AIML331 Assignment 1

Gerard Cabauatan
NSN: 300651470

Link:
https://github.com/Canteenboy/AIML331-Assignment-1

<u>1.1 - Compute the [R, t] matrix converting world coordinates to camera coordinates</u>

The pinhole camera is at [0, 0, -10] and is pointing to the right 30 degrees so like I said below, we have to translate the camera coordinates by moving it forward by 10 and rotate it 30 degrees anti clockwise along the y-axis so that objects in the world is shown correctly

1.1

We need to move (translate) the world co-ordinates of the camera to the origin which means we have to move the camera forward by 10 on the z-axis because the camera is at [0, 0, -10]

the camera is also at 30° so we need to turn it 30° anti-clockwise

$$R_y(\theta) = \begin{bmatrix} \cos(\theta) & 0 & \sin(\theta) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_y(30) = \begin{bmatrix} \cos(30) & 0 & \sin(30) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(30) & 0 & \cos(30) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \frac{\sqrt{3}}{2} & 0 & \frac{1}{2} & 0 \\ 0 & 1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad t = \begin{bmatrix} 0 \\ 0 \\ 10 \\ 1 \end{bmatrix}$$

$$Rt = \begin{bmatrix} \frac{\sqrt{3}}{2} & 0 & \frac{1}{2} & 0 \\ 0 & 1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 10 \\ 1 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 5\sqrt{3} \\ 1 \end{bmatrix}$$

$$[R \quad Rt] = \begin{bmatrix} \frac{\sqrt{3}}{2} & 0 & \frac{1}{2} & 5 \\ 0 & 1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 5\sqrt{3} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

1.2

1.2

$$K = \begin{bmatrix} 0.1 & 0 & 0 & 0 \\ 0 & 0.1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \quad P_1 = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} \quad P_2 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} \quad P_n = K[R \;\; Rt]P_n$$

$$P_1 = \begin{bmatrix} 0.1 & 0 & 0 & 0 \\ 0 & 0.1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{3}}{2} & 0 & \frac{1}{2} & 5 \\ 0 & 1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 5\sqrt{3} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{\sqrt{3}}{20} & 0 & \frac{1}{20} & 0.5 \\ 0 & 0.1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 5\sqrt{3} \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0.5 \\ 0.1 \\ 5\sqrt{3} \end{bmatrix}$$

$$P_2 = \begin{bmatrix} 0.1 & 0 & 0 & 0 \\ 0 & 0.1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \frac{\sqrt{3}}{2} & 0 & \frac{1}{2} & 5 \\ 0 & 1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 5\sqrt{3} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{\sqrt{3}}{20} & 0 & \frac{1}{20} & 0.5 \\ 0 & 0.1 & 0 & 0 \\ -\frac{1}{2} & 0 & \frac{\sqrt{3}}{2} & 5\sqrt{3} \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 0.55 \\ 0 \\ \frac{11\sqrt{3}}{2} \end{bmatrix} = \begin{bmatrix} 0.55 \\ 0 \\ 5.5\sqrt{3} \end{bmatrix}$$

$$P_1 \times P_2 = \begin{bmatrix} 0.5 \\ 0.1 \\ 5\sqrt{3} \end{bmatrix} \times \begin{bmatrix} 0.55 \\ 0 \\ 5.5\sqrt{3} \end{bmatrix} = \begin{bmatrix} 0.55\sqrt{3} \\ 0 \\ -0.055 \end{bmatrix}$$

Line equation

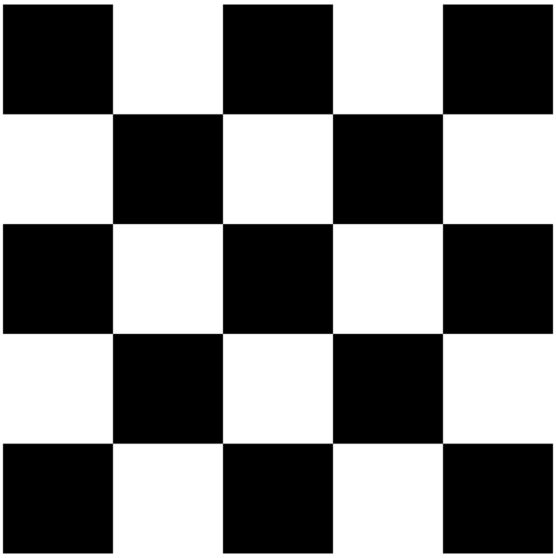
$$0.55\sqrt{3}x - 0.055 = 0$$

Vector form

$$\begin{bmatrix} 0.55\sqrt{3} \\ 0 \\ -0.055 \end{bmatrix} x = 0$$

2.1

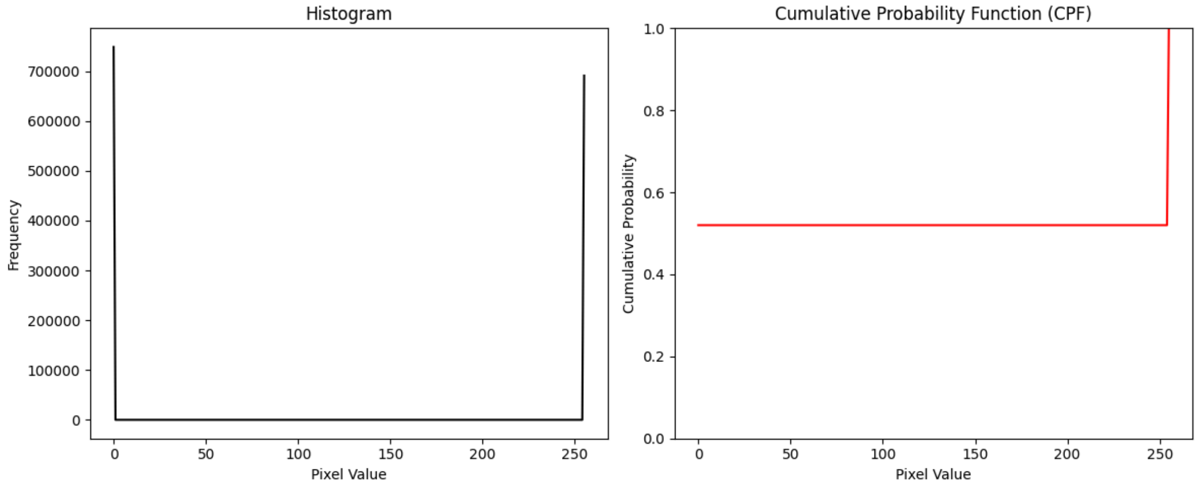
My image is 1200 by 1200 pixels and is converted to grayscale using the .convert('L') from the PIL library. I then converted it to an image array so it's easier to make calculations with the image



https://en.wikipedia.org/wiki/Check_%28pattern%29

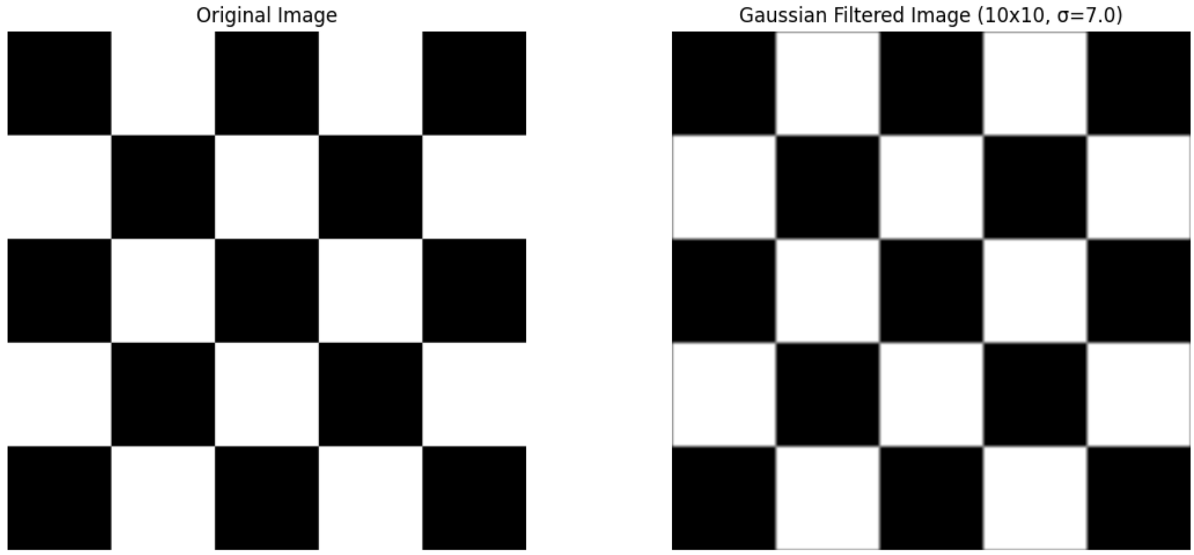
2.2

From the graphs below we can see that for the checkerboard image there is only 2 pixel values being black and white but from what we can see there is more black than white due to the difference of the 2 peaks in the histogram



2.3

When applying the gaussian filter, I set my sigma to 7 which means that it would be more blurry as we can see below with the 2 images. This is because as the checkerboard image has fine lines sectioning each black and white square, having a larger sigma smoothes out those fine lines making them blurry



2.4

I chose the gaussian filter and yes it is separable. As I also said in my jupyter notebook, for a filter to be separable it should be able to decompose into the product of 2 1D filters.
Since the equation for a gaussian filter is:

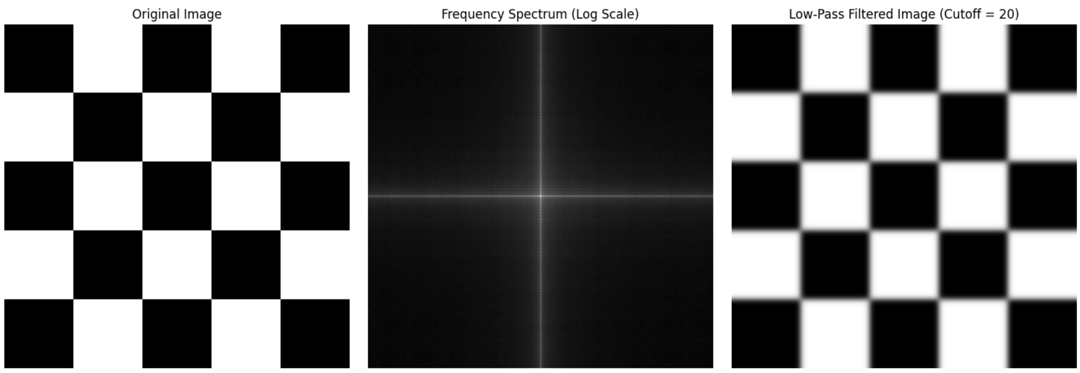
$$w(i,j) = K\mathrm{e}^{-\frac{i^2+j^2}{2\sigma^2}}$$

We can change this into 2 1D filters:

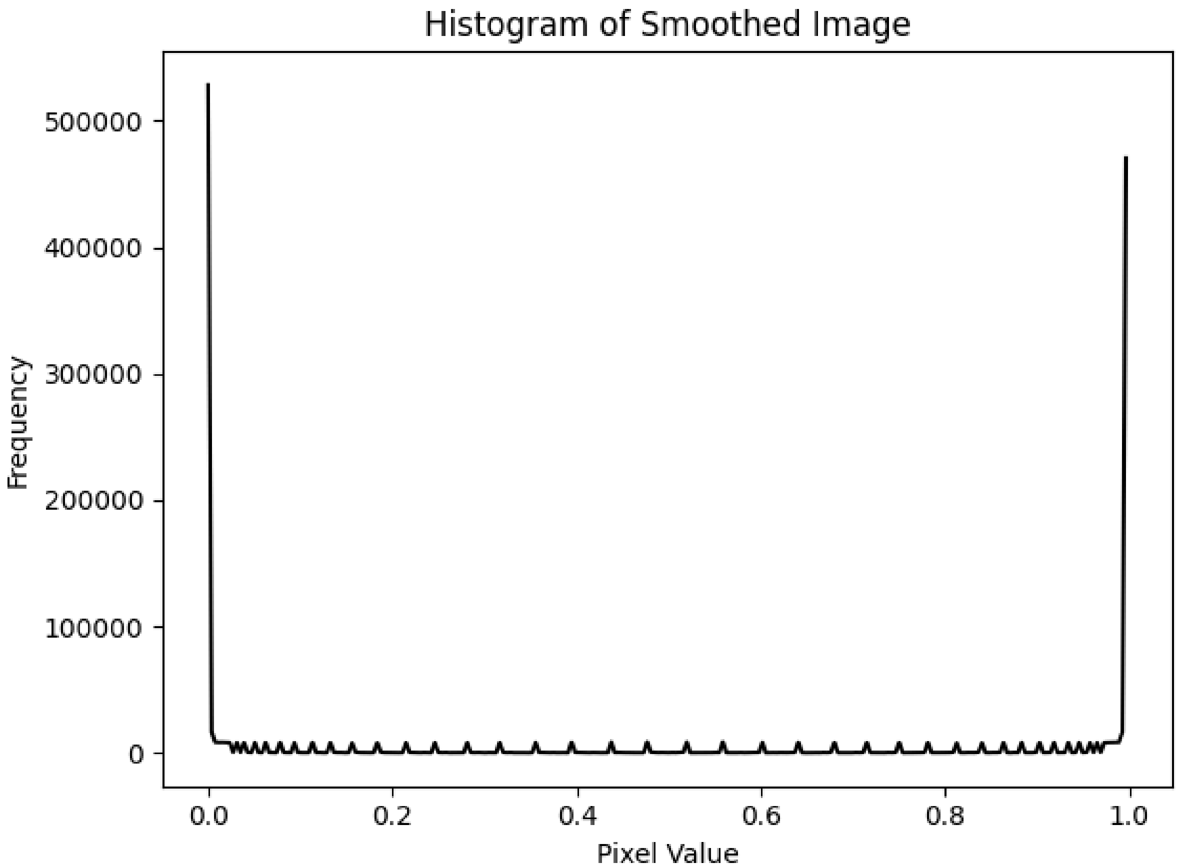
$$e^{-\frac{i^2}{2\sigma^2}} \text{ and } e^{-\frac{i^2}{2\sigma^2}}$$

2.5

To convert from the spatial domain to the frequency domain I used fast fourier transform (FFT) and after converting to the frequency domain I applied the gaussian low-pass filter and converted it back to the spatial domain to give the image on the very right. I used a cutoff frequency of 20 which means that any frequency 20 will be filtered out which is why the fine lines are again blurred



2.6



2.7

To have a uniform probability of intensity levels for the low pass filtered checkerboard image I used histogram equalization which maps the original pixel intensities to the new pixel intensities which is defined by the normalised CDF