ECE 345: Linear Systems and Signals

Fall 2020

**Lab #2 Report**

Note: you can use the equation editor in MS Word or a tool such as LaTeXiT to generate formulas for questions which ask about formulas. Alternatively, you can write your derivation and put a photo into the box.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Mini-Lab 1 (58 points)** |  | **Mini-Lab 2**  **(42 points)** |  |  | **TOTAL (100 points)** |
|  |  |  |  |  |  |

Group members:

* A
* B
* C
* D

**Minilab 1: Image Processing (xx points)**

1. (4 points) Provide the color image and the grayscale image that you produced using rgb2gray().
2. (6 points) Show the row blurs for M = 2, 8, 32 and the column blurs for M = 4, 16 (5 images total. Be sure to label them so we know which M we are looking at.
3. (8 points) Show the image results from row and column edge detection for thresholds tau = 1 and tau = 10.
4. (6 points) Show the results from convolving with the 2d gradient filters. Choose an appropriate threshold tau, and indicate in the lab report which value you choose to show your results.
5. (8 points) Write down the 2D filter that you chose to detect the edge of the roof and give the resulting image. Why is this the best choice of filter for this task? Explain any tradeoffs you may have considered in choosing the filter as well as your choice of the threshold tau for your displayed image.
6. (8 points) Show the image of the coefficients from the DWT exactly using the code from the documentation. Then show the results using imagesc(). What threshold did you use and why? Explain how the coefficients for the horizontal, vertical, and diagonal parts are related to parts (c) and (d) from the lab. What is similar and what is different?
7. (6 points) Show the reconstructed image and provide the values for the total squared error and the maximum absolute difference. How good is the reconstruction? How does that relate to the quantitative measures you computed?
8. (12 points) How many numbers do you need to store the DWT versus the image? What is the *compression ratio* (number of values kept over number of values in the original image)?   
     
   Give the reconstructed image. What changes do you see? Describe what the affect the compression has and explain whether it looks acceptable or not. Make sure you write a real discussion and not just one sentence.   
     
   Display the difference image between the original and the reconstruction. Provide the values for the total squared error and the maximum absolute difference. How do these numbers compare to the reconstruction you did earlier?   
     
   Try zeroing out multiple rows in the original image, starting from the top, so that the squared error per pixel is almost the same as in the reconstruction you just made. Display the image with zeroed out rows.  
     
   Supposedly the two images you just generated are the same in terms of squared error per pixel. Given the perceptual quality of the reconstruction, do these measures seem appropriate for the problem of image compression?

**Mini-lab 2: Feedback control**

1. (12 points) What is the impulse response of the system (as a formula)? Show your work.  
     
   Plot your calculated impulse response from 0 to 5 seconds.  
     
   Using MATLAB and the impulse() function, give a plot of the impulse response of the system from 0 to 5 seconds. Verify that the two plots match.
2. (4 points) What are the poles and zeros for the system? Draw the pole-zero diagram by hand.  
     
   Plot the pole-zero diagram using MATLAB and verify that the diagrams match.
3. (6 points) Give the transfer function for the overall system. Calculate the value of K\_p needed to put the poles on the complex axis. Show your work.
4. (12 points) Give the plots of the different pole zero diagrams for K\_p equal to 0.5, 1, the value from the previous part, and twice that value.  
     
   From your analysis, describe the benefits and costs of using proportional control in terms of implementing the feedback system. For context, imagine the output of the plant is a very high-voltage signal. What does the feedback signal look like?
5. (8 points) Give the formula for the closed-loop control system. Give values of K\_p and K\_d that can stabilize the system.  
     
   Give the pole-zero diagram using MATLAB for the feedback control parameters that you chose.  
     
   How does PD control help stabilize the system? Is it better than P control? If so, how?