Fall 2023 EE 313 Linear Systems and Signals Prof. Evans

Mini-Project #2: Image Filtering

By Prof. Brian Evans

Assigned on Sunday, October 22, 2023, 8:30pm
Due on Wednesday, Nov. 1, 2023, by 11:59pm pm via Canvas submission

Late submission is subject to a penalty of two points per minute late.

Reading: McClellan, Schafer and Yoder, *Signal Processing First*, 2003, Chapter 3.
Companion Web site with demos and other supplemental information: http://dspfirst.gatech.edu/

E-mail address for TA Elyes Balti is ebalti@utexas.edu. Please consider posting questions on Ed Discussion, which can be answered by anyone in the class. You can post anonymously.

Lecture and office hours for Mr. Balti and Prof. Evans follow:

Time Slot	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*
11:00 am		**Evans (ECJ 2.104)**		**Evans (ECJ 2.104)**	
11:30 am		**Evans (ECJ 2.104)**		**Evans (ECJ 2.104)**	
12:00 pm		**Evans (ECJ 2.104)**		**Evans (ECJ 2.104)**	
12:30 pm					
1:00 pm					
1:30 pm					
2:00 pm			**Evans (EER 6.882 and Zoom)**	**Evans (EER 6.882 and Zoom)**	**Balti (EER 3.648)**
2:30 pm			**Evans (EER 6.882 and Zoom)**	**Evans (EER 6.882 and Zoom)**	**Balti (EER 3.648)**
3:00 pm			**Evans (EER 6.882 and Zoom)**	**Evans (EER 6.882 and Zoom)**	**Balti (EER 3.648)**
3:30 pm		**Balti (EER 3.648)**			
4:00 pm		**Balti (EER 3.648)**			
4:30 pm		**Balti (EER 3.648)**			
5:00 pm				**Balti (EER 3.648)**	
5:30 pm				**Balti (EER 3.648)**	
6:00 pm				**Balti (EER 3.648)**	

Introduction

When students described what they had hoped to get out of our class, several students mentioned image processing and filtering. In our department, ECE 371Q Digital Image Processing taught by Prof. Alan Bovik every Fall would be a great course to consider.

For an introduction to image processing, please watch this sequence of videos by Prof. Shree Naya at Columbia University on YouTube:

- "Overview". 3:40.
- "Pixel Processing". 2:46.
- "Linear Image Filters". 21:10.

A Linear Shift Invariant System is the image processing version of a Linear Time Invariant System.

Before Tuesday's class, please run these demos:

- imageRampsCosines.m is a Matlab script that connects a single sinusoid in the horizontal dimension to image features.
- "Cascading Two FIR Filters" shows an original image and the images that result from applying a five-point averaging (lowpass) filter and a first-order difference (highpass) filter.

Assignment

Please complete Sections 2.5 and 3.2 of Lab P-9 Sampling, Convolution and FIR Filtering from the lab assignments on the online *Signal Processing First* companion site.

Please see the mini-project #2 hints on the homework page.

Partners

You may work individually or with one partner. If you work with a partner, then create one report together. Each of you would submit the same report on Canvas. Be sure that the mini-project report represents the independent work of the author(s) on the report.

Appendix: Homework and Mini-Project Guidelines

Here are some things you should follow for all assignments.

Amount of work to show:

1. An explanation should be given for every single answer. Answers written without explanation will lose two-thirds of the points allotted for that part.
2. Only "standard" formulas (like Euler's formula, trigonometric formulas, etc.) can be used without a reference. If you're using something non-standard, then please put a reference to the formula number in the book, or whatever source you got it from. Just using the final result of a similar problem done in the class, and omitting the intermediate steps, is not okay. You have to show show your work.
3. There shouldn't be big jumps in logic from one step to the next.
4. For everything, expect to show at least one intermediate step between the first line and the answer. Even if it seems unnecessary to you, please err on the side of caution. Things that seem obvious to you when you're writing the solution are not quite so obvious for someone reading it.
5. If you're in any doubt about how much work to show, please ask the instructor or the teaching assistant.

MATLAB source code guidelines:

1. Put a comment before the solution of each part, telling the question number of the solution.
2. If you're using complicated logic, leave a comment telling what that block of code is supposed to do.
3. Use variable names that related to their meaning/use.
4. Avoid using two different variables for the same thing.
5. Try to avoid using "magic numbers" in the code. If you're using a number, write a comment telling me how you derived it.
6. Make sure that your code will compile & run in a clean workspace; i.e., one without any variables present. Use a clear all; at least once before submitting it.
7. No marks will be deducted based on the efficiency of the code unless the problem asks you to write efficient code.

Technical points:

1. Merge all the files together into one PDF file.
2. Please adjust the contrast, exposure etc., to get a good scan quality so that the TA can easily read what you write. Take extra care to get a good scan for parts written in pencil.
3. For the MATLAB code you write for an assignment, please copy the code into Word or include a screenshot showing the code. Do not submit handwritten code.

Other things:

1. All plots must have axis labels, with units.
2. Final answers must be boxed, or underlined or otherwise differentiated from the rest of the solution.
3. All final answers must have units, if they exist.
4. Read the questions carefully.
5. Try to answer all parts of a question together. If the solution to some parts of a question is written elsewhere, then leave a note telling the reader where to find it.

Organization of a mini-project report:

Please write a self-contained narrative report. The audience is someone who has taken the equivalent of this class. The report should provide references to the textbook and other sources as needed. Please refer to the hints above, which apply to homework assignments and mini-project reports, as well as the following additional guidelines for the mini-project:

1. Introduction -- explain in your own words when a sum of sinusoids can be used to analyze and synthesize a signal. Build on your experiences so far in the class. You can also use ideas from the Introduction section in the mini-project assignment. Use appropriate references. Probably half of a page for this section.
2. Overview -- explain in your own words and with appropriate references the general approach for representing a signal as a sum of sinsuoids in the mini-project, including mathematical formulas. You can also use ideas from other sections in the mini-project #1 assignment. About a page for this section.
3. Analyzing an audio signal -- answer the questions in Section 2 of the assignment and use information from Section 2 in your writeup.
4. Synthesizing an audio signal -- answer the questions in Section 3 of the assignment. and use information from Section 3 in your writeup.
5. Conclusion -- draw conclusions from your work and explanations in the earlier sections. Probably half of a page for this section.

This mini-project report is something that you could bring with you on interviews to show as an example of your work. Here are example mini-project #1 reports written by the instructors on "FM Synthesis for Musical Instruments" (2018) and "Sinusoidal Speech Synthesis" (2021).