CS653 Digital Image Processing
Assignment # 1

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Q1

$$V_{rms} = \frac{2^n S}{2\sqrt{2}}$$
$$V_{qn} = \frac{S}{\sqrt{12}}$$
$$SNR = 20 * log\Big(\frac{V_{rms}}{V_{qn}}\Big)$$
$$SNR = 20 * log\Big(\frac{\frac{2^n S}{2\sqrt{2}}}{\frac{S}{\sqrt{12}}}\Big)$$
$$SNR = 20 * log\Big(\frac{2^n S}{2\sqrt{2}}\frac{\sqrt{12}}{S}\Big)$$
$$SNR = 20 * log\Big(\frac{2^n}{2\sqrt{2}}\frac{\sqrt{6}\sqrt{2}}{1}\Big)$$
$$SNR = 20 * log\Big(2^n\frac{\sqrt{6}}{2}\Big)$$
$$SNR = 20 * log(2^n) + 20 * log\Big(\frac{\sqrt{6}}{2}\Big)$$
$$20 * n = SNR - 20 * log\Big(\frac{\sqrt{6}}{2}\Big)$$
$$n = \frac{SNR}{20} - log\Big(\frac{\sqrt{6}}{2}\Big)$$

As you can see n (bits per pixel) is directly proportional to SNR. If we try to quantized image with higher number bits, it is expected we will have higher SNR. Constants $log(\frac{\sqrt{6}}{2})$ can be discarded.

Q2

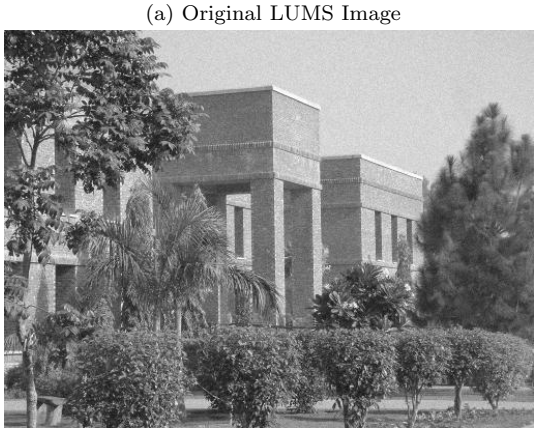
All working of this quesiton can be found in `Q2.m` file.

Part (a)

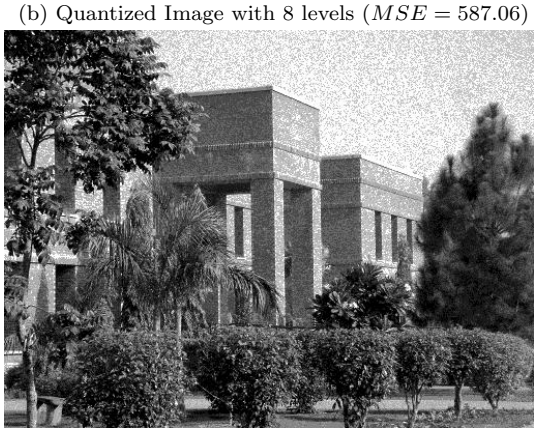
I quantized both `lums_g.pgm` and `yahya_g.pgm` with 8 levels and result is show below in part (a) and (b) of figure 1 and 2. False contouring is clearing evident which means we have lost few detials in the image but human eye can still perceive the image and differentiate between objects.

(a) Original LUMS Image

(b) Quantized Image with 8 levels ($MSE = 587.06$)



(c) Noise ($J = 10$)



(d) Quantizing noisy image with 8 levels($MSE = 754.49$)

Figure 1: LUMS image comparison with 8 quantization levels

Part (b)

Below in part (c) and (d) of figure 1 and 2 are the results produced after adding noise with $J = 10$ and then quantizing the noisy image with 8 levels.

Part (c)

The noisy quantized lums image subjectively look much better than the original quantized image. Yahya noisy quantized image was also better than the original quantized image. MSE for dithered quantized image was higher but the image looked better, subjectively.
i. Looking at the result of lums image it makes sense to add some random noise of very low magnitude and then quantizing the image will produce better detailed image.

(a) Original Yahya Image

(b) Quantized Image with 8 levels ($MSE = 339.30$)

(c) Noise ($J = 10$)

(d) Quantized noisy image with 8 levels ($MSE = 692.37$)

Figure 2: Yahya image comparison with 8 quantization levels

ii. If your are planning to compress your image then dithering will not work as noisy images are not compressable.
iii. No, MSE is not a good measure of image quality. First of all we don't have a reference image all the time. Also we could have a very good image but few bad pixels (inverse pixels) and that could drive MSE very large because of the square factor. Also, MSE is not a absolute measure of error. For some image it could be higher but it would still look and for some images MSE would be lower but they would look worse.

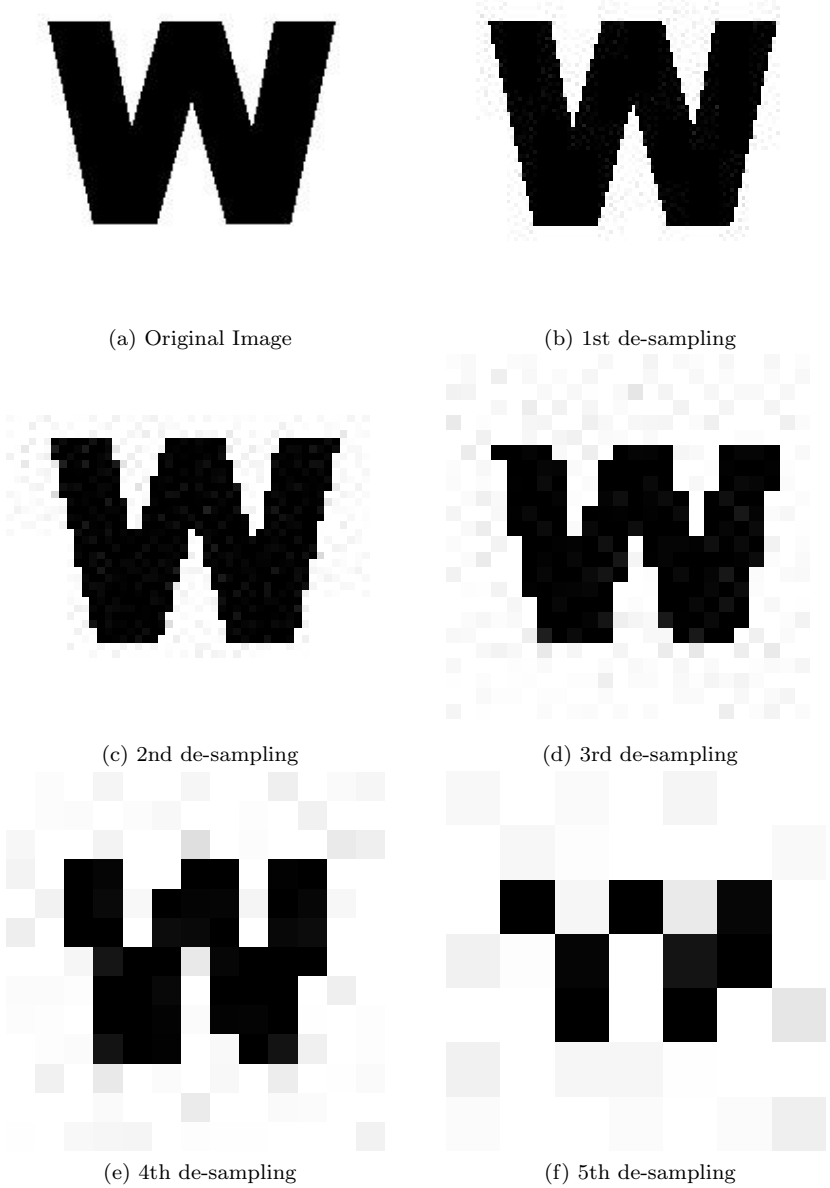
Part (d)

Similarly, for 4 quantization levels dithering is more useful but fore 16 quantization levels the original quantized image was looking better. For both 4 level and 16 level quantization, noisy image has higher MSE but results were looking better for dithered image. Images of both these can be generated by running `Q3.m` and setting the quantization_levels equal to 4 or 16 (Also generated images are submitted with this assignment).

```
quantization_levels = 16; % or 4, 8
```

Q3

All working of this quesiton can be found in `Q3.m` file. After doing 5th de-sampling on `w.pgm` image have lost its original meaning (all the intended info is lost). Results can be seen in figure 3.



(a) Original Image

(b) 1st de-sampling

(c) 2nd de-sampling

(d) 3rd de-sampling

(e) 4th de-sampling

(f) 5th de-sampling

Figure 3: W image after de-sampling 5 times without low pass filter