Wet exercise 1 image processing

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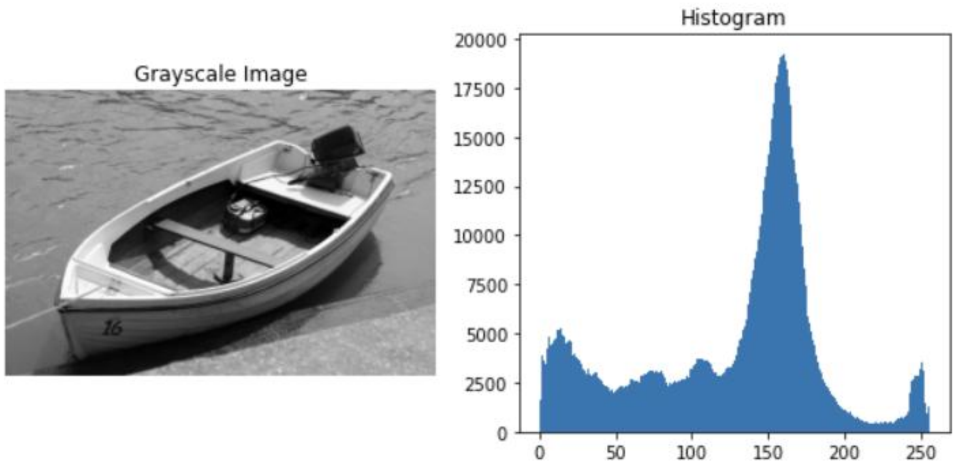
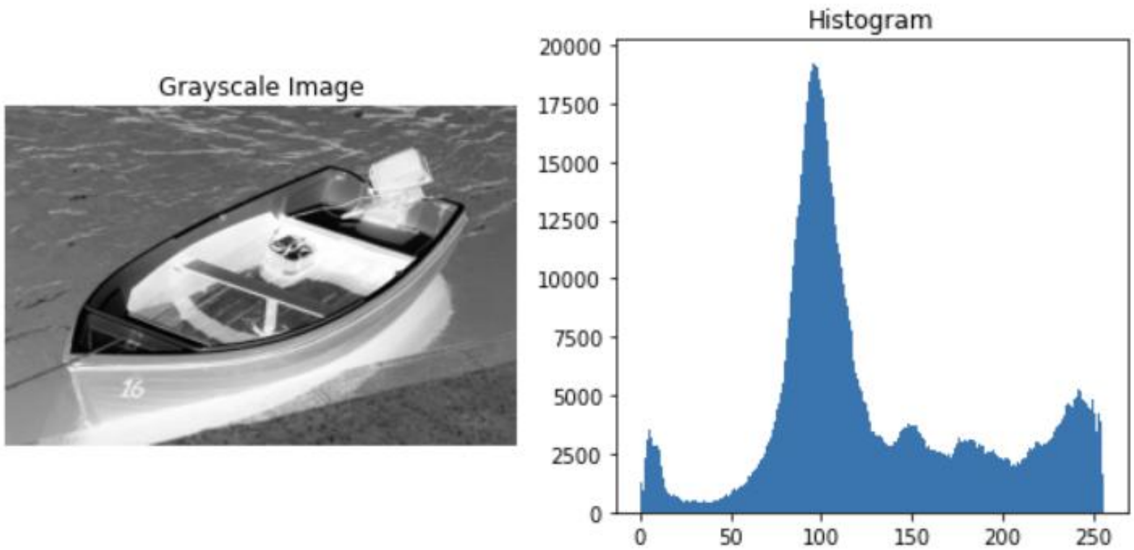
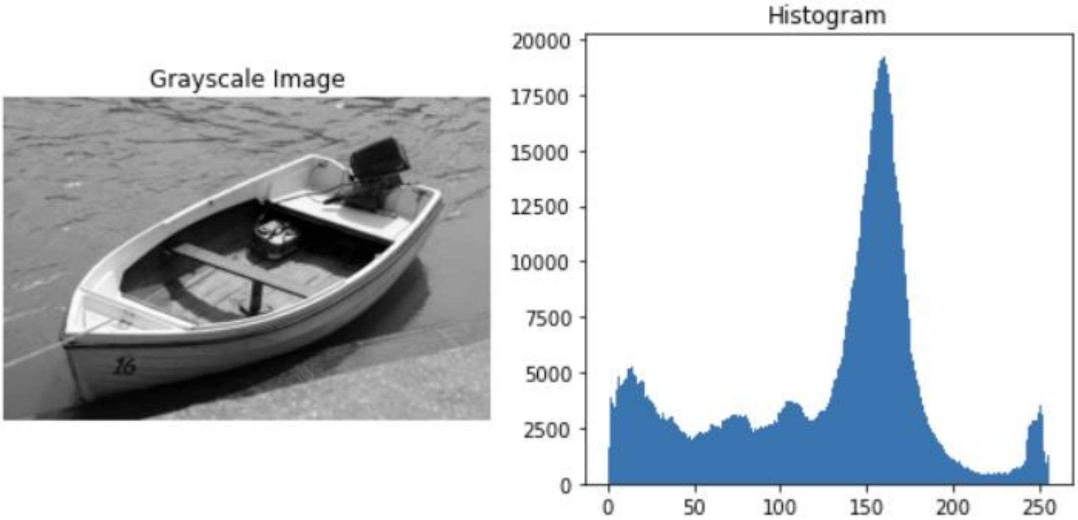
1a. We can see from the histogram the distribution of grayscale pixel across the image, we can quite an even distribution except for a significant peak in the middle leaning to the right, which can be expected for “natural” images maybe indicating an area of particular properties(maybe shadows? Or the color of the boat?)



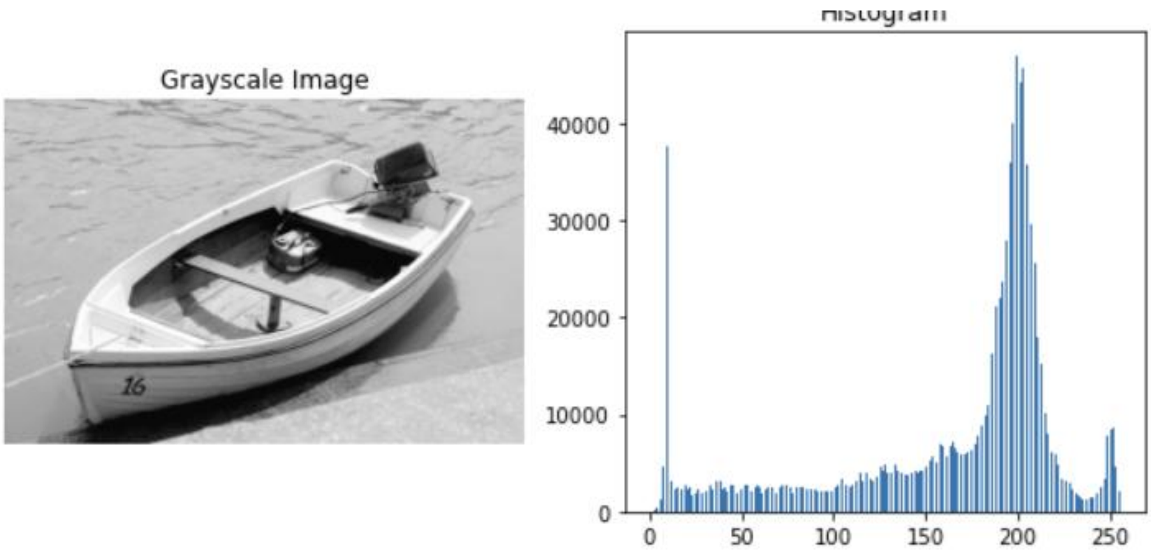
1b. As can be expected, we receive a “mirror” histogram, since we inverted every pixel in the image.



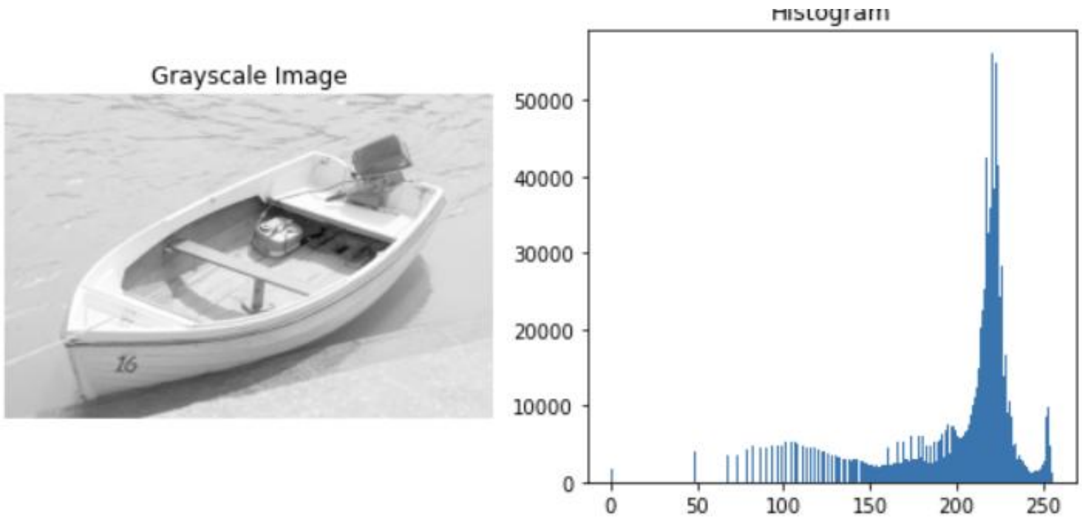
1c. On the original image the contrast enhancing did only minor changes if any(I did not notice any changes) and the histogram looks nearly identical, but this makes sense if the original photo already had a balanced contrast(as we can deduct from section 1a that it did),



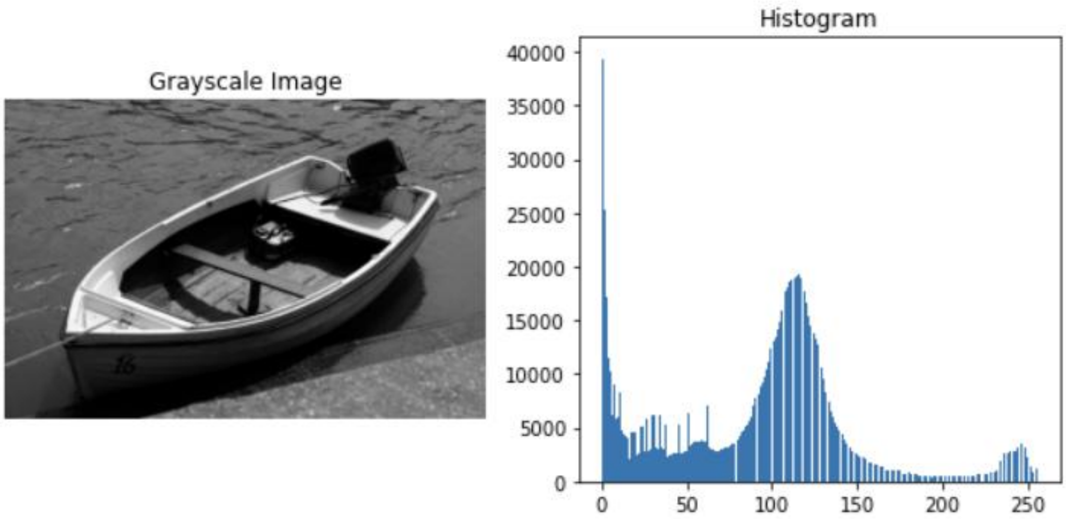
with the brightened photo we did see how the function helps spread out the pixels along the histogram, helps make the photo clearer to notice details. Also note the the histogram now has “holes” due to the rounding factor of the formula.



1d. As we learned gamma correction is used to adjust image brightness in a non linear way, as expected when using gamma = 0.3 on the original image we made it brighter(as will any gamma < 1) and moved the histogram towards higher intensity values.

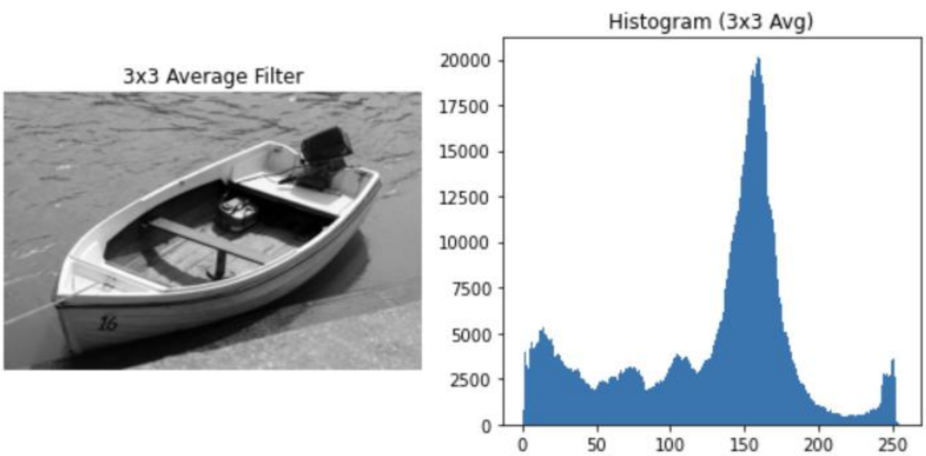


When using gamma = 1.7 we made the image darker (as will any gamma > 1) and moved the histogram towards lower intensity values

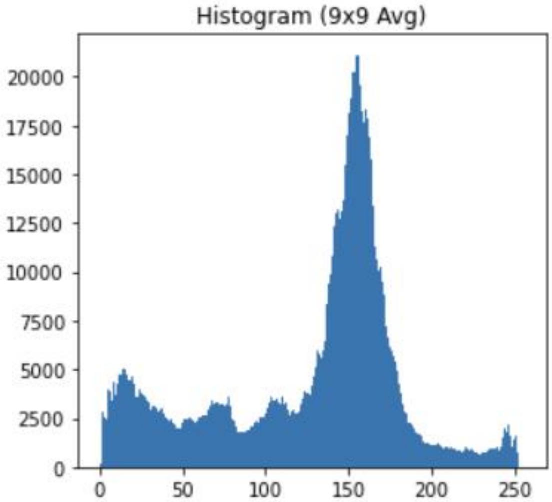


1e.

The 3x3 filter slightly smoothes the image, and concentrated the histogram very lightly.



The 9x9 avg filter makes more significant blurring, and starts to erase edges, also changed the histogram to have more pixels move to the center.



The 9x9 median filter removes noise while preserving the edges better than the 9x9 avg filter and also change the histogram less significantly.

2a.

1. The 2D Fourier transform for f(x,y) is:

$$F(u,v) = \iint f(x,y)\ e^{-2\pi i(ux+vy)}\, dx\, dy$$

In spatial: x = rcosθ, y = rsinθ

In Frequency: u = ρcosϕv = ρsinϕ

Thus ux + vy = ρrcos(θ-ϕ)

The fouirer transform becomes:

$$F(u,v) = \iint f(r)\ e^{-2\pi i\rho r\cos(\theta-\phi)}\, r dr\, d\theta$$

F(r) is independent of θ, and the exponent depends only on θ – ϕ, thus F(u,v) = F(ρ)

And the Fourier transform depends only on radial frequency. Therefore a fourier transform of a spatial symmetric image will be radially symmetric.

2. Furthermore, any directional low-pass filter will introduce distortions in the frequency domain because it will jeopardize the images spatial symmetry.
3. In conclusion, a radially symmetric low pass filter will be optimal since it will not “ruin” the original spatial property of the image.

2d. 3

- No, X and Y LPF will have same MSE only when the image is symmetric in regard to x,y as well as radially, which i got in a coincidence but choosing different n/m will result in the MSE getting different results due to the directional filter
- Not always, MSE measures the absolute error pixels-wise, but the human eye might think an image with a slightly larger MSE “looks better” than the minimal MSE image, though it is still a useful indicator to an image quality.

2e:

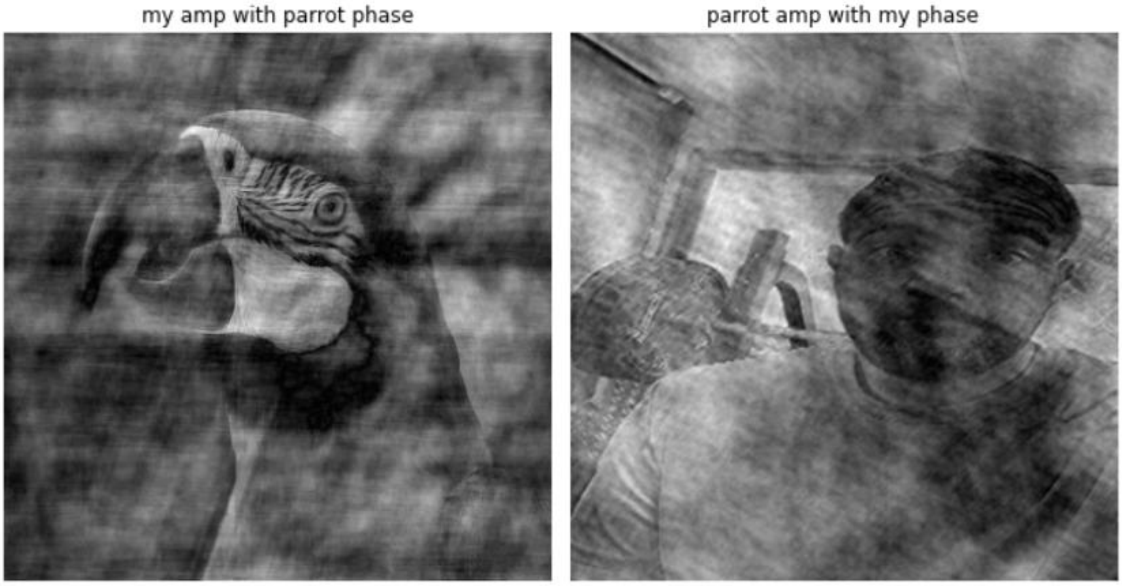
1) The radial LPF preformed best because it is most fitting for preserving the original images radial functions, while the X/Y filters added anisotropy in one direction.
2) Symmetry: as n increases we lose the radial symmetry and become more dependent on the angle(azimoth) of the shape.

Visual appearance of filters: X/Y filter begin to remove structure unevenly, and the circle still preserves radially but since the image is no longer completely radial we start to get distortions as well.

MSE of filters: they all increase, circular is still better for small n but x/y might outperform on certain asymmetric images.

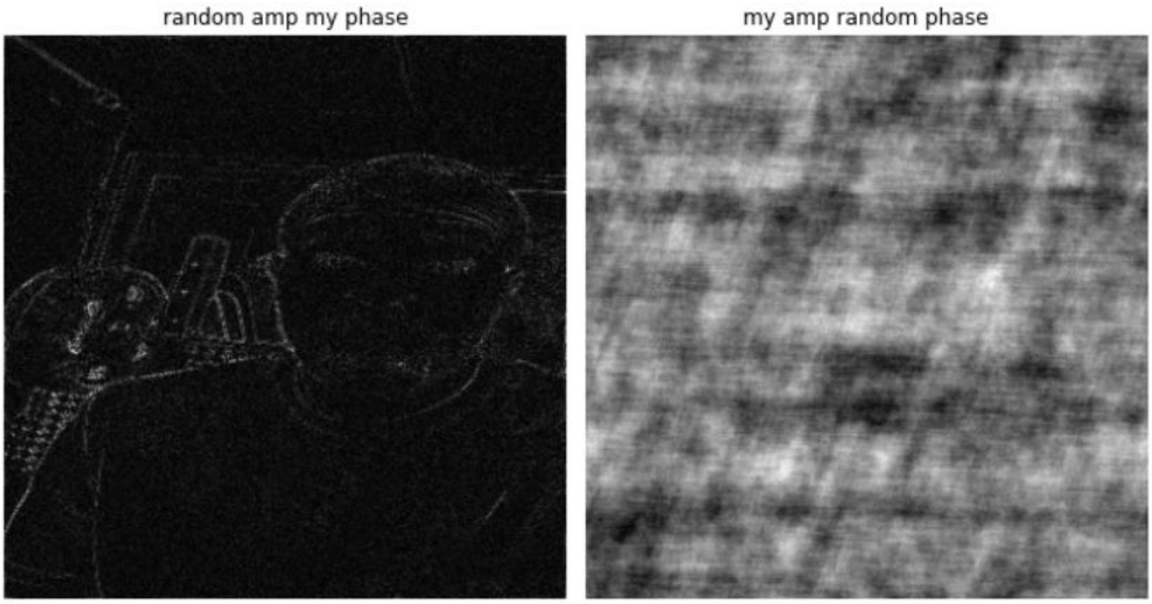
3) Since MSE is pixels-wise and doesn’t account for out perception, an image with higher MSE but sharper edges might look better than one with lower MSE but more blurring.
4) Not necessarily, if an image is highly directional a directional filter may preserver structure better.
5) At high values(i got for 10) the image shows a lot of angular noise, and less symmetry, while the directional filter got better MSE, we can assume some threshold around(6<n<=10) where the radial filter is no longer optimal.

3c.



The image with the parrot’s amplitude but my phase is significantly closer to my image than the other option.

3d.



The image with random amplitude but original phase lost all contrast but retained the most noticible edges in the original image, while the image with random phase lost all “information” about the original image, as far as i can tell its pure noise.

3e. Based on the results of the last 2 section. It is clear that the phase of an image is much more important in the information than the amplitude. The phase appears to hold information about the visual and structure information of the image, while amplitude affects only the grayscale range.