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%%%%%%%%%%%%%% Problem 2  %%%%%%%%%%%%%%%%%%%%%

%%%%% Problem 2.a
 %% Read raw data from file: 256x256, NEX = 1
in = 'RAW_512_512.mri';
Nx = 512;
Ny = 512;
IM_512 = read_raw(in,Nx,Ny,1);
 % show the k-space magnitude
imshow(log(abs(IM_512)+1),[]); colorbar;truesize;
title('log(mag(IM))','FontSize',14,'FontWeight','bold')
 % show the k-space phase
imshow(angle(IM_512),[]); colorbar;truesize;
title('phase(IM)','FontSize',14,'FontWeight','bold')
 % show the real channel of k-space
imshow(log(abs(real(IM_512))+1),[]); colorbar; truesize;
title('log(mag(real(IM)))','FontSize',14,'FontWeight','bold')
 % show the imaginary channel of k-space
imshow(log(abs(imag(IM_512))+1),[]); colorbar; truesize;
title('log(mag(imag(IM)))','FontSize',14,'FontWeight','bold')

% 2b) reconstruct the image
im_512 = fftshift(ifft2(fftshift(IM_512)));
 % show the magnitude of the image
imshow(abs(im_512),[]); colorbar;truesize;
title('mag(im)','FontSize',14,'FontWeight','bold')
 % show the phase of the image
imshow(angle(im_512),[]);colorbar;truesize;
title('phase(im)','FontSize',14,'FontWeight','bold')
 % show the phase of the image
imshow(real(im_512),[]);colorbar;truesize;
title('real(im)','FontSize',14,'FontWeight','bold')
 % show the phase of the image
imshow(imag(im_512),[]);colorbar;truesize;
title('imag(im)','FontSize',14,'FontWeight','bold')




%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%% 2e) partialM Fourier - REDUCE ky max
%%%% Now simulate reduced spatial resolution in ky
[Ny,Nx]=size(IM_512);
IM_512_LR = IM_512(Ny/4+1:3*Ny/4,:);
% show the magnitude of k-space
imshow(log(abs(IM_512_LR)+1),[]); colorbar;axis on;truesize
title('log(mag(IM_512_LR))','FontSize',14,'FontWeight','bold')



% reconstruct the image
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im_lr = fftshift(ifft2(fftshift(IM_512_LR)));
 % show the magnitude of the image
imshow(abs(im_lr),[]);colorbar; truesize;axis on
title('magnitude (im partialFour))','FontSize',14,'FontWeight','bold')
% show the phase of the image
imshow(angle(im_lr),[]);colorbar;truesize;axis on
title('phase (im partialFour))','FontSize',14,'FontWeight','bold')



%%%% zero-fill to get aspect ratio right
[Ny,Nx]=size(IM_512);
IM_512_LR_ZF = zeros(Ny,Nx);
IM_512_LR_ZF(Ny/4+1:3*Ny/4,:) = IM_512_LR;
imshow(log(abs(IM_512_LR_ZF)+1),[]); colorbar;axis on;truesize
%%% little trick here: avoid log(0) by adding 1
title('log(mag(IM FT LR ZF + 11))','FontSize',14,'FontWeight','bold')

% reconstruct the image
im_lr_zf = fftshift(ifft2(fftshift(IM_512_LR_ZF)));
 % show the magnitude of the image
imshow(abs(im_lr_zf),[]);colorbar; truesize;axis on
title('magnitude (im partialFour zf))','FontSize',14,'FontWeight','bold')
 % show the phase of the image
imshow(angle(im_lr_zf),[]);colorbar; truesize;axis on
title('angle (im partialFour zf))','FontSize',14,'FontWeight','bold')

%%% 2f SNR estimates

%% create simple ROIs for signal and for noise analysis
im_mask_n = zeros(Ny,Nx);
im_mask_n(130:290,20:70)=1;
roi_n = find(im_mask_n>0);

im_mask_s = zeros(Ny,Nx);
im_mask_s(180:230,150:240)=1;
roi_s = find(im_mask_s>0);

% display the ROIs
imshow(abs(im_512)+0.2*im_mask_s+0.2*im_mask_n,[]);colorbar; truesize;axis on
title('ROIs for SNR analysis','FontSize',14,'FontWeight','bold')

% calculate signal and mean for fully sampled image
data_s = abs(im_512(roi_s));
data_n = abs(im_512(roi_n))
SNR_512_NEX1 = mean(data_s)/std(data_n)

% calculate signal and mean for partial Fourier image
data_s = abs(im_lr_zf(roi_s));
data_n = abs(im_lr_zf(roi_n))
SNR_512_partial_Fourier = mean(data_s)/std(data_n)
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%  ratio (theory predicts sqrt(2)
SNR_512_partial_Fourier / SNR_512_NEX1
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