Nulling Filter

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Introduction

In this lab we're going to be developing a nulling filter to filter out noise in a given black and white image. A nulling filter

NOTE: In this particular image a white pixel takes on a value of 255, and a black pixel takes on a value of 0.

NOTE: In MATLAB, the datatype unit8 obeys integer division rules, so for example if a=4 is of the unsigned integer datatype, then a/2 returns a value of 2, but rounding occurs if a would be a decimal, so a/3 returns a value of 1, even though as humans if we divided 4/3 we get a=1.3333. To fix this you can cast values to "double" as you see appropriate for this lab.

Part 1

The lab instructions use the MATLAB commands but you're definitely welcome to use the Python opencv equivalents if you want to be a boss. 1. Using the matlab `imread`, and `imshow` commands, read in the attached image "homework.png". We will use the `imshow` command with the open and square bracket option to automatically scale our image throughout this lab.

2. Create a figure with two subplots. The first subplot should contain the values of each pixel in the 99th ROW of the image, and have labels "index (n)" and "pixel value" on the x and y axis respectively. The second subplot should be a graph of the "index (n)" on the horizontal axis, but the y axis will be the data in the 99th row passed through an 11 point moving average filter.

3. **How to achieve the 11 point moving average filter:** You can implement this filter by convolving (`conv(a,b)`) the data in the 99th row of the homework image with the coefficients $b_k = \frac{1}{L}\{111...111\}$, which is a vector of ones, of length L, and $L = 11$.

Part 2

Repeat the steps of part 1, except implement the running average filter over the entire image, and display the output on a figure with two subplots, showing what the image looked like before and also after.

Part 3

I've corrupted the image such that for each row in the image, the corrupted output is

$$x_1[n] = 128 + 128\cos(\frac{2\pi}{11}n) + x[n] \tag{1}$$

1. Using the `diric` command in matlab, or the equation

$$D_L(\hat{\omega}) = \frac{1}{L}\frac{\sin(L\hat{\omega}/2)}{\sin(\hat{\omega}/2)}$$

Plot the magnitude part of the frequency response, with "normalized radian frequency" on the horizontal axis, and $|H(e^{j\hat{\omega}})|$ on the vertical axis.

Part 4

Pass the filter over the entire corrupted image and explain why it works, using the plot of the Dirichlet function in part 3 as a reference. Also explain some of the side effects of this filter.

Part 5

Answer the following questions:

1. What is the relationship between $\hat{w}$ and w?

2. State the Nyquist Sample theorem and explain why sample rate is not a factor in this particular example. Also state when sample rate WOULD be a factor.

Inspirational Quote

You can do it!