E9 241 Digital Image Processing
Assignment 2

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1. Spatial Filtering and Binarization

Ans: This problem is a classic example of the trade-off done between retaining useful information and removing noise while choosing a appropriate blur filter.

The first case with 5×5 window removes lesser amount of noise than the other two filters but retains more information than other two cases. Consequently, the edge is little noisy but the shape of the moon is retained. It has the lowest σ_w^2. That is evident from the histogram, two clear modes with the boundary values having less intensity. This is both mathematically and visually the best results.

In the second case with 29×29 window, while the histogram is still bimodal but the intensity in the boundary pixels between the mode is more. That result is a little deformation of the shape of the moon though the boundary is smoother than the earlier one. σ_w^2 is also large.

In the third case with 129×129 window, all of the information is lost. It looks like a gradient and the histogram is unimodal. The σ_w^2 value is lesser than the second case because the overall variance of the image intensities is less. Here the mathematical value may be misleading. Any analysis on this image is meaningless. Following are the results in detail:

1. Optimal Threshold:**125**
   Optimal Within Class Variance:**158**

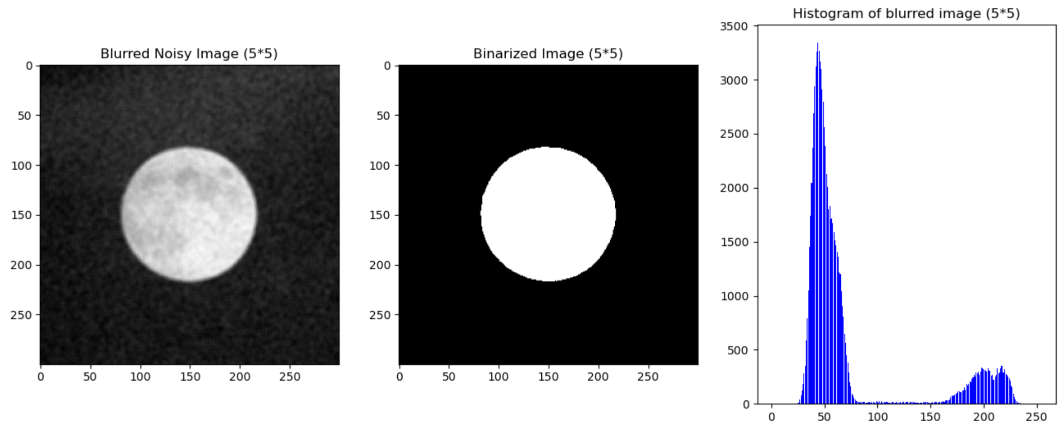

Figure 1: 5×5 Window

2. Optimal Threshold:**119**
   Optimal Within Class Variance:**279.39**

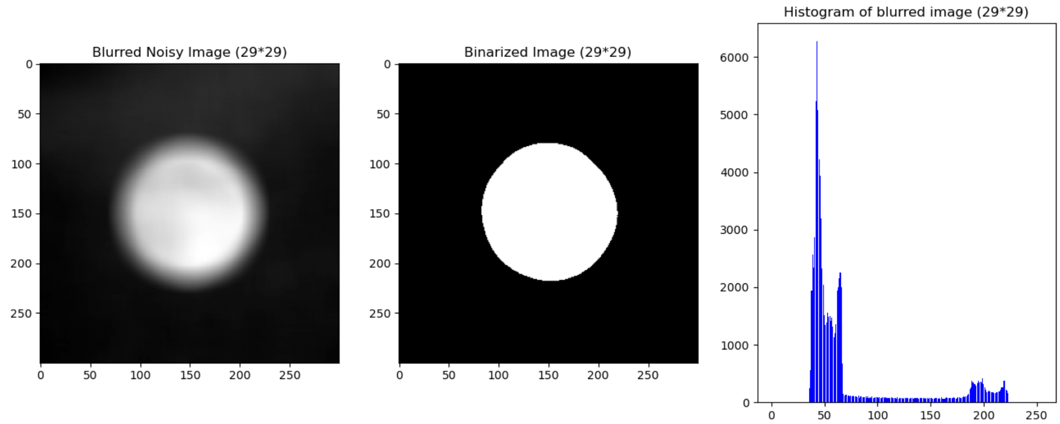

Figure 2: 29×29 Window

3. Optimal Threshold:**89**
   Optimal Within Class Variance:**268.89**

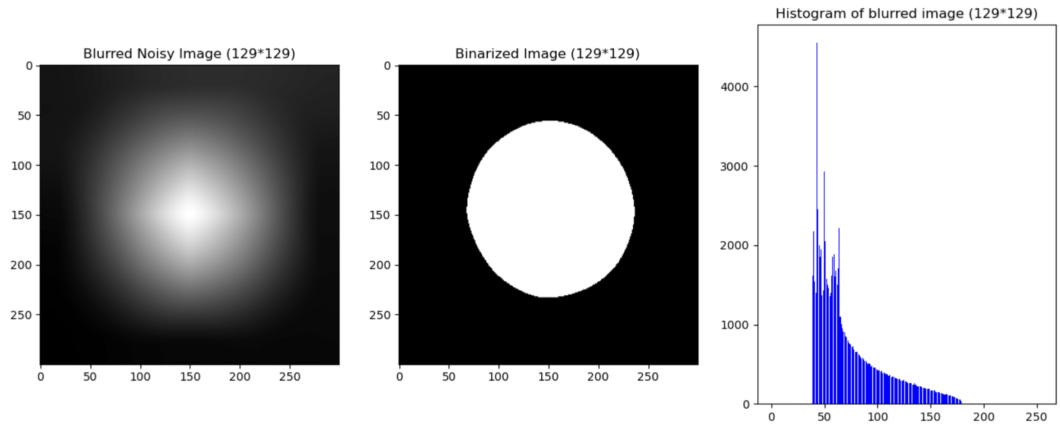

Figure 3: 129×129 Window

2. Scaling and Rotation with Interpolation

Ans: The results are not identical. The reason behind is the order of operation and approximation using Bilinear Interpolation. The first operation $Upscale \rightarrow Rotate \rightarrow Result1$ gives much more appropriate approximation. Since the image is upscaled first, making the image dense and then when it is rotated the values are interpolated on a dense set of values. The second operation $Rotate \rightarrow Upscale \rightarrow Result2$ rotates the image on less information and those approximation are further approximated when upscaling the image. The difference can be observed in the two images when looked closely, the second image is clearly a bit hazy.

I have plotted the `Diff = Result1 - Result2` in two different ways:

- `plt.imshow(diff)`

  In this plot, the image comes out to be mostly gray. The reason behind is how the `matplotlib imshow` function works. The range of values taken by the `Diff` is -172.23 to 178.64. The function considers the lowest value as black and the highest value as white. Then around 0 should be the gray region. Since majority portion of the `Diff` is around 0. So, max portion of the image appears gray. The edges are the portions that are visible because those are the portions where the interpolation value approximation differs more. Those are the values either close to `min` or `max`.

- `plt.imshow(diff, vmin = 0, vmax = 255)`

  This plot appears mostly black. What is tells is pixel value $\leq 0 = 0$ and pixel value $\geq 255 = 1$. All the other values are scaled linearly. All the values around `max(diff)` is visible(Intensity is less, they are also scaled). Rest most of the portion is black. Only very few edges are visible.

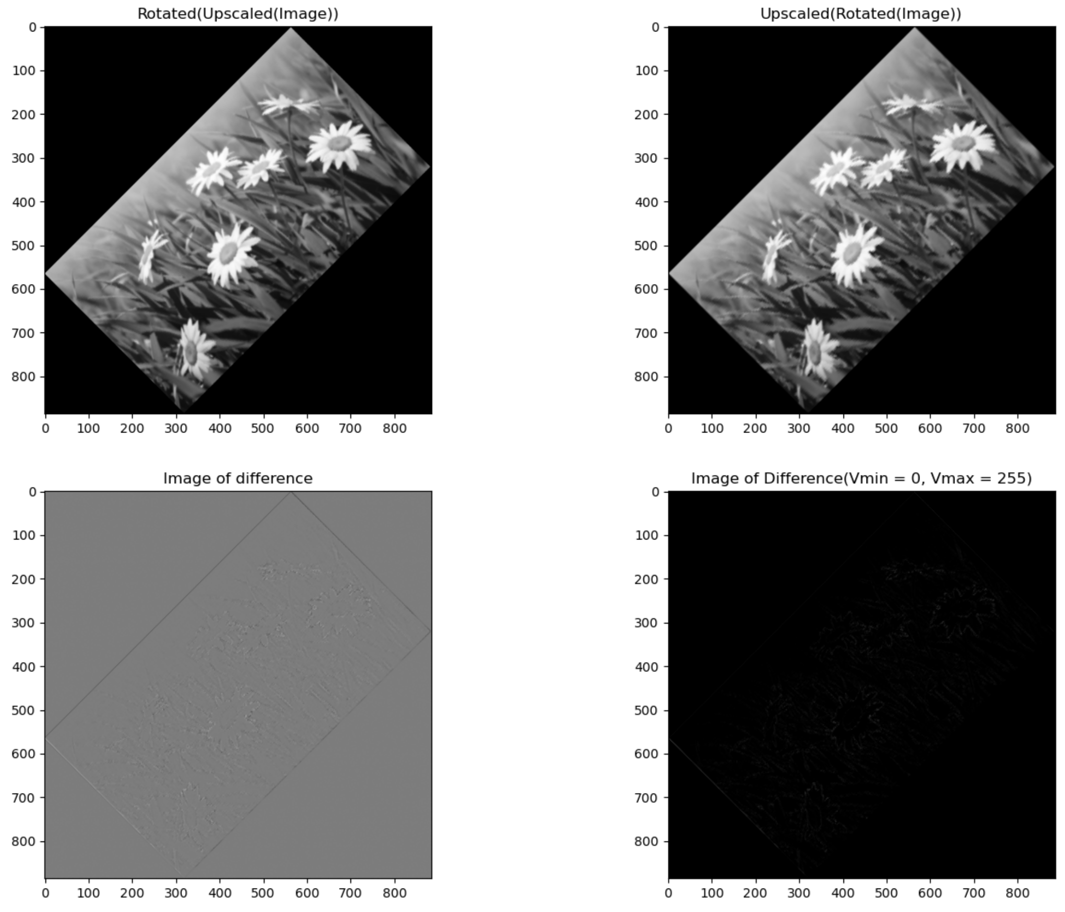

Figure 4: Rotated Upscaled Image and Upscaled Rotated Image along with the image of diff and diff with particular vmin and vmax

3. Image Sharpening Concept

Ans: I have implemented Unsharp Masking. The mask is implemented by removing the blurred version (low frequency) from the image which retains the high frequency data of the edges. Now, that data can be added to the original image to get the sharpened image.

$$g(m, n) = f(m, n) + p \times (f(m, n) - f'(m, n))$$

where $f'(m, n)$ is the blurred image. When $p = 1$, It gives the halo effect. and when $p = 0$ it gives the original image. I have implemented the algorithm on the image given in the assignment. Along with that, I have implemented the algorithm in two of the test images for Digital Image Processing - Lena and Barabara. One critical observation is the increase in the noise in the `study.png` image. The principle of sharpening filter is to increase the intensity of the high frequency elements. The algorithm does not differentiate between nosie and edges. Both of which are high frequency component. So as a consequence the noise also increases. In the other pictures, the original image was not noisy, no the final image carries not much effect.

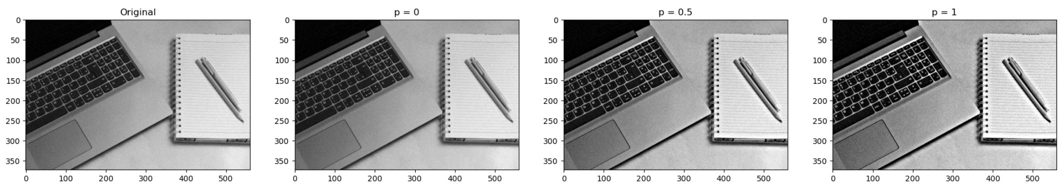

Figure 5: Study Image with different value of p

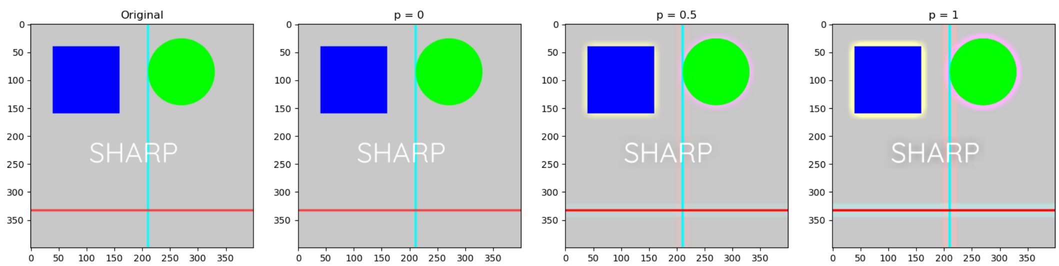

Figure 6: Given Assignment Image with different value of p

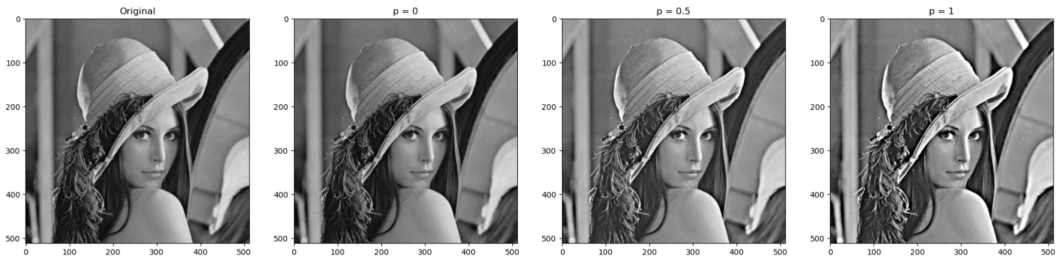

Figure 7: Lenna standard test image with different value of p

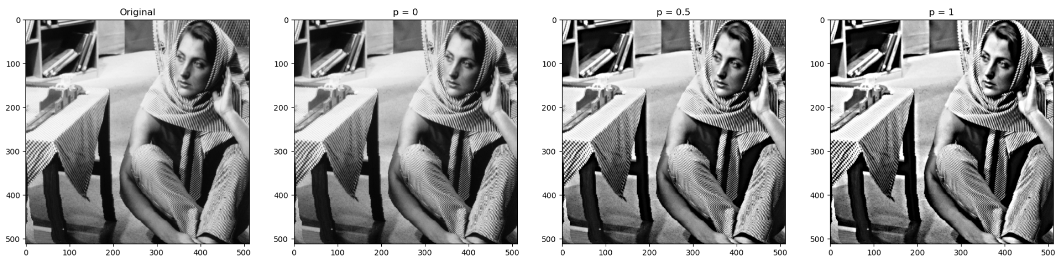

Figure 8: Barbara standard test image with different value of p