Assignment 1

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1 Question 1

f. Compute MSE between I and I_R.

```
folder = '/Users/mamatashrestha/Downloads/OneDrive_1_1-30-2023';
files = dir(fullfile(folder,'*.png'));
I = imread(fullfile(folder, files(1).name));
I = rgb2gray(I);
I = imresize(I,[256 256]);
I = double(I);

K = fft2c(I);
M = RandomMask(256, 256, 1, 2);
K_U = M.*K;
I_R = ifft2c(K_U);

mse_err = immse(I, abs(I_R));
fprintf('\n The mean-squared error is %0.4f\n', mse_err);
```

Listing 1: Image reconstruction

The MSE between I and I_R is 161.43.

g. Display followings using imshow() function: Image I, k-space K, K_U and reconstructed image I_R.

```
subplot(2,2,1)
imshow(I, [])
title('Image (I)','FontSize', 24)
subplot(2,2,2)
imshow(abs(K))
title('Image Kspace (K)','FontSize', 24)
subplot(2,2,3)
imshow(abs(K_U))
title('Undersample Kspace (K_U)','FontSize', 24)
subplot(2,2,4)
imshow(abs(I_R),[])
title('Reconstructed image (I_R)','FontSize', 24)
```

Listing 2: plot for image and kspace

The plot for Image I, k-space K, K_U and reconstructed image is shown in Fig. 1

h. Also display $1 + log(abs(K))$ **and** $1 + log(abs(K_U))$**.**

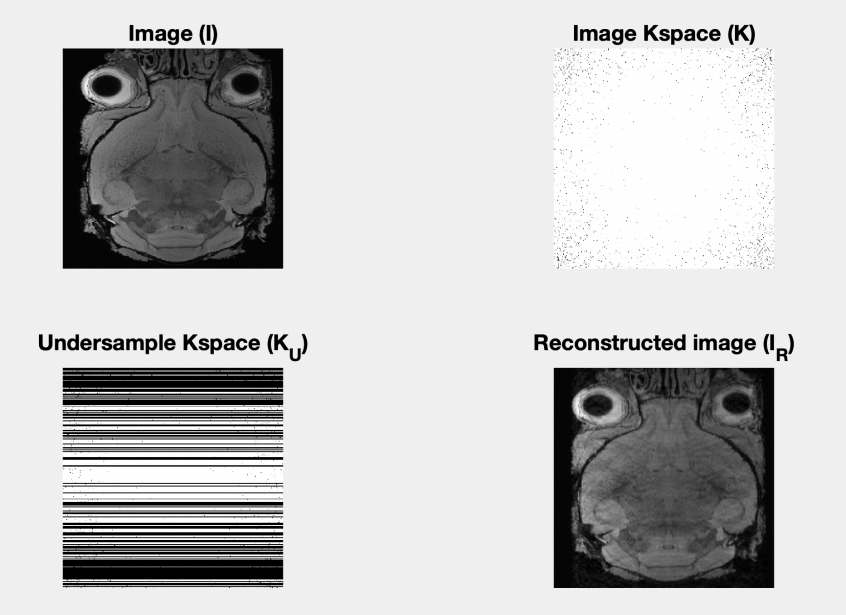

Figure 1: plot for images and kspaces

```
subplot(1,2,1)
imshow(1+log(abs(K)), [])
title('Log scaling of K','FontSize', 24)
subplot(1,2,2)
imshow(1+log(abs(K_U)),[])
title('Log scaling of K_U','FontSize', 24)
```

Listing 3: Log scale plot of kspace

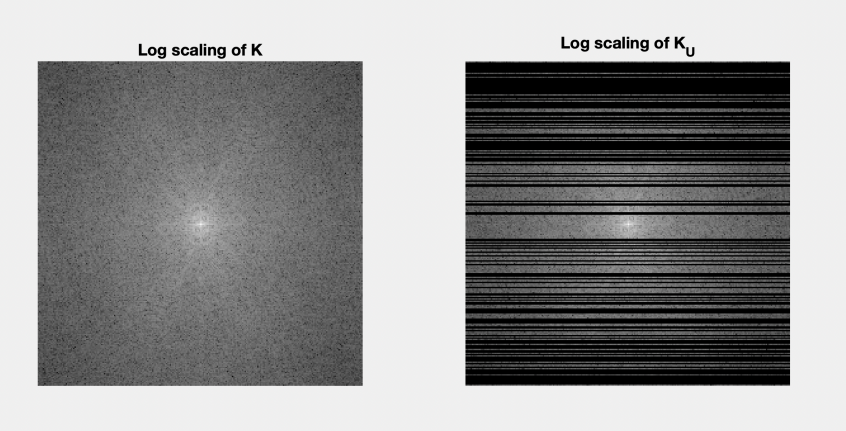

Figure 2: plot for $1 + log(abs(K))$ and $1 + log(abs(K_U))$

The plot for $1 + log(abs(K))$ and $1 + log(abs(K_U))$ is shown in Fig.2

2 Question 2

b. Generate several masks with down (undersampling factor) = 2, 3, 4, 5, 6,7, 8 and corresponding K_U and I_R. Display all masks and all I_R. Also compute 3 metrics: MSE, PSNR and SSIM for each I_R corresponding to each mask.

```
M2 = RandomMask(256, 256, 1, 2);
K_U2 = M2.*K;
I_R2 = ifft2c(K_U2);

mse_err2 = immse(I, abs(I_R2));
peaksnr2 = psnr( abs(I_R2),I);
ssim2 = ssim(I,abs(I_R2));

fprintf('\n The mean-squared error for udersample factor 2 is %0.4f\n'
    , mse_err2);
fprintf('\n The psnr for udersample factor 2 is %0.4f\n', peaksnr2);
fprintf('\n SSIM value for udersample factor 2 is %0.4f\n', ssim2);

subplot(2,7,1)
imshow(abs(M2), [])
title('Undersample Mask 2')
subplot(2,7,8)
imshow(abs(I_R2),[])
title('Reconstructed image 2')
```

Listing 4: plotting undersampling masks for factor 2

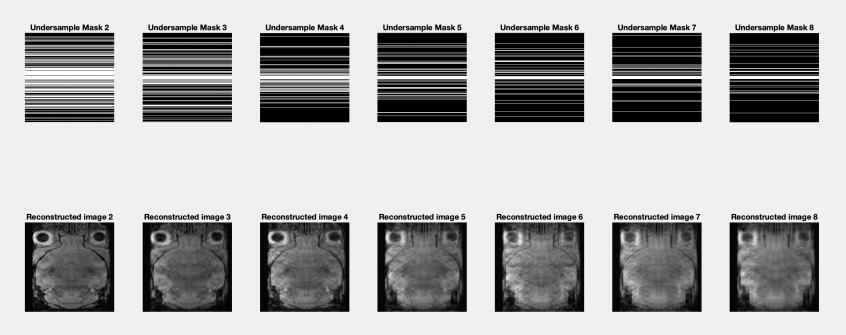

Figure 3: plot for undersampling mask and reconstructed image

The MSE values for undersample factors 2,3,4,5,6,7,8 are 161.43, 119.06, 294.82, 350.109, 453.28, 363.3 respectively.
The PSNR values for undersample factors 2,3,4,5,6,7,8 are -22.07,-20.75, -24.69, -25.44, -24.94, -26.56, -25.60 respectively.
The SSIM values for undersample factors 2,3,4,5,6,7,8 are 0.65, 0.56, 0.43, 0.35, 0.34, 0.27, 0.29 respectively.

c. Plot down vs Metrics i.e., down vs MSE, down vs PSNR and down vs SSIM.

```
M2 = RandomMask(256, 256, 1, 2);
K_U2 = M2.*K;
I_R2 = ifft2c(K_U2);
down =[];
psnr_list = [];
ssim_list = [];
mse_list = [];

mse_err2 = immse(I, abs(I_R2));
peaksnr2 = psnr( abs(I_R2), I);
ssim2 = ssim(abs(I_R2), I);

down(end+1) = 2;
mse_list(end+1) = mse_err2;
psnr_list(end+1) = peaksnr2;
ssim_list(end+1) = ssim2;
```

```
fprintf('\n The mean-squared error for udersample factor 2 is %0.4f\n'
    , mse_err2);
fprintf('\n The psnr for udersample factor 2 is %0.4f\n', peaksnr2);
fprintf('\n The ssim value for udersample factor 2 is %0.4f\n', ssim2)
    ;

subplot(1,3,1)
plot(down,mse_list)
title('Undersample factor vs MSE','FontSize', 24)

subplot(1,3,2)
plot(down,ssim_list)
title('Undersample factor vs SSIM','FontSize', 24)

subplot(1,3,3)
plot(down,psnr_list)
title('Undersample factor vs PSNR','FontSize', 24)
```

Listing 5: plotting undersampling masks for factor 2

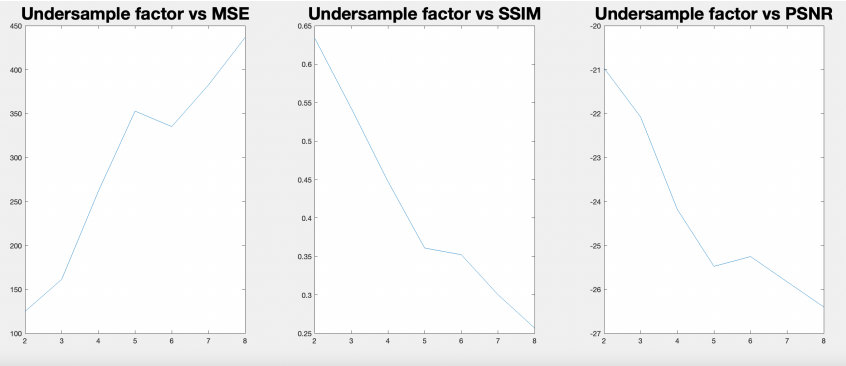

Figure 4: Image quality metric vs undersampling factor

d. What is your conclusion on effect of down sampling vs 3 image quality metrics that you computed? In General, MSEs are supposed to increase as undersampling factor increases. Did you see this pattern in your experiment? If not, do you have any thoughts what might have caused that?

Yes, the mean squared error (MSE) increases as the undersampling factor increases in general. However, for undersample factors 5 and 6, the MSE decreases as we move from factor 5 to factor 6 as shown in Fig. 4. This is usually due to the random nature of our undersampling mask and the proportion of low frequency regions that are sampled during the process.

3 Question 3

b. Repeat Q1 but in this case, after step c in Q1 to generate M, use M=ifftshift(M,1); Which MSE is higher? Mask in Q1 and Q3 both use down =2, which means we acquired half of kspace. Why MSE are different even though we have same down sampling rate down = 2

The mean-squared error (MSE) is increased when the mask is applied with ifftshift operation along the first dimension. The low frequency components of an image contain the maximum information such as contrast, luminance. Despite having the same undersampling factor, the shift in the mask leads to heavy undersampling of low frequency region as shown in Fig. 5, resulting in a poorer quality image compared to a mask without the shift.

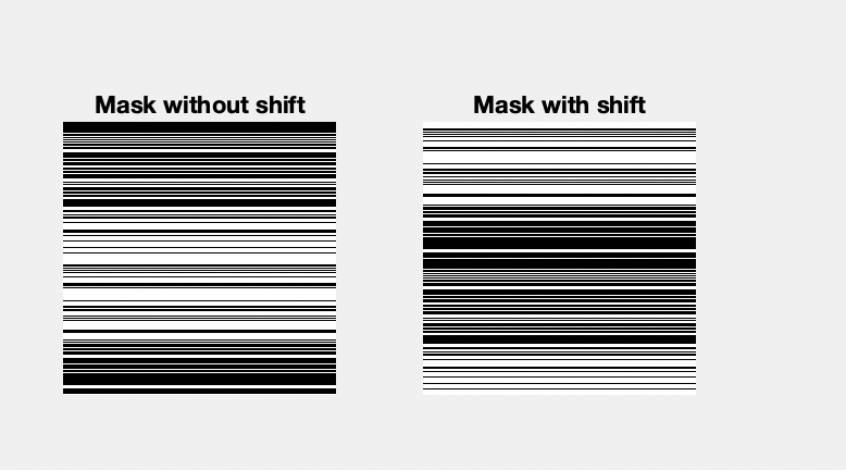

Figure 5: Sampling mask without and with shift