ECE 418 Lab 4

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In this lab we generate images to learn about the human visual system and how it processes images. Images with vertical and horizontal match bands, sinusoidal grating, center fields for simultaneous contrast were also implemented. Lastly, to verify Webbers law we performed several experiments by changing the pixel intensity of the center till the eye could differentiate between the center and the surrounding colors.

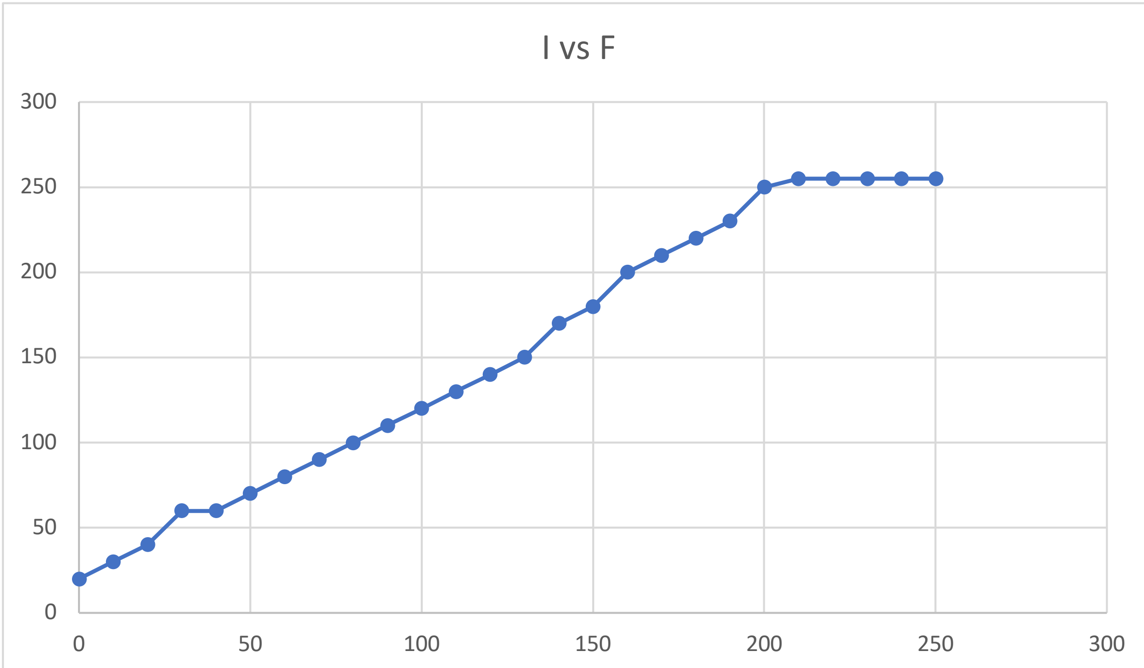
In part A1 and A2, both horizontal and vertical band shoots were implemented in a picture by dividing the image into 8 bands and changing the pixel intensity linearly as we transverse the image resulting in several bands with changing intensities. The intensity discontinuities that exist at the boundaries between bands cause overshoots and undershoots in perceived brightness. This happens because the receptors in the retina absorb light and initiate the neural response. The ganglion cells generate the electric pulses that are transmitted to the visual cortex through the optic nerves and the amacrine and horizontal cells use their lateral connection to reduce signal from adjacent cells when excited by the light stimulus. This is called lateral inhibition. In the images of the match band effect, filtering is performed by the visual system and the luminance of the image is captured by the retina resulting in lateral inhibition among neurons. Therefore, the lateral inhibition makes the dark area seem darker and the light area seem lighter.

For part B, we use sinusoidal grating to generate an image and we found that the frequency range with the highest contrast is from 0 to pi/21. Increasing the amplitude increases the contrast of the dark and light colour bands and the frequency range of the strongest contrast increases, resulting in strong contrast region expanding to the right. This describes that Modular Transfer Function is decreasing function of spatial frequencies. As the spatial frequencies increases, the magnitude response from the optical system decreases. If I am further away from the computer the contrast of the bright and dark regions is less obvious especially for the high spatial frequency regions and the image seems like a bended mixture of color.

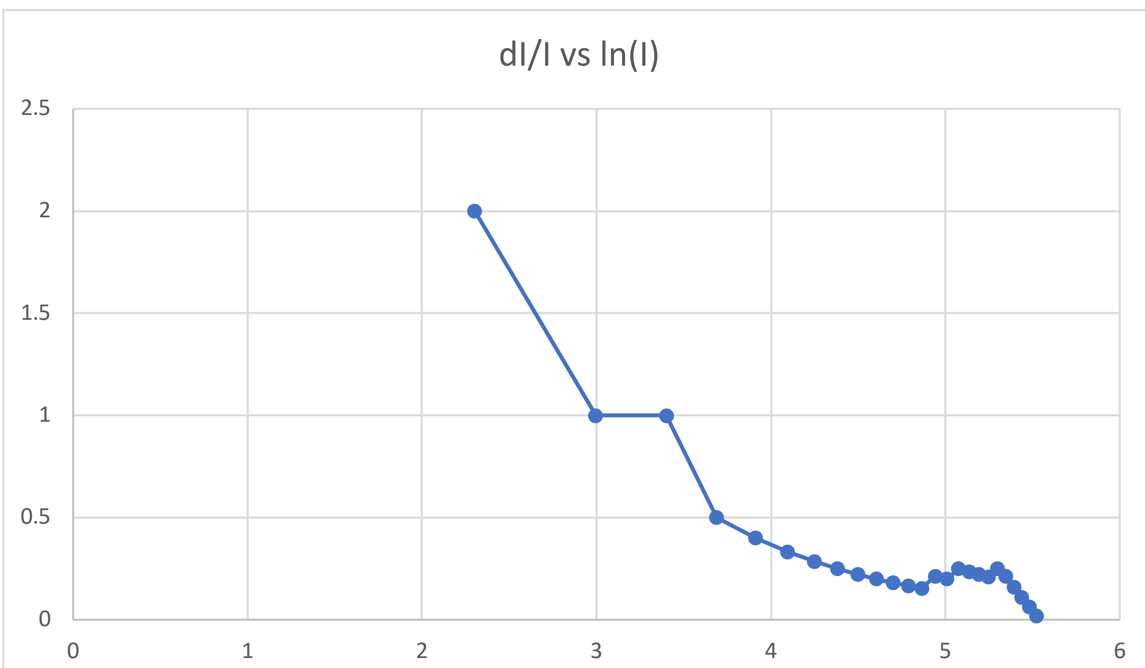
For part C, we created a 512x1024 image consisting of 2 512x512 boxes enclosing a 64x64 boxes each in the middle. We found out that even though the small middle boxes each have the same intensity, they appear to have different brightness based on the backgrounds of the boxes. This happens because the eyes ability to detect changes in intensity level is small compared to the total adaptation range, so even though the intensity of the boxes are the same, it appears to be different based on the background color.

For part D, we create a 512x512 image with intensity I enclosing a small 8x8 box of intensity F. We compare the difference between F and I as dI. We then examine dI for different values of I and F based on when the difference in intensity was noticeable. Based on the observation we get generate the table below:

I	F	dI/I	ln(I)
0	20	0	0
10	30	2	2.3026
20	40	1	2.9957
30	60	1	3.4012
40	60	0.5	3.6888
50	70	0.4	3.9120
60	80	0.3333	4.0943
70	90	0.2857	4.2484
80	100	0.25	4.3820
90	110	0.2222	4.4998
100	120	0.2	4.6051
110	130	0.1818	4.7004
120	140	0.1666	4.7874
130	150	0.1538	4.8675
140	170	0.2143	4.9416
150	180	0.2	5.0106
160	200	0.25	5.0751
170	210	0.2352	5.1357
180	220	0.2222	5.1929
190	230	0.2105	5.2470
200	250	0.25	5.2983
210	255	0.2142	5.3471
220	255	0.1591	5.3936
230	255	0.1087	5.4380
240	255	0.0625	5.4806
250	255	0.02	5.5214



x-axis = F and y-axis = I



x-axis = ln(I) and y-axis = dI/I

The plot above is not exactly consistent with the Weber's law but it shows similar pattern like for smaller I, the dI/I increases. However, due to the pixel intensity limitation (max of 255), for large I, the Weber ratio which was supposed to be extremely large was not able to show. But it is harder for me to tell the difference between F and I if the dI is small for very large I. This is consistent with Weber's Law. Therefore, I believe that our results are consistent with Weber's law, however it looks like its inconsistent at higher I because of the limitation on the max intensity of the pixels in the image.

Three important applications:

1. Fingerprints recognition by computer. Computer need to differentiate fingerprints by noticing the difference in the fingerprints shape and its dark and light curving patterns.
2. Barcode imaging. Barcode contains black lines of varying width and distance from one another containing important information about items. When we need to estimate the barcode depth directly from the raw sensor image, we need to characterize the relationship between depth and the code's spatial frequency.
3. Facial Recognition. Spatial frequencies are important to recognize faces which is used to fast process the facial image and therefore spatial frequencies should be selected carefully for it.

We used images to study the human visual system by examining the human eye response and at the end examined the Weber's Law.