EE 475 HOMEWORK 1

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Q1. Generating image patterns

I defined the sizes of the background as 512 X 512 pixels and the center is at 256,256. The result image can be shown in Figure 1.1.

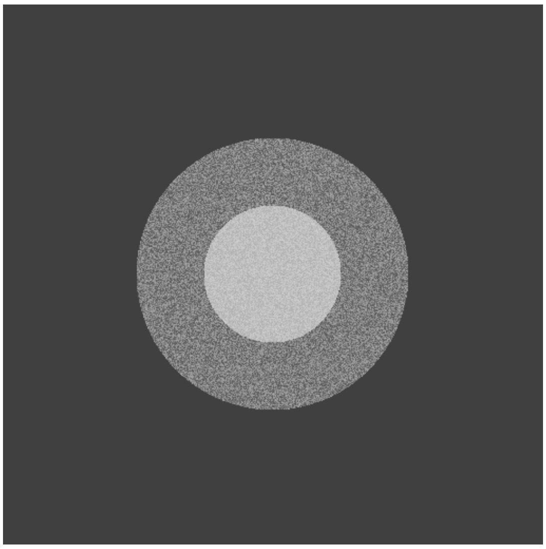

Figure 1.1

Q2. Image read & writes; histogram plots:

The original photo of peppers can be shown at Figure 2.1.

Figure 2.1

a) Extract R, G, B color components of "peppers.png" and display (plot) separately each component.

The first index of 3D matrix is for red values, the second one is for green values and the third one is for blue values.

Figure 2.2 (Red Component)

Figure 2.3 (Green Component)

Figure 2.4 (Blue Component)

b) Find the spatial locations (x, y) of the pixels having the following R, G, B color values: R>90, G>10, B<40. Create a new binary matrix (image) that has 1 in the corresponding spatial locations, otherwise 0. Display the binary image and comment on the result. (1 should be plotted as 255, and 0 as 0; or vice versa)

I used logical matrix for the condition. The binary image can be shown at Figure 2.5.

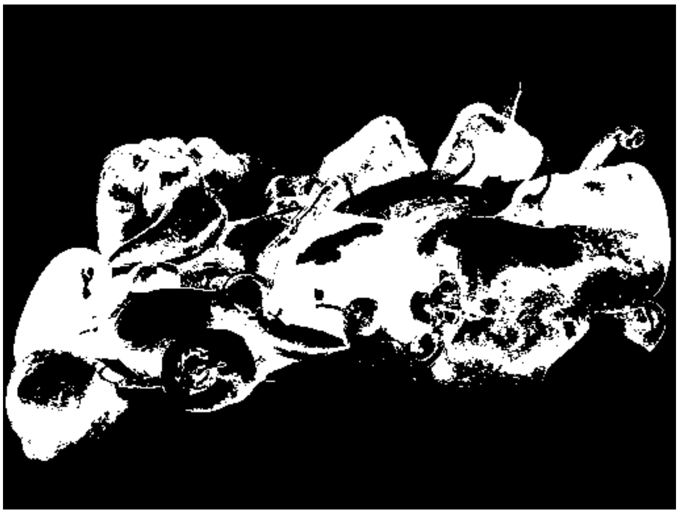

Figure 2.5 (binary image)

The white pixels are the pixels which satisfy our condition. Our condtitons want the pixels to be more red and green rather than blue. It's logical that these pixels are generally on peppers. They are red, green and orange.

c) Create a new image named "gray.bmp" by taking the average of the color components (R+G+B)/3 and display it.

I used formula (R/3 + G/3 + B/3) to take the average of components, because I made calculation with uint8 number type.

Figure 2.6 (gray.bmp)

d) Use the imhist function and plot the histogram of "gray.bmp". Comment on the plot: what are the x- and y-axis? Are there definite peaks? Does the histogram occupy the whole gray level range?

The histogram of "gray.bmp" can be shown at Figure 2.7.

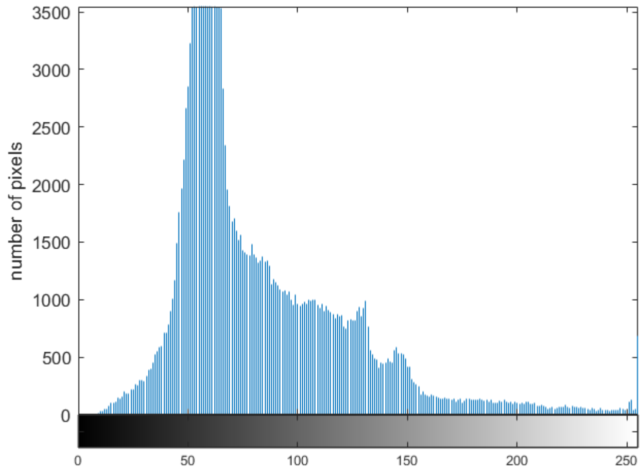

Figure 2.7

X axis shows the value of pixels and Y axis shows the number of pixels at this value defined at X axis. There are definite peak at value 57. There are 6594 pixels whose values is 57. It can be shown by making zoom in (Figure 2.8).

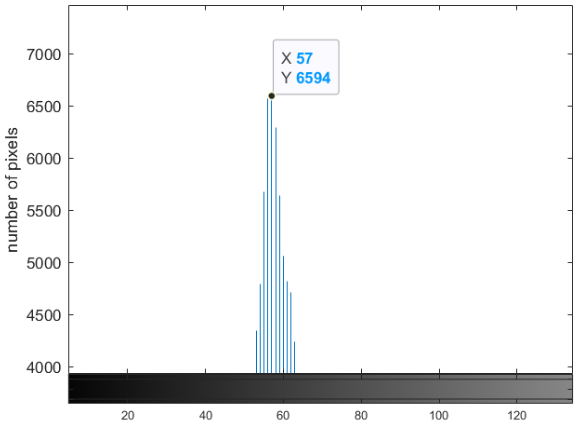

Figure 2.8 (zoom in Figure 2.7)

The histogram doesn’t occupy the whole gray level range. There is not any pixels whose value is lower than 8. The minimum value is 8 (Figure 2.9). It means there is not any completely black pixel.

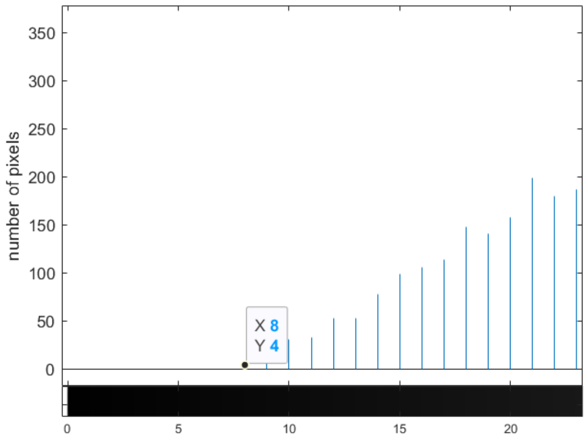

Figure 2.9 (zoom in Figure 2.7)

e) Divide all the gray-scale pixel values of “gray.bmp” by 2 and display the resulting image and its histogram. Comment on the results. Add 64 to all gray levels (any value exceeding 255 should be truncated to 255) and plot its histogram. Comment on the results.

The image whose pixel values are divided by 2 can be shown at Figure 2.10 and the histogram at Figure 2.11.

Figure 2.10 (gray.bmp /2)

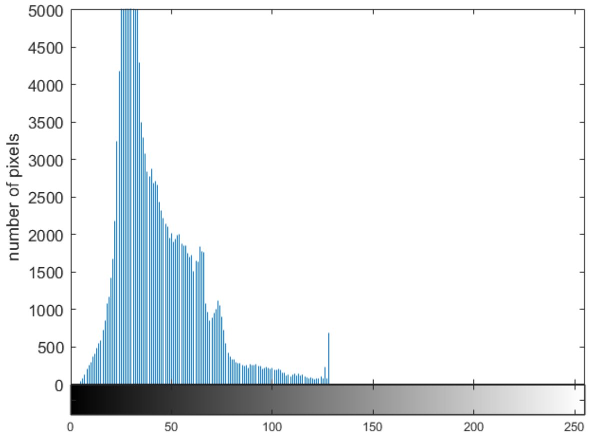

Figure 2.11 (gray.bmp /2)

When the figure 2.6 (gray.bmp) and figure 2.10 are compared, the second image (gray.bmp /2) is darker. Because image pixels’ values are about light and dark. When the pixel values are divided by 2, the gray image becomes darker. Also, this situation can be shown at the histogram of the second image (Figure 2.11). There are more darker pixels. Also, there is not any pixel whose value is more than 128. The max value is 128 because the max value at the first image is 256 (Figure 2.12).

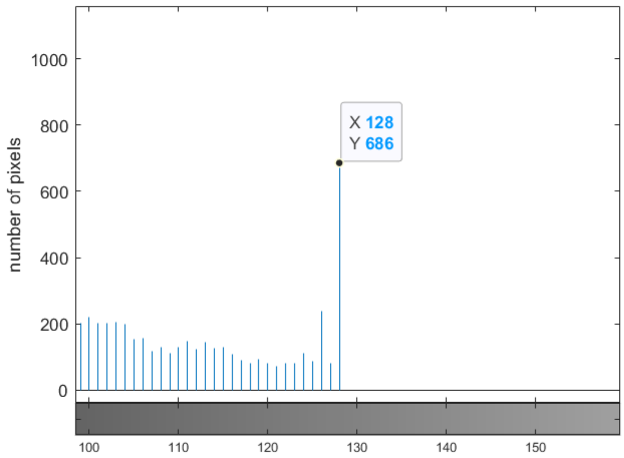

Figure 2.12

Adding 64 to pixels' values makes the image lighter a bit. The image can be shown at Figure 2.13 and it's histogram at Figure 2.14.

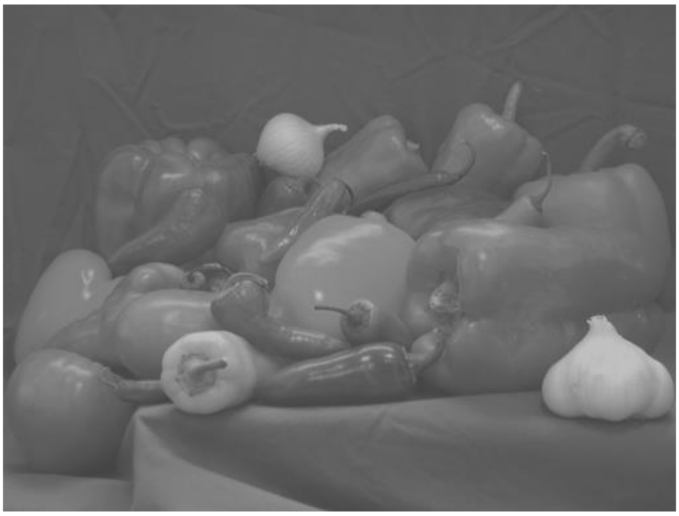

Figure 2.13

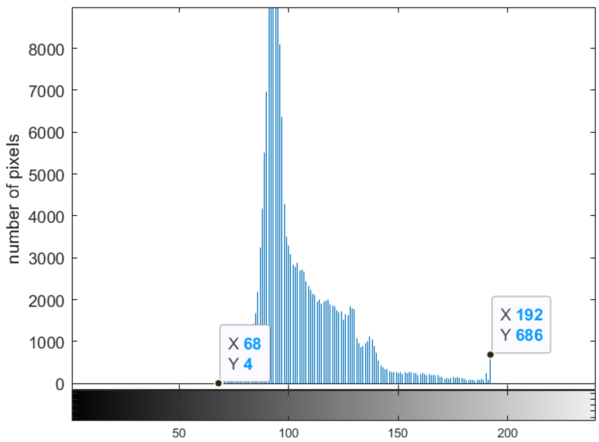

Figure 2.14

The values are shifted 64 to right side (lighter). When the second image and the third image (Figure 2.14) are compared, the second image is darker but a bit blurred. Also, its min and max values are 68 and 192.

68= min(image 1) /2 + 64 = 8 /2 + 64 = 68

where min(image 1) is 8 (Figure 2.9)

192 = max(image 1) /2 + 64 = 256/2 + 64 = 128 + 64 = 192

where max(image 1) is 256 (Figure 2.7)

Q3. Pixels Varieties

a) If the object is self-luminous, as in the Cetus galaxy (actually, a small galaxy in the constellation Cetus, contains 200 million suns' worth of stars), what are the approximate coordinates of the point that emits the most amount of light?

The image can be shown at Figure 3.1.

Figure 3.1

The point that emits the most amount of light is the lightest point (max value). The approximate point can be detected by looking the stars. I think the star which emits the most amount of light is pointed at Figure 3.2.

Figure 3.2

When I use the matlab tools (data tips), I can see its approximate coordinate (Figure 3.3).

Figure 3.3

Its coordinate is 741, 546 and its value is 255, it's max value.

b) If the image is taken with a range camera, as in the Office image, what are the approximate coordinates of the closest point and the farthest points?

The image can be shown at Figure 3.4.

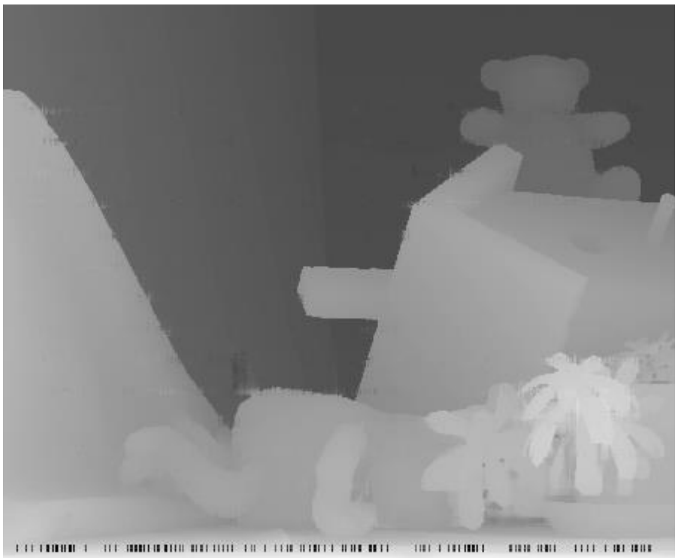

Figure 3.4

Darker pixels represent farther points whereas lighter pixels represent closer points. To find the closest point, the lighest pixel should be investigated and to find the farthest point, the darkest pixel should be investşgated.

The closest and farthest points can be shown at figure 3.5 and their values and coordinates can be shown at figure 3.6 (closest pointed by red) and 3.7(farthest pointed by blue).

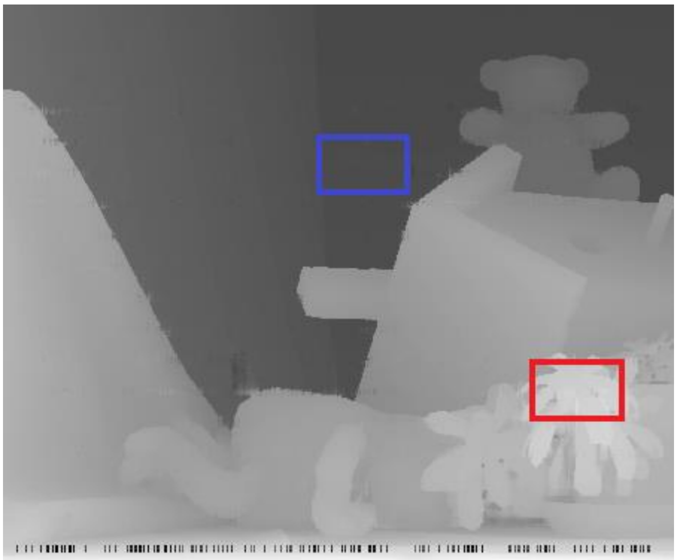

Figure 3.5

Figure 3.6 (closest point)

The approximate coordinate of the closest point is 392, 268 when I select the point with data tips tool.

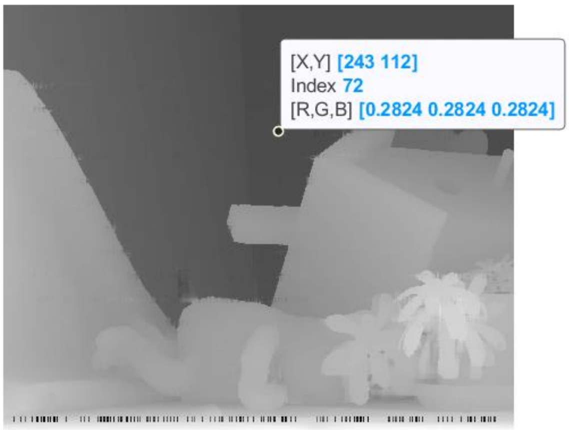

Figure 3.7

The approximate coordinate of the farthest point is 243, 112.

c) If the image represents material density, as in the Breast and Skull images, what are the approximate coordinates of the opaquest (densest) and least opaque (most transparent) points with the Region of Interest (RoI)?

The breast image is at figure 3.8 and skull image is at figure 3.9.

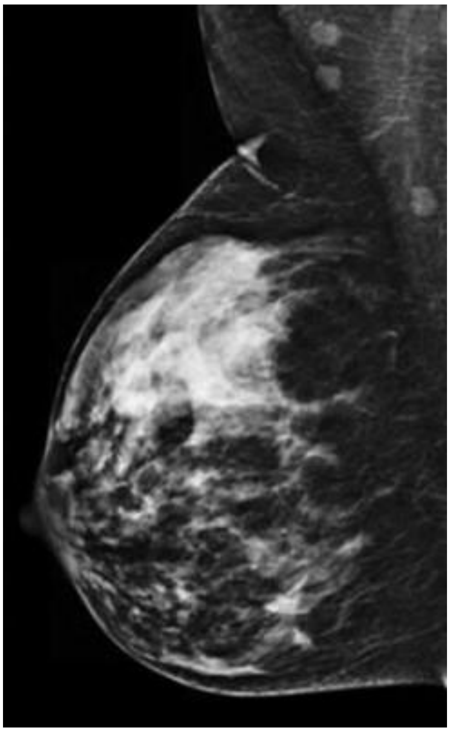

Figure 3.8

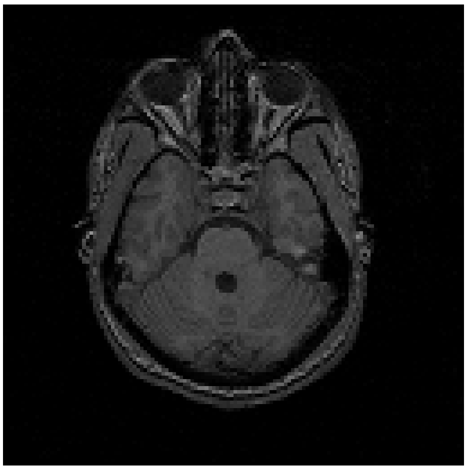

Figure 3.9

Darker pixels represent more transparent points and lighter points represent more opaque (more dense) points. The red figures show most transparent regions on the breast and skull, whereas the blue figures show most dense region. (Figure 3.10 and Figure 3.11)

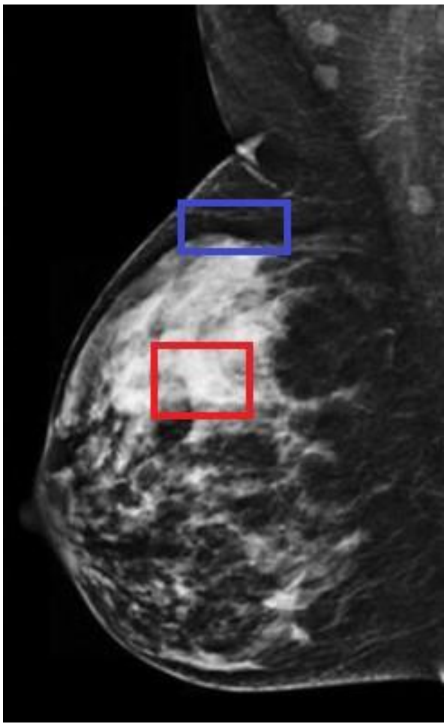

Figure 3.10

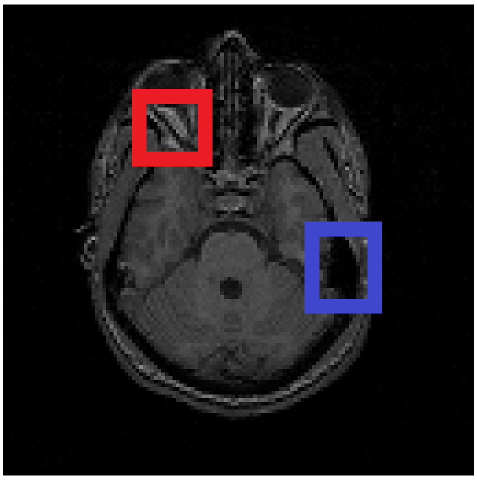

Figure 3.11

By using matlab tools, data tips, the coordinates of selected points can be found.

The approximate coordinate of the most transparent point on breast is 138, 128 (Figure 3.12)

The approximate coordinate of the most dense(most opaque) point on breast is 116, 208 (Figure 3.13)

The approximate coordinate of the most transparent point on skull is 93, 76 (Figure 3.14)

The approximate coordinate of the most transparent point on skull is 48, 32 (Figure 3.15)

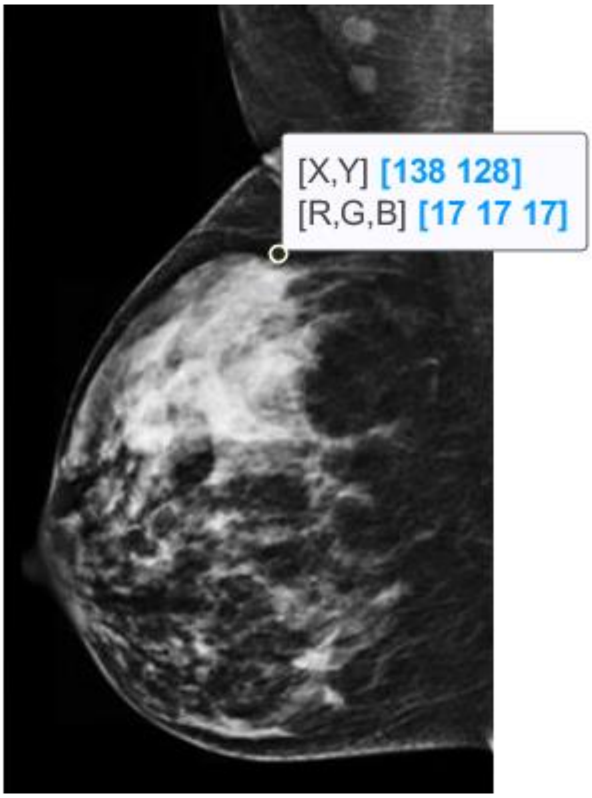

Figure 3.12

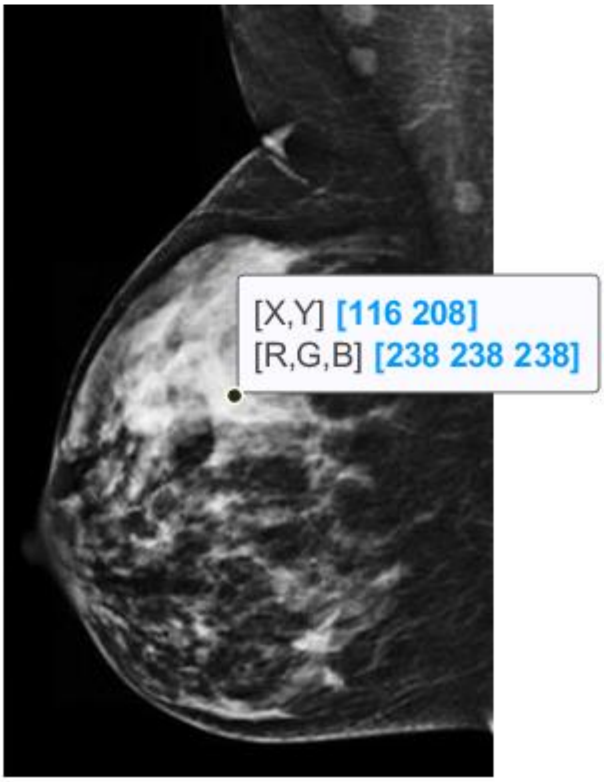

Figure 3.13

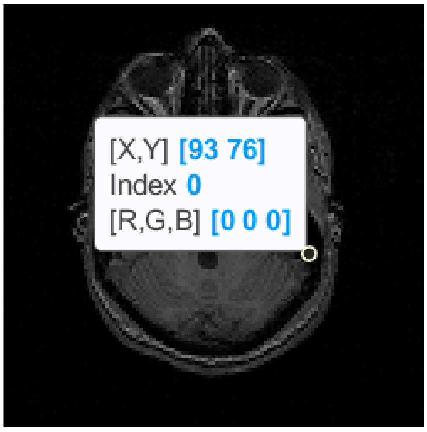

Figure 3.14

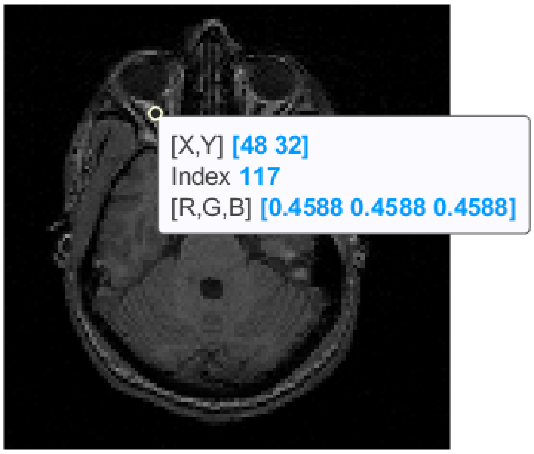

Figure 3.15

d) If the image is captured with a thermal camera, where are the hottest points?

The original image is at figure 3.16.

Figure 3.16

The hottest point is the lighest pixel when a thermal camera is used to take photo. The lighest point on the head of the third man (figure 3.17)

Figure 3.17

The approximate coordinate of the hottest point is 47, 72 (figure 3.18).

Figure 3.18

e) In the sequence of three images from Hamburg Taxi sequence (taxi36, taxi38 and taxi40.pgm), where are the fastest changing points?

Original photos are at figure 3.19, 3.20 and 3.21.

Figure 3.19

Figure 3.20

Figure 3.21

Actually, to investigate which point is changing fastest is difficult, so I need extra methods. I take the difference between images to determine changing points. The values of pixels represent the change value of these pixels (Figure 3.22). The brighest points are on the white car because the road is gray-black, so changing of pixels on the white car is more than other pixels.

Figure 3.22

I applied threshold about 100. If the changing is more than 100, the value is 1; otherwise it is zero. The result is binary images (figure 3.23).

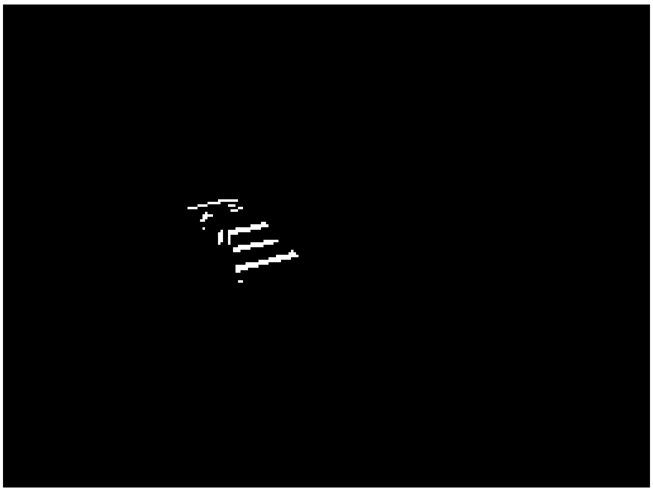

Figure 3.23

There are only pixels on the white car. I increased the threshold quantity(changing quantity) until there is only one pixel to find fastest changing pixel. The figure 3.24 is the result when the threshold is 150.

Figure 3.24

When the threshold is 172, the result is the image at figure 3.25. There is only one pixel. This point is the fastest changing point. Its coordinate is 102, 88 (figure 3.26).

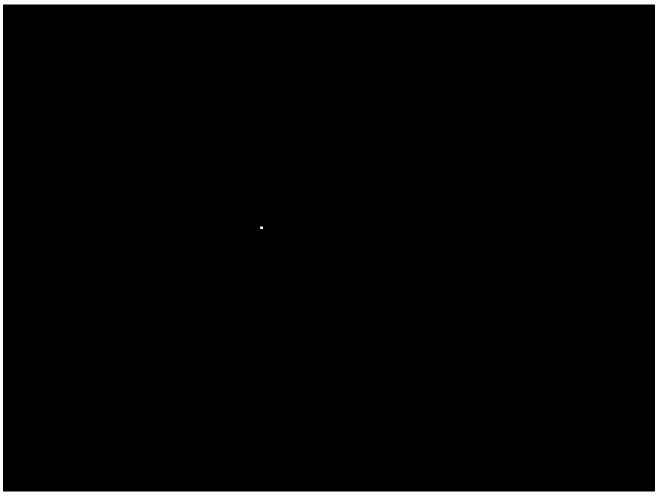

Figure 3.25

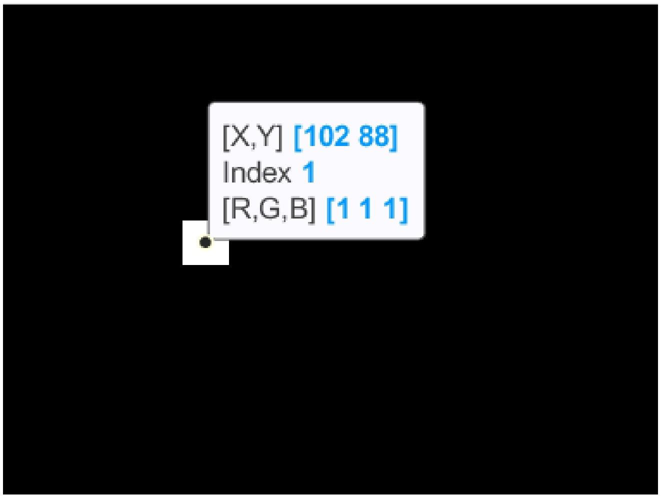

Figure 3.26

Q4. Imaging System Design

A pool-playing robot uses an overhead camera to determine the positions of the balls on the pool table. Assume that: a) We are using a standard billiard table of size 150x280. b) We need at least 100 square pixels per ball to reliably determine the identity of each ball; the ball diameter is 5.7 cm. c) The center of the ball can be located to a precision of +- one pixel in the image. d)We need to locate the ball on the table to an accuracy of +- one cm. e) We are going to mount the camera on the ceiling, looking straight down. The distance from the camera to the table is 2 m. Determine a configuration of the camera resolution and lens field of view (FOV) that will meet these requirements. Assume that you can choose from the following parts: Lenses with field of view 30, 60, 90 degrees. Cameras with resolutions of 256x256, 512x512, or 1024x1024 pixels. Choose the lowest camera resolution that will meet the requirements.

a) *First determine the viewing angle needed. The camera is looking down from 2 m and most span 280 cm. Use tangent formula to field of view.*

b) *To determine the camera resolution, there are two criteria to be satisfied: a) The precision of 1 cm for the ball center; b) The requirement of having 100 pixels per ball. Check both conditions and take the larger of the two.*

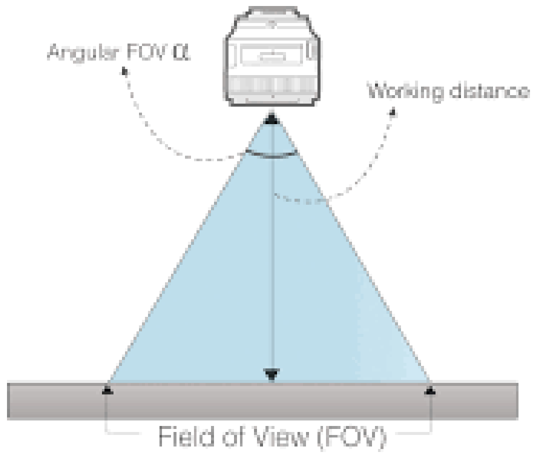

Figure 4.1

a)The system is like figure 4.1. The height (working distance at the figure) is 2 meters, the field of view must span the pool-table (280X150 cm^2) and the angle must be selected to satisfy this condition. The formula is :

min viewing angle = 2*arctan(the maximum vertical or

horizontal distance from the center / height) ,

where the maximum vertical or horizontal distance from

the center = 140 cm, height = 200 cm

min viewing angle = 2*arctan(140/200) = 2*arctan(0.7)

2*(34.99 degree) = 69.98 degree

If I selected 60 or 30 degree, the camera couldn't span the desk. So, I must select the camera with 90 degree.

Width of field of wiev = 2*tan(viewing angle/2)*height,

where viewing angle = 90 degree, height 200 cm

Width of field of wiev = 2*tan(45 degree) *200 = 400 cm

The field of view is 400X400 cm^2.

b) I must select proper resolution and there are two conditions.

1) The first one is the precision of 1 cm for the ball center. Because of this, one-pixel width represents maximum 1 cm.

pixel width <= 1 cm

I can calculate the pixel width by dividing the width of fov to the number of pixels (n_1)

(eq1):

Pixel width = the width of fov / the number of pixels (n_1)

$= 400 / n_1 <= 1$ cm

$n_1 >= 400$

Minimum the number of pixels is 400. The resolution must be higher than 400X400 pixel^2. 512X512 and 1024X1024 resolutions are proper for this condition.

2) The second condition is the requirement of having 100 pixels per ball.

The diameter is 5.7 cm, then I need to calculate its area.

area = π*(diameter/2) ^2 = π*(2.85) ^2 = 25.51 cm^2

The mininum number of pixels on 25.51 cm^2 is 100 pixel^2.

25.51 cm^2 >= 100 pixel^2

pixel^2 <= 0.2551 cm^2

<u>pixel width <= 0.51 cm</u>

I can use same formula (eq1) at the 1. part.

Pixel width = the width of fov / the number of pixels (n_2)

$= 400 / n_2 <= 0.51$ cm

$n_2 >= 792$

Minimum the number of pixels is 792. The resolution must be higher than 792X792 pixel^2. 1024X1024 resolution is proper for this condition

To satisfy both conditions, I must select larger resolution, because 512X512 resolution doesn’t satisfy the second condition. For this system and these conditions, the proper resolution is 1024X1024 and the camera with 90 degree viewing angle.