Department of Electrical and Computer Engineering
The University of Alabama in Huntsville
Spring 2015

CPE 381: Fundamentals of Signals and Systems for Computer Engineers

Programming Assignment: Real-time Signal Processing
Phase I due: Monday, March 16, 2015 at 2:15 pm
Phase II due: Wednesday, April 15, 2015 at 2:15 pm
(20 % of the grade, additional 5% bonus)

Please bring hardcopy of the report to the class and
upload single ZIP file with all files to Angel

Write a program in C/C++ to perform real-time audio signal processing. The program will read audio record from WAV file, perform the processing <u>sample-by-sample</u>, and store the result back to the new WAV file.

Phase I (40 points, due: Monday March 16, 2015 at 2:15 pm)

Please follow the following steps:

1. Record your own voice in wave file (.WAV). The record must start with your introduction of yourself, followed with additional content (e.g. music). The record length is 30 sec $< T_{rec} < 1$ min.

2. Write C/C++ program to read the file and write modified WAV file. Program should:
   - process file sample by sample,
   - add sine wave with amplitude equal to 25% of the maximum amplitude and frequency of 2.4 KHz,
   - find sample with the maximum amplitude in the entire signal, and
   - measure the performance of the program (*end-time – start_time*).
   - Create new summary text file with the sampling frequency, record length in seconds calculated from the number of samples, maximum amplitude, and execution time of the program.

Prepare Report and submit hard and soft copy of the report. The report must contain the following numbered sections:

1. Short description of the problem and proposed solution.
2. Short description of WAV file format. What control fields do you have in the header? What is their location?
3. Summary text file. Explain if your program can work in real-time.

Deliverables

- Complete source code of your project (MS Visual Studio or Linux gcc/g++ with all files necessary to compile the project & make file in the single ZIP file).
- Projects that can not be compiled and run in either environment will lose 40% of the grade. Only original and independent work will be graded. Plagiarized work will not receive any credit.

- PDF or DOC file of your Report with the following format of the filename: Lastname_first-initial.DOC or PDF
- Sound files in the following format (use your last name and first initial):
  - Lastname_first-initial_orig.WAV   - original record
  - Lastname_first-initial_mod.WAV   - processed record

Phase II (60 points, due: Wednesday April 15, 2015 at 2:15 pm)

Please follow the following steps:
1. Use wave file from Phase I.
2. Read WAV file in Matlab and find the dominant spectral component in the signal (frequency and amplitude).
3. Design a low pass filter to eliminate added sine wave from Phase I with minimum attenuation of 60dB. Pay attention to trade-off between real-time performance and the quality of the filter. Describe implementation of your filter. Discuss your decisions in the report.
4. Write C/C++ program to read the file, check the sampling frequency from the file header and select appropriate filter for that frequency. It is acceptable to assume that you will have only two standard sampling frequencies (Fs), but you must process the signal according to the sampling frequency of the record. Measure the performance of the program (*end-time – start_time*).

Prepare Report and submit hard and soft copy of the report. The report must contain the following numbered sections:
1. Short description of the problem and proposed solution.
2. Documented design of the filter in Matlab that includes
   a. Plot of filter characteristics (magnitude and phase)
   b. Type of filter (FIR/IIR) and reasons for choosing that particular filter.
   c. Filter coefficients
   d. Organization of processing; how do you perform your processing in C/C++.
3. Spectrum of the input WAV file and spectrum of the processed file.
4. Performance of the program (execution time). Explain if your program can work in real-time.
5. Short description of your experience and "lessons learned"

Deliverables

- Complete source code of your project (MS Visual Studio or Linux gcc/g++ with all files necessary to compile the project & make file in the single ZIP file).
- Projects that can not be compiled and run in either environment will lose 40% of the grade. Only original and independent work will be graded. Plagiarized work will not receive any credit.
- PDF or DOC file of your Report with the following format of the filename: Lastname_first-initial.DOC or PDF
- Matlab script used to prepare the assignment.
- Sound files in the following format (use your last name and first initial):
  - Lastname_first-initial_orig.WAV   - original record
  - Lastname_first-initial_mod.WAV   - modified record
  - Lastname_first-initial_fil.WAV   - filtered output

Bonus Assignment
(extra 25% of the assignment grade, or 5% of your overall course grade)

Write a C/C++ program to determine the dominant spectral component in WAV file. Full credit (20%) can be received if you provide the same documentation of the design and performance of the additional solution.