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Q3a. By preservation of mass, we have (α is given in question)

$$\int_0^a h_{1e}(I)dI = \int_0^a h_1(I)dI = \alpha \quad \& \quad \int_a^1 h_{2e}(I)dI = \int_a^1 h_2(I)dI = 1 - \alpha$$

where $h_{1e}(I)$ & $h_{2e}(I)$ are equalized histograms for regions [0, a] and (a, 1] respectively
Equalized histograms imply $h_{1e}(I)$ and $h_{2e}(I)$ are constants in their respective domains

$$h_{1e}(I) = \frac{\alpha}{a} \text{ and } h_{2e}(I) = \frac{1-\alpha}{1-a}$$

Mean Intensity for the new histogram = $\int_0^a I.\, h_{1e}(I)dI + \int_a^1 I.\, h_{2e}(I)dI = \frac{1 + a - \alpha}{2}$

Q3b. Given the mean intensity of the original histogram

$$\int_0^a I.\, h_1(I)dI + \int_a^1 I.\, h_2(I)dI = a$$

And the median intensity of the original histogram is also a:

$$\int_0^a h_1(I)dI = \int_a^1 h_2(I)dI$$

$$\Rightarrow \alpha = 1 - \alpha \quad \Rightarrow \quad \alpha = 0.5$$

Mean intensity of resulting = $\frac{0.5 + a}{2}$

Q3c. Simple histogram equalization is likely to fail where there are a high number of pixels concentrated at some bright pixel value than the others and we flatten/normalize it across the 0 to 255-pixel intensity range, hence losing the brightness. Or if there is noise of a contrasting pixel value in the background, it can get amplified upon normal histogram equalization.

Please refer to the next page for part d

Q3d. I found a picture in the assignment itself. Figure 2 and figure 1 respectively in the code file are showing Bi-histogram and equalized histogram images.