Homework 1- Machine Vision

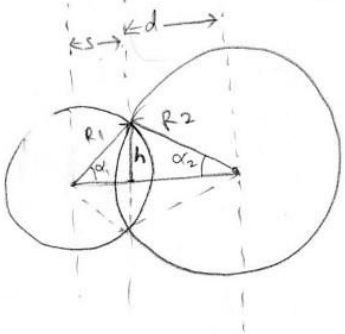
Arpit Patel

1-a

ME 6406

$\alpha_2 =$

1 (a)

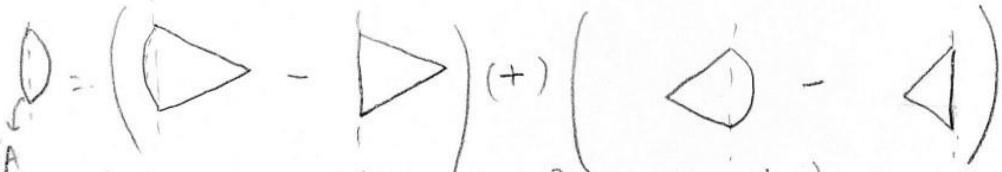


$$h = \sqrt{R_1^2 - s^2}$$

$$\sin\alpha_2 = \frac{h}{R_2} \Rightarrow \alpha_2 = \sin^{-1}\left(\frac{h}{R_2}\right) = \sin^{-1}\left(\frac{\sqrt{R_1^2-s^2}}{R_2}\right) = \sin^{-1}\left(\frac{\sqrt{1-s}}{\lambda}\right.$$

$$\cos\alpha = \frac{d}{R_2} = \cos\left(\sin^{-1}\left(\frac{h}{R_2}\right)\right)$$

$$\Rightarrow d = R_2 * \cos\left(\sin^{-1}\left(\frac{h}{R_2}\right)\right)$$



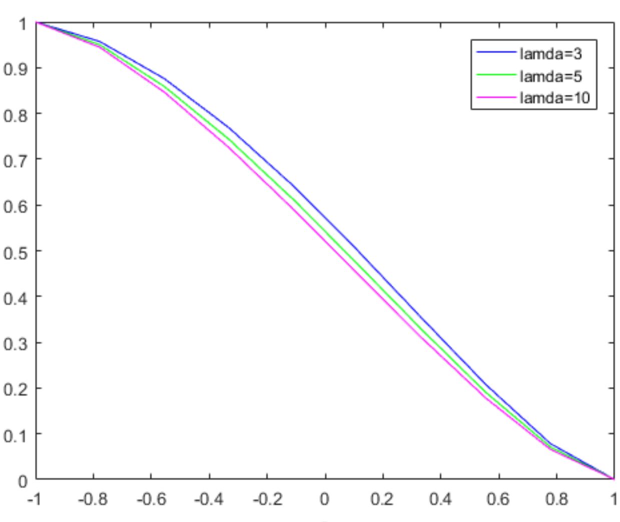
$$= \left(\pi R_2^2\left(\frac{2\alpha_2}{2\pi}\right) - hd\right)(+)\left(\pi R_1^2\left(\frac{2\alpha_1}{2\pi}\right) - sh\right)$$

$$= \left(R_2^2\alpha_2 - \left(\sqrt{R_1^2-s^2} * R_2\cos\left(\sin^{-1}\left(\frac{h}{R_2}\right)\right)\right) + \left(R_1^2\alpha_1 - s\sqrt{R_1^2-s^2}\right)\right.$$

$$\frac{\delta A}{\delta O} = \frac{\delta A}{\pi R_1^2}$$

$$= \frac{\lambda^2}{\pi}\sin^{-1}\left(\frac{\sqrt{1-s^2}}{\lambda}\right) - \left(\frac{\lambda}{\pi}\sqrt{1-s^2} * \cos\left(\sin^{-1}\left(\frac{\sqrt{1-s^2}}{\lambda}\right)\right)\right) + \left(\cos^{-1}(s) - s\sqrt{1-s^2}\right)\frac{1}{\pi}$$

1 (b)



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We can see that as 'S' increases to reach 1(s =R → The two circles are separate), the overlap area is same as the area of the projected pin hole, which makes sense. This phenomenon is also repeated when 'S= -1 which again logically makes sense. However, in between, we observe that the projected area is a complex function which is proportional to lamda, and as R2/R1 increases , the projected area increases. We can also observe that the projected area is only a function of 'S' and 'lamda' and not R1 and R2 in particular.

2-a

Gray level	# of pixels	cdf	q(k)	round(qk)
117	1	1	5.3125	5
118	2	3	15.9375	16
119	2	5	26.5625	27
120	0	5	26.5625	27
121	3	8	42.5	43
122	3	11	58.4375	58
123	2	13	69.0625	69
124	5	18	95.625	96
125	4	22	116.875	117
126	4	26	138.125	138
127	5	31	164.6875	165
128	5	36	191.25	191
129	5	41	217.8125	218
130	3	44	233.75	234
131	2	46	244.375	244
132	2	48	255	255

Sub-region matrix after histogram equalization

96	165	191	234	245	245	218	218
117	69	117	117	191	244	234	234
218	165	69	96	117	138	191	191
218	165	96	43	58	58	138	138
244	218	138	58	27	27	43	96
191	165	165	96	43	16	16	5

B(1)

Original Image: Eyeball.png

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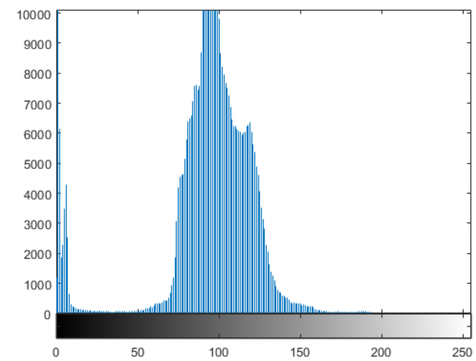
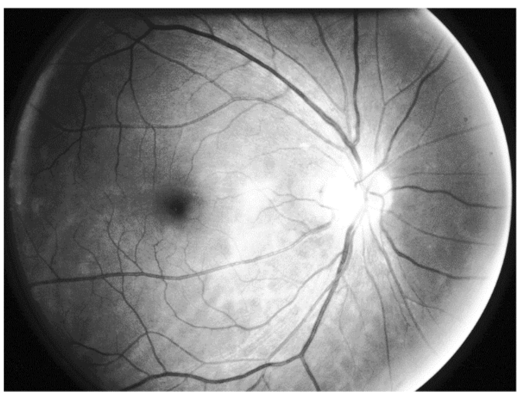
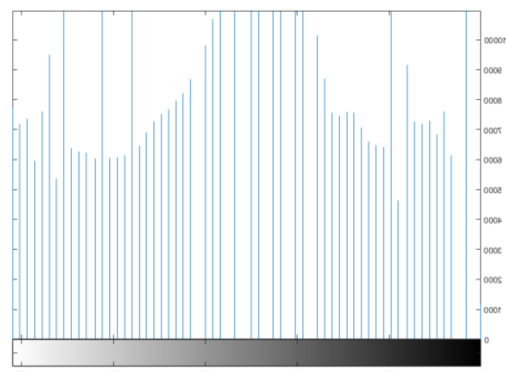
ORIGNAL IMAGE and HISTOGRAM



PROCESSED IMAGE and HISTOGRAM





We can observe that after histogram equalization , the picture intensity evenly distributed and the picture is much clearer as the new image has a lot more contrast. The nerve optics in the eye, which were originally hidden, becomes clearer after the histogram equalization.

3(a). H(x)= [-1 -2 -1; 0 0 0;1 2 1]

H(y)= [-1 0 1;-2 0 2;-1 0 1]

I = [125 123 125;129 127 123;129 127 124]

I(3,2) = 127

G(x) = [-125 -246 -125;0 0 0;129 254 124]

= 11

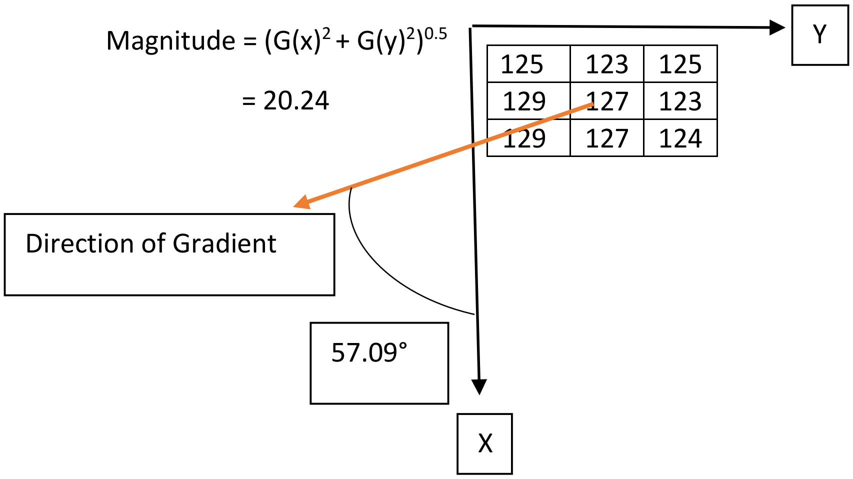
G(y) = [-125 0 125;258 0 246;-129 0 124]

= -17

Direction = $\tan^{-1}(-17/11) = -57.09°$

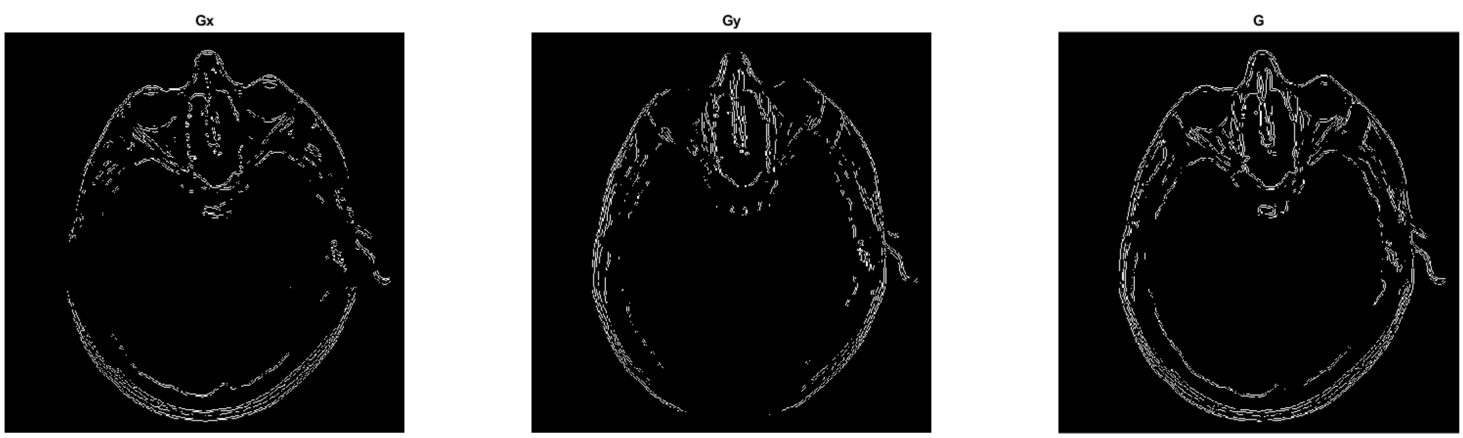
Magnitude = $(G(x)^2 + G(y)^2)^{0.5}$

= 20.24



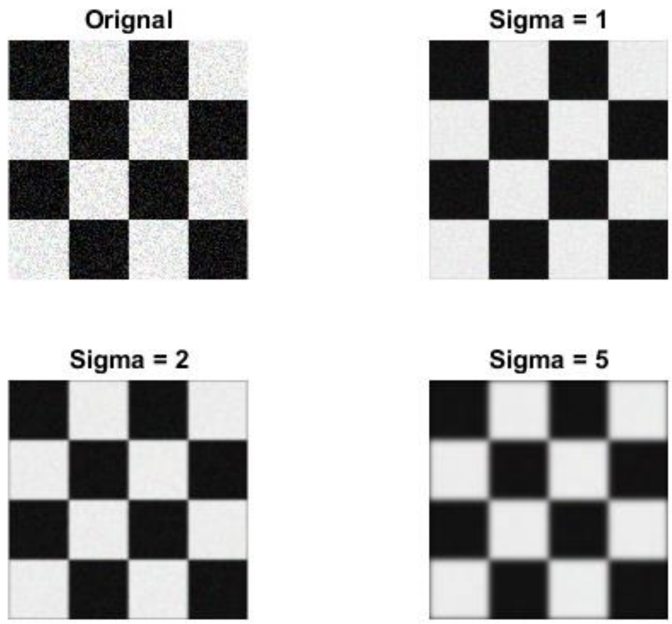
We can observe that the gradient is pointed towards the pixels with high gray scale (125,129 and 129), which makes sense. If all the numbers on the lower left quadrant were 129, we could expect the gradient to be at -45°. However, since one of the numbers is -127, the gradient is weighed towards the -ve Y axis and thus makes sense.

3 (b)



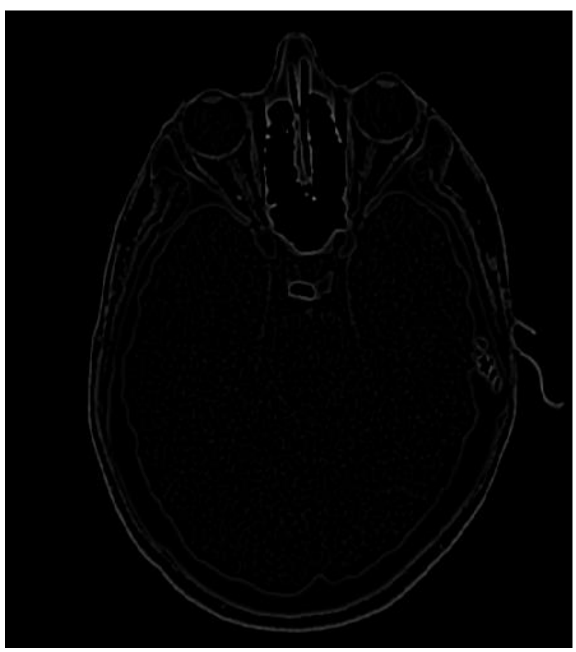
We can observe how as we incorporate the gradient in the both X and Y direction, we get the complete gradient, which is able to give most of the information needed for edge detection. We can also see how G incorporates data from both G_x and G_y , which confirm with our theory.

3(c)



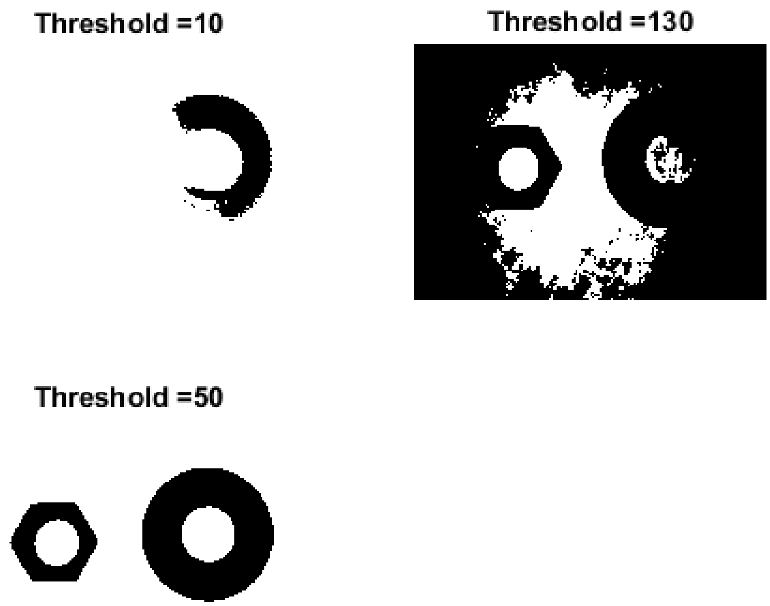
We can observe that as we increase the value for sigma, we incorporate more and more standard deviation. Thus the Gaussian curve becomes wider and smoother. We can also observe this effect on the image, as a Gaussian helps reduce the noise at low sigma (sigma= 1) , however, if we increase sigma beyond a point, we lose data and the image becomes blurry.

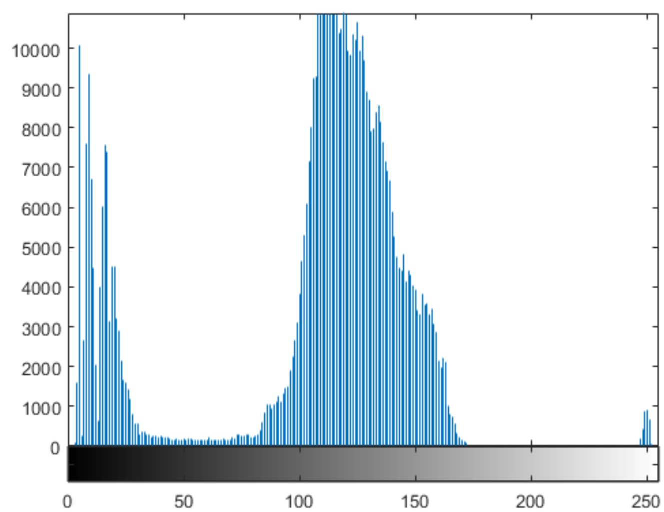
3(d)



We can see that DOG helps for the purpose of reducing noise(since the noise from the two sigma's cancels out) and is helpful in making the image clearer and thus identify boundary edges.

4(a)





We can observe from the histogram that the threshold region is between (30 and 80) approximately. Anything >80 would be an overestimate and anything <30 . We can confirm that belief by looking at the image above .

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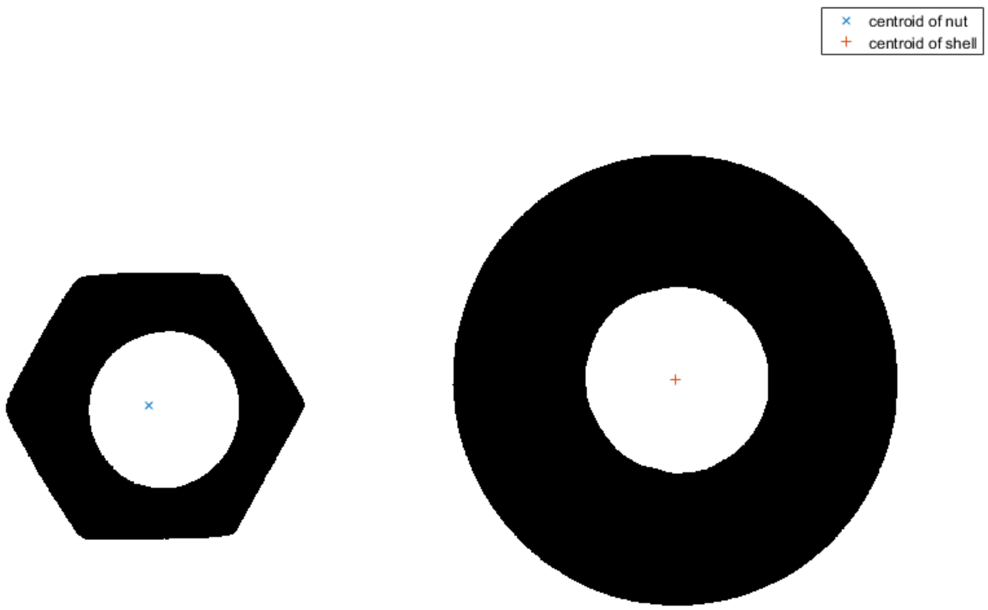
(b)



Area of nut = 25159

Area of shell = 78178

4(c)