CS 576 Fall 2014– Assignment 1
Instructor: Parag Havaldar

Assigned on 09/08/14
Solutions due on 09/29/14 (before 12:00 noon)
Late Policy: None, unless prior arrangement has been made

Written Part: (20 points)
Each question has marks displayed

Q.1 Suppose a camera has 450 lines per frame, 520 pixels per line, and 25 Hz frame rate. The color sub sampling scheme is 4:2:0, and the pixel aspect ratio is 16:9. The camera uses interlaced scanning, and each sample of Y, Cr, Cb is quantized with 8 bits

- What is the bit-rate produced by the camera? *(2 points)*
- Suppose we want to store the video signal on a hard disk, and, in order to save space, re-quantize each chrominance (Cr, Cb) signals with only 6 bits per sample. What is the minimum size of the hard disk required to store 10 minutes of video *(3 points)*

Q.2 The following sequence of real numbers has been obtained sampling an audio signal: 1.8, 2.2, 2.2, 3.2, 3.3, 3.3, 2.5, 2.8, 2.8, 2.8, 1.5, 1.0, 1.2, 1.2, 1.8, 2.2, 2.2, 2.2, 1.9, 2.3, 1.2, 0.2, -1.2, -1.2, -1.7, -1.1, -2.2, -1.5, -1.5, -0.7, 0.1, 0.9 Quantize this sequence by dividing the interval [-4, 4] into 32 uniformly distributed levels (place the level 0 at -3.75, the level 1 at -3.5, and so on. This should simplify your calculations).

- Write down the quantized sequence. *(4 points)*
- How many bits do you need to transmit it? *(1 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/hr and you record the car using a film, which traditionally record at 24 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 in a theatre, what do you perceive the rate of tire rotation to be in rotations/sec? *(5 points)*
- If you use your camcorder to record the movie in the theater and your camcorder is recording at half the film rate (ie 12 fps), at what rate (rotations/sec) does the tire rotate in your video recording *(5 points)*

Programming Part: (80 points)

This assignment will help you gain a practical understanding of issues that relate to video resampling, spatial and temporal aliasing effects, image aspect ratios and pixel aspect ratios. In this assignment you will be given a video file as input and produce a spatially & temporally resampled output. This problem does have very practical applications today – for example, you might have a high definition image/video that you want to down sample prior to uploading or streaming to a lower capability device eg cell phone.

We have provided a Microsoft Visual C++ project as well as a java project to display an image. This source has been provided as a reference for students who may not know how to read and display images and render audio. You are free to use this as a start, or write your own in C/C++ or any other programming language such as Java. We do not allow scripting environments such as matlab, and the only other restriction is that we should be able to easily compile and run your program on the university computing platforms.

Input to your program will be 6 parameters where:

- The first parameter is the name of the input video file. (file format description provided)
- The second parameter is a floating pointing number that will be the scaling factor for your width.
- The third parameter is a floating pointing number that will be the scaling factor for your height
- The fourth parameter controls the output frame rate (that will change your video playback)
- The fifth parameter controls whether anti-aliasing should be turned on. A value of 0 indicates this should be off, and a value of 1 indicates it should be switched on.
- The last parameter controls the analysis/extra credit portion of your assignment – could have a value of 0, 1 or 2. 0 is for the default implementation, 1 is for the analysis part and 2 is for the extra credit, should you choose to do so.

Remember all input files will have the same format as explained on the class website. They will by of size 352x288 (CIF format), at 30 fps.
Typical invocations to your to your program would look like

MyExe Video.rgb 1.0 1.0 30 0 0
This should not change your input signals by anything and the output is the same as the original file

MyExe Video.rgb 0.5 0.5 30 0 0
This should change your video file to half its size at the same frame rate

MyExe Video.rgb 0.5 0.5 30 1 0
This should change your video file to half its size at the same frame rate but have anti aliasing turned on which will make your scaled video frames look more smooth.

Implementation (55 points)

Your implementation should create a video player that takes the described parameter as input, scales the images and appropriately display the video at the right frame rate. You will need to extend the given code (or write on your own) to provide

- Functionality to read the whole video file
- Ability to resize each frame
- Implementation of an averaging filter to perform anti aliasing as discussed in class. Here instead of copying the pixel value (r,g,b) from your source position to the destination position, you copy the average of a small 3x3 window from your source position to your destination position.
- Render video that plays the output video in a synchronized manner as per the fps parameters

Analysis of Pixel Aspect Ratio (25 points)

The original image aspect ratio of the video is 1.222: 1. When the width and heights are scaled non-proportionally, there is a pixel scaling or pixel stretching effect that changes your pixel aspect ratio. This is disturbing, and not desirable, but unavoidable in these cases. There are simple smart operations that can minimize this effect. One suboptimal solution is letter boxing, where the black areas are minimally fitted to the top/bottom or left/right sections to maintain the same pixel aspect. An improvement to this would be non-linear mapping. So while the target width and height are maintained, the mapping is controlled non linearly such that a larger part of the central area (which is the focus of attention) has the same original pixel aspect, but the peripheral areas seem scaled to compensate. Implement a nonlinear mapping function that appropriately changes the content. This will be invoked by using 1 for your last parameter.

Extra Credit

In recent years, there have been some smart "content aware" rescaling functions which have made their way to commercial applications. As demonstrated in class, recent work by Ariel Shamir from Mitsubishi Electric Research Lab (MERL) shows how to intelligently resize images by being *content aware* by a gradient domain based energy minimization process called *"seam carving".* See example below

Original Image


Scaled


Cropped


Seam Carved

Go to (http://www.faculty.idc.ac.il/arik/SCWeb/imret/index.html) and understand how the algorithm works by reading the paper and examples.
Source code is available on various platforms (code.google.com)
C++ - (http://www.corsix.org/retargetr.html)
Java – (http://www.its.caltech.edu/~justinj/cs176/HW1/index.htm)
You may reuse source code for this algorithm to scale each frame to the resize width and height. Resizing each frame independently should resize your video. Your program will be invoked using the last parameter as 2.

- What problems do you see to implement the rescaling on each frame?
- What changes will you make to the implementation to rectify this, will it work all the time?

What should you submit ?

- Your source code, and your project file or makefile. Follow the submission steps provided in the following section and contact the TAs if you have any questions. Please do not submit any binaries or data sets. We will compile your program and execute our tests accordingly.
- Along with the program, also submit an electronic document (word, pdf, pagemaker etc) for the written part and any other analysis/extra credit explanations.
- Zip all the files for the Assignment including the electronic document and project files into a single file and follow the naming convention as CSCI576_YourLastName_YourFirstName_Assignment1.zip

The following is a step by step navigation on D2L for submitting the Assignment
1. Login to courses.uscden.net
2. Select CSCI 576 course from the right hand side tab on the home page
3. Click on My Tools and select Dropbox
4. On this page you will see a folder called Assignment 1, click on it and make the submission by uploading your files and add any comments for the grader