Department of Computer Science

Digital Image Processing

CS-371

Assignment 4 - Playing with Images in the Frequency Domain

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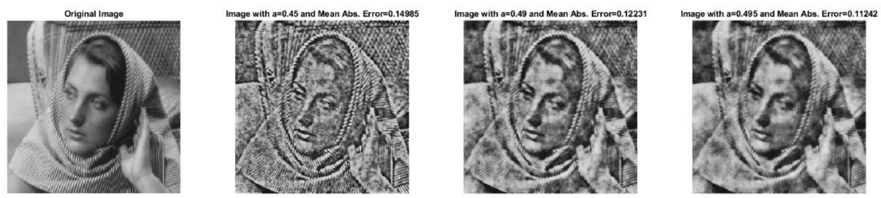
Phase 2 of the Assignment
Discrete Fourier Transform & Image Compression

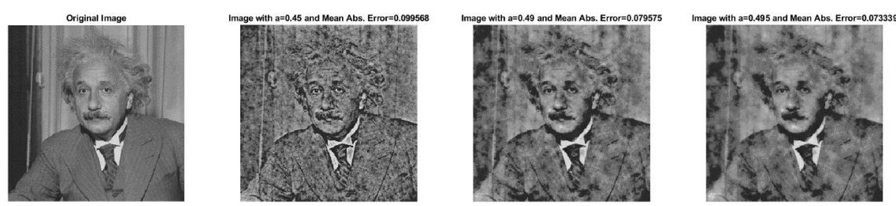
2.1 The role of the phase and magnitude:

Part 1:

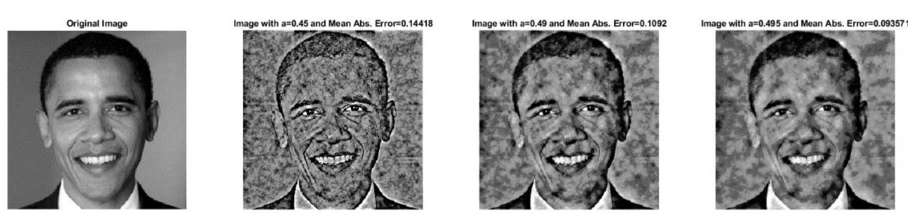
As we can observe from the images below, as we increase the value of α, the Mean Absolute Error gets every time a little bit smaller, we achieve a slight smoothing effect and the edges are slowly getting less intense. By examining the magnitude of an image's Fourier transform, we can get a sense of the frequency content of the image. When an image has a lot of high frequency content (e.g. fine details, sharp edges, etc.), the magnitude of its Fourier transform will have a lot of high values.(light pixels in magnitude display). On the other hand, when an image has mostly low frequency content (e.g. smooth gradients, large flat regions, etc.), the magnitude of its Fourier transform will have mostly low values (dark pixels in magnitude display). We can see that the Einstein & Obama images are the images that have the smallest impact and the Barbara image has the biggest impact of all the images. As we described about the magnitude of the Fourier transform, we can clearly understand from the figures of the magnitudes that Einstein and Obama images are closer to the original image because their magnitude is spread instead of Barbaras where we can see that in the values of the magnitude are not wide-spread.



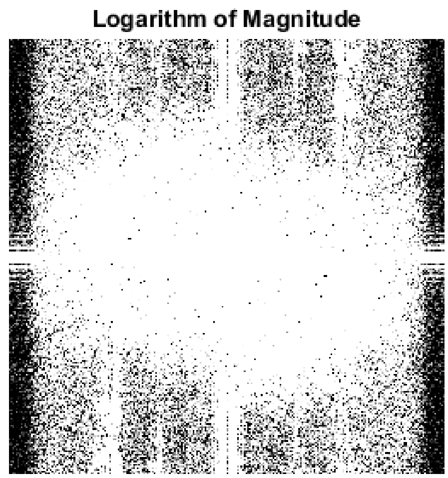
(2.1.1) Barbara transformed image with the values of α set



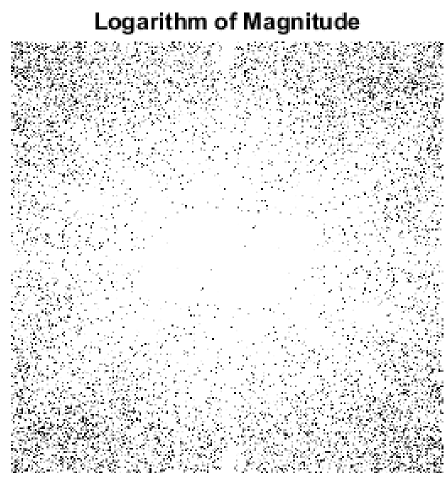
(2.1.2) Einstein transformed image with the values of α set



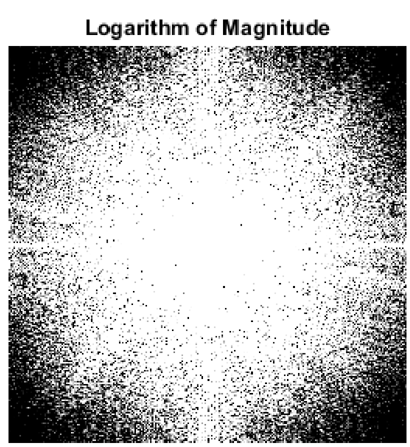
(2.1.3) Obama transformed image with the values of α set



Magnitude of Barbara Image



Magnitude of Einstein Image



Magnitude of Obama Image

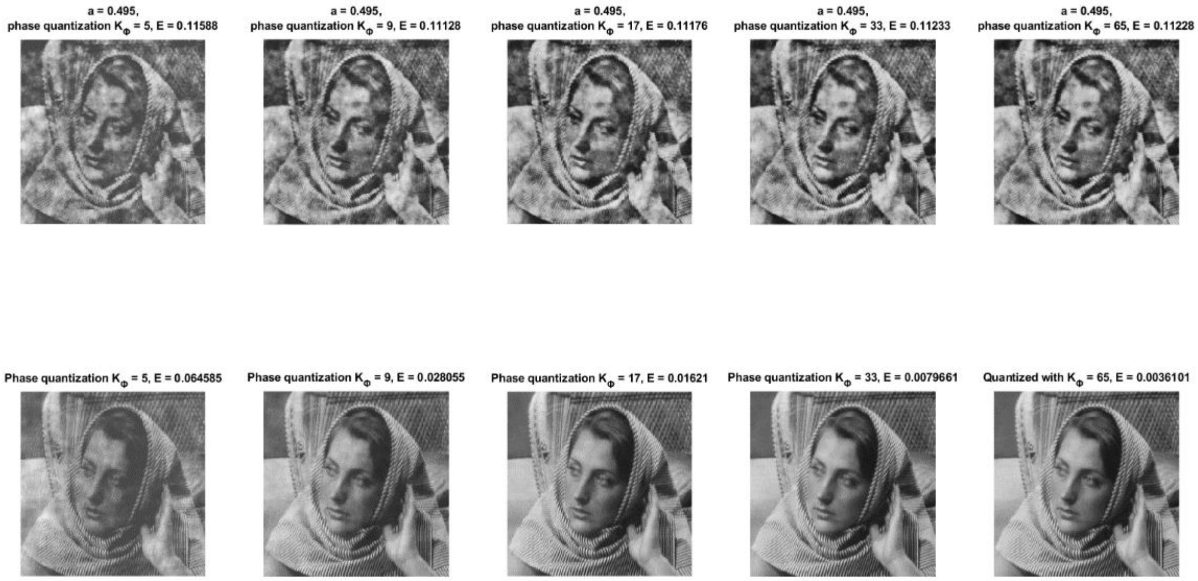
Part 2:

When we quantize the phase of the images, we are reducing the number of possible values that the phase can take on. As the levels of quantization increase, the number of possible values that the phase can take on decreases, resulting in a coarser representation of the phase information.

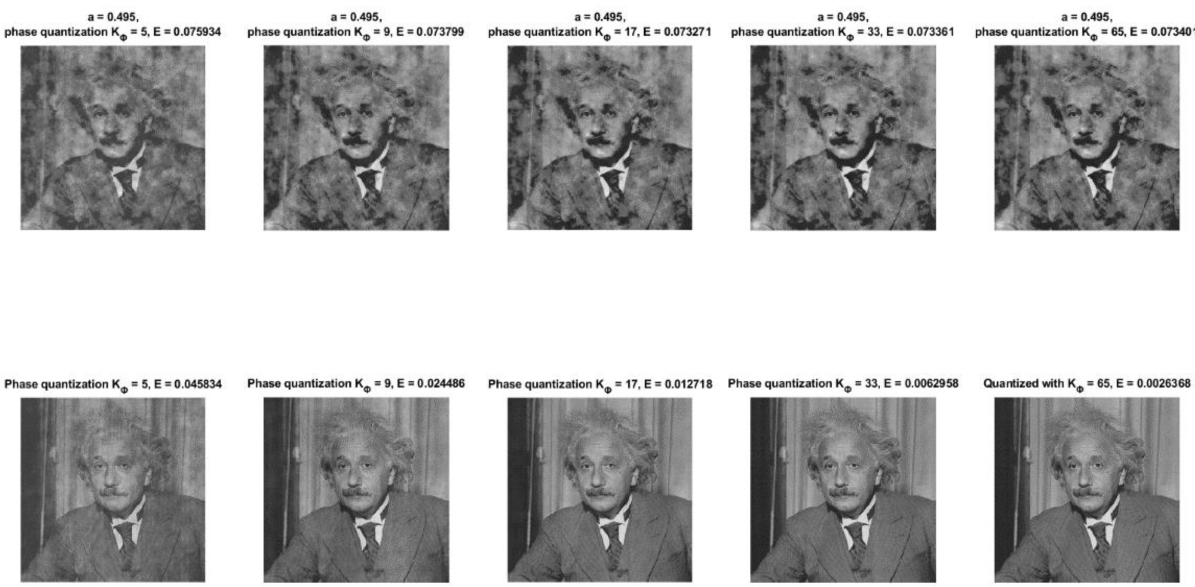
In the case when we keep the magnitude of the image unchanged and only quantize the phase, we generally see a degradation in image quality as the levels of quantization increase. This is because the phase information carries important details about the image, such as the orientation of edges and patterns. By reducing the number of possible values that the phase can take on, we are losing some of this detail, which can result in a loss of sharpness and clarity in the reconstructed image.

When alpha is set to 0.45, the magnitude of the high frequency components in the image is reduced, which results in a loss of detail and sharpness in the reconstructed image. On the other hand, when the magnitude of the original image is used, the image quality is relatively unchanged, since the magnitude of the original image is being preserved. We can clearly see this visually and the Mean Absolute Error can confirm this observation.

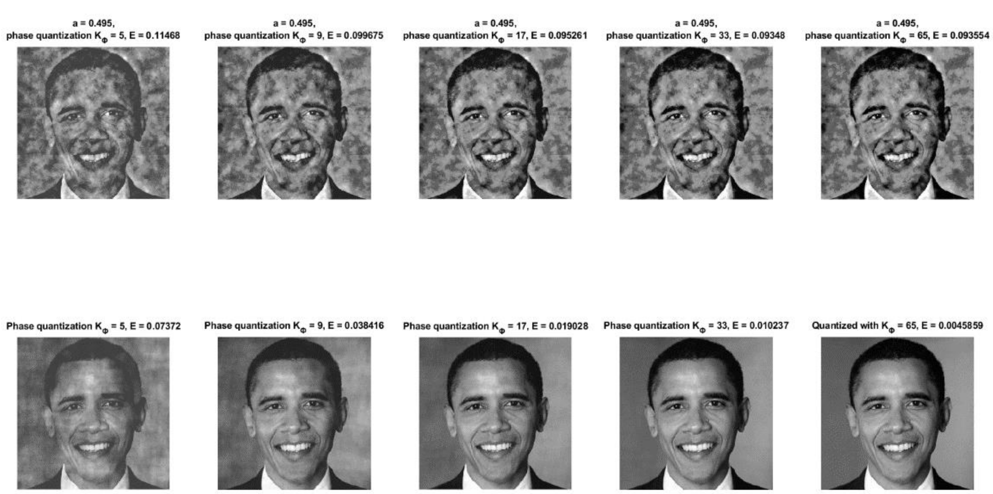
Overall, quantizing the phase of an image have a significant impact on the image quality, while altering the magnitude have a more subtle effect depending on the value of alpha.



(2.1.4) Barbara phase quantized image with different values of K_Φ



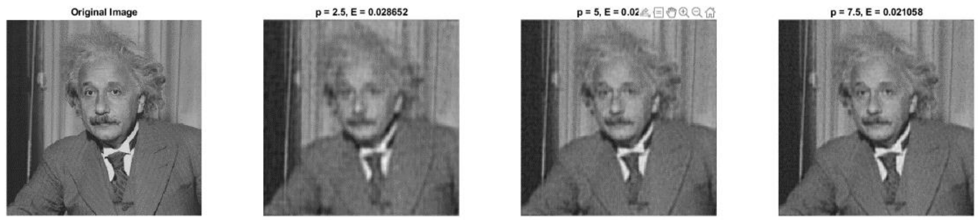
(2.1.5) Einstein phase quantized image with different values of K_Φ



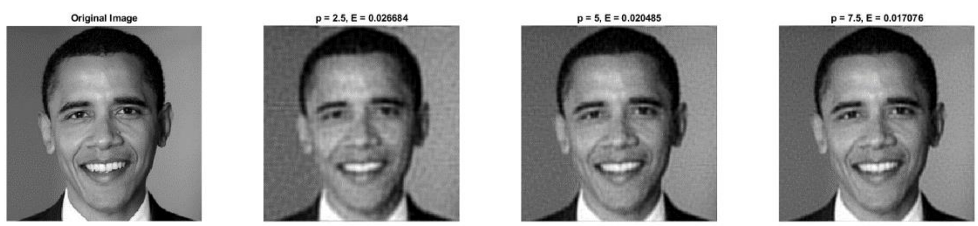
2.2 Image Segmentation:

After applying image compression in our 3 images with the formula of p% that we were given, where the value of p determines how many of the spatial frequencies are retained in the image. We can observe that, smaller value of p result in fewer spatial frequencies being retained, which leads to a lower quality image. We also observe a loss of details and the image appear blurry when using a small value of p. On the other hand, a larger value of p results in more spatial frequencies being retained, which leads to a higher quality image. Furthermore, we can see that the Mean Absolute Error is getting smaller as we increase the value of p, but not so significantly as we can see. Beside that, the image is still blurry and for sure not so detailed as the original image with p = 7.5, but we can understand the main characteristics of the person in each image. In general, a lower percentage of frequencies retained will result in a higher level of compression, but also a lower quality reconstructed image with more distortion.

(2.2.1) Barbara Image after applying compression for different values of p



(2.2.2) Einstein Image after applying compression for different values of p



(2.2.3) Obama Image after applying compression for different values of p