio file in relation to the original file, as well as the maximum per sample absolute error.

12. Implement a program that prints the signal-to-noise ratio (SNR) of a certain image file in relation to the original file, as well as the maximum per pixel absolute error. Extend the program to work with video.

Part E

Elaborate a report, where you describe all the steps and decisions taken in all the items of the work. If appropriate, include measures of processing time, compression ratios and SNR (when applied). Also, include histograms of both the original audio/video and of the quantizes ones, as they are important in understanding the properties of the audio/video signals.

You should include the Doxygen documentation.

Take as reference the images and audio files available on e-learning and the following videos available on https://media.xiph.org/video/derf/:

a. ducks_take_off
b. in_to_tree
c. old_town_cross
d. park_joy