CS 576 – Assignment 1
Instructor: Parag Havaldar

Assigned on 08/28/2017,
Solutions due on 09/15/2017 by midday 12 pm noon
Late Policy: None, unless prior arrangement has been made

Theory Questions: (20 points)
Each question has marks displayed

Q.1 A 5-minute video is recorded with 1080i resolution (1920x1080 pixels, interlaced) and 30 Hz frame rate. The color sub sampling scheme is 4:2:0, and each sample of Y, Cr, Cb is quantized with 8 bits.

- What is the size (MB) of this video without compression? (*2 points*)
- In order to save space, we re-quantize each chrominance (Cr, Cb) signals with only 6 bits per sample. What is the compression ratio needed to store this video in a USB flash drive with 256 MB storage *(3 points)*

Q.2 Suppose we have a medical imaging that records brain activity and store as gray-scale images. The raw signal in a small region in a moment is given below:

-6.7	0.6	0.8	0.4	0.3	0.5	0.2	-5.7
-0.1	-6.6	0.6	0.3	0.2	0.1	-5.9	0.8
0	1.0	-6.5	0	-0.3	-5.5	0.4	0.5
-0.2	0.8	0.2	-7.0	-5.8	-1.0	0.2	0.6
0.1	0.6	0.3	-6.0	-6.9	-0.6	-0.3	0.1
0.3	0.5	-6.1	0.1	0.2	-6.9	0.2	0.3
0.2	-5.6	-0.1	0	-0.5	-0.1	-6.4	0.2
-6.2	0.7	0.2	0.3	-0.1	0.4	0.6	-6.3

Quantize this data by dividing the interval [-8, 8] into 64 uniformly distributed levels (place the level 0 up to -7.75, the level 1 up to -7.50, and so on. This should simplify your calculations)

- Write down the quantized region above. *(5 points)*
- Down-sample this quantized region to the size 4x4 using a specific sampling. Is there any better way to down-sample this region? *(1+2 points)*
- What is the size (kB) of this quantized image, if its resolution is 400x400? *(2 points)*

Q.3 Temporal aliasing can be observed when you attempt to record a rotating wheel with a video camera. In this problem, you will analyze such effects. Assume there is a car moving at 36 km/h and you record the car using a film, which records at 8 frames per second. The tires have a diameter of 0.4244 meters. Each tire has a white mark to gauge the speed of rotation.

- If you are watching this projected movie, what do you perceive the rate of tire rotation to be in rotations/sec? Explain your result *(5 points)*
- What is the highest speed of the car so that you perceive the rate of tire rotation correctly? *(5 points)*

Programming Part: (80 points)

This assignment will help you gain a practical understanding of Resampling and Filtering and how it affects visual media types like images and videos.

Firstly, you will have to write a program to display images in the RGB format. We have also provided a Microsoft Visual C++ project and java to display images. This source has been provided as a reference for students who may not know how to read and display images. You are free to use this as a start, or write your own in any language of your choice (no matlab please!), as long as your program can be easily evaluated on our UCS computer systems.

You will take an image an input in a 4:3 aspect ratio, which will be a high resolution image (4000x3000) or a low resolution image (400x300). Your program will generate an output image which will be one of the following standard formats

- O1: 1920x1080
- O2: 1280x720
- O3: 640x480

In each case, depending on your input size, you will need to either down sample or up sample the image. In each case implement these two methods to choose your sample value.

- In the down sample case, use
    1. Specific/Random sampling where you choose a specific pixel
    2. Gaussian smoothing where you choose the average of a set of samples
- In the up sample case, use
    1. Nearest neighbor to choose your up sampled pixel
    2. Bilinear/Cubic interpolation

Correspondingly you will have five input parameters to your program

- FileName (string) – gives you the location of the file containing the image.
- Width (int) – width of the image in pixels.
- Height (int) – height of the image in pixels.

- Resampling method (int) – has values of 1 or 2. You will have to determine whether the image is being up sampled or down sampled and decide accordingly.
- Output format (string) – can have values O1, O2 or O3 for the three formats discussed above.

To invoke your program we will compile it and run it at the command line as

YourProgram.exe C:/myDir/myImage.rgb 4000 3000 1 O2

The expectation here is that your program will read the image of size 4000x3000 and down sample it to 1280x720 and use specific/random sampling to decide each pixel value in the output.

Additional discussion points to submit:

1. All the outputs here are different from the 4:3 aspect ratios, resulting in a change in pixel aspect ratios in the output. This will either cause pixel stretching or compression which are undesired effects. Propose and implement at least **two methods** to eliminate, or at least minimize the change in pixel aspect ratio. You do not need to submit your program which does this but please attach outputs of your method(s) on high res and low-res image samples in your submission document.
2. As shown in class, seam carving is another smarter way to resize your image that takes the content of the image into account. Read the paper available here (http://perso.crans.org/frenoy/matlab2012/seamcarving.pdf).
   Download the code to perform scene carving (http://code.google.com/p/seam-carving-gui/), compile it and run it on the images given to you and attach them in your submission. Comment on the results – the pros and especially the cons. Where do you think the method performs well or does not perform well?
3. You will notice that the outputs of up sampling to a specific resolution are worst off in quality compared to down sampling to the same resolution. This should be no surprise because in the latter case you have samples to decide and choose from where as in the former case you are interpolating and "imagining" what a best output might be. Research into improving this and propose and intelligent way to up sample and get better results. Hint - you may find it useful pointers by googling"Super - resolution from a single image".

What should you submit?

Your submission should have three parts:

- A PDF or WORD document that shows your work and solutions of the theory questions.
- Source code of your program, along with any project files or makefiles necessary to compile.We will compile your program and execute our tests accordingly. Please do not submit any binaries or images. Doing so, will adversely penalize your Grade.

- A PDF file that contains the any specific instructions to compile, along with your discussions, analysis and output images. Please include your name and USC ID on the first page of the pdf.

Archive all your submitted files into one .ZIP and submit it to HW1 DropBox (Content → Assignments → HW1) on courses.uscden.net. The name of the .ZIP file must be HW1_lastname_firstname.zip.

Evaluation:
The theory part has 25 points. We will run tests you evaluate your resampling for a total of 80 points. Marks will be deducted for incorrect outputs. Each discussion part is worth 15 points. So the total evaluation score will be out of 150.