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Advanced Topics in Computer Vision

Practice1 Frequency domain filtering

Problem 1: Notch Filters to remove noise

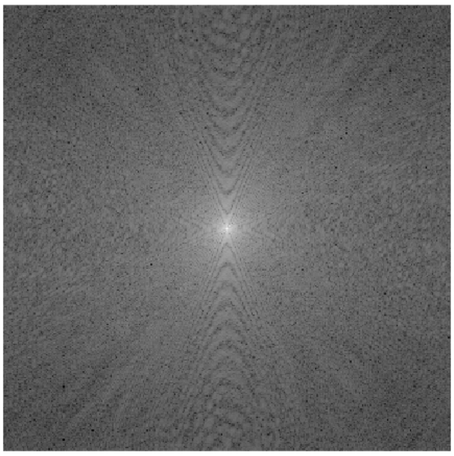
In this problem, the objective is to remove periodic noise present in an image by means of the Fourier transform.

We start off with the original image ('moon.jpg'), separately generate a periodic (sinusoidal) noise along the vertical direction and then merge the two components together to obtain the image with noise:

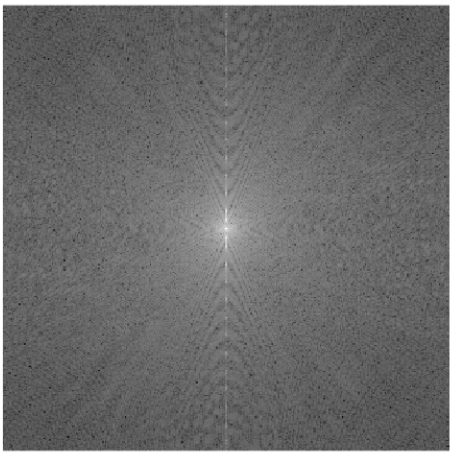
```
% Generating the noise matrix
I2 = zeros(size(1),size(2));
noise_freq1 = 1/8;
for i=1:size(1)
    I2(i,:) = sin(i*noise_freq1)*127; % Sinusoidal noise
End

noise_image = imfuse(I,I2,'blend');
```

After that, we compute the Fourier transform of the original and the noise image, shift the result to the centre and display the spectrums in order to visualize (and compare) the frequency representation of the noise.

Fourier spectrum of original image



Fourier spectrum of noise image

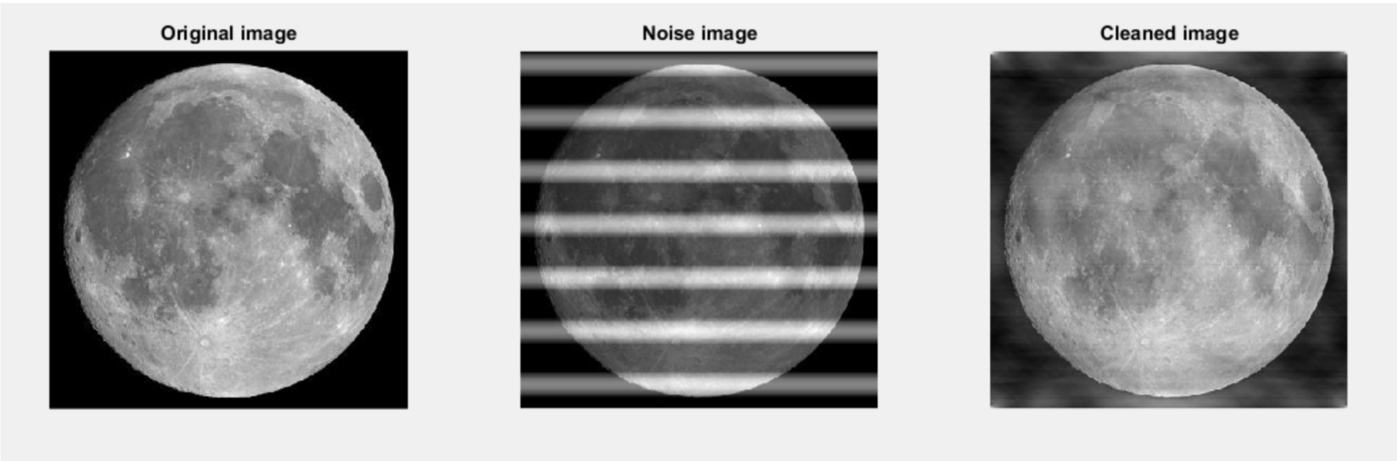


In the spectrum of the noise image, the task now is to eliminate these bright spots that represent the periodic noise. We generate a loop that searches for the pixels inside the spectrum that have absolute values beyond 0.6*the maximum value. These pixels correspond to the same pixels in the Fourier transform that represent the noise, so we have to eliminate them to enhance the quality of the image. However, we need to read the central bright part of the frequency in order to keep the high frequencies corresponding to the original image:

```
% analysing the spectrum and deleting (zeroing) the pixels of the bright
frequencies in the Fourier transform accordingly

for i = 1:size(1)
    for j = 1:size(2)
        if abs (s2(i,j)) > max(max(abs(s2)))*0.6
             f7s(i,j) = 0;
        end
    end
end


% restoring the central high frequencies in the Fourier transform

for i = size(1)/2 - 4: size(1)/2 + 4
    for j = round(size(2)/2) - 4: round(size(2)/2) + 4

    f7s(i,j) = f7s2(i,j);
    end
end
```

Next, we need to invert the shift done in the Fourier transform and invert the Fourier transform itself in order to get back to the image format and check the result of our cleaning process:

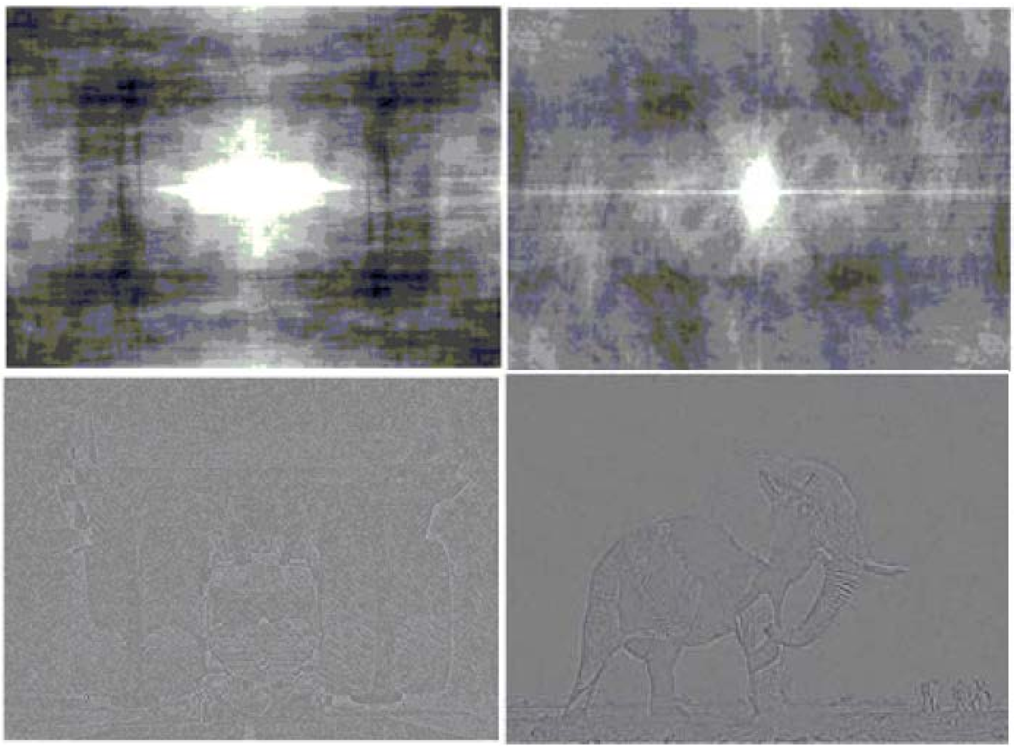
```
F = ifftshift(f7s);     % inverse shift og the fourrier
clean_image = real(ifft2(F));   % inverse of the fourrier transform
```



Problem 2: Where is the information? In the Magnitude or in the Phase?

In this problem, the objective is to figure out which part of the frequency transform (magnitude or phase) is the most dominant or contains most of the information about the image display. In order to do that, we first read two images (`'elephant.jpg'`) and (`'truck.jpg'`), and transform them to grey scale. After that, we get their Fourier transforms and obtain their respective magnitudes and phases:

```
i1 = imread('elephant.jpg');% reading the images of elephant and truck
i2 = imread('truck.jpg');

i1 = rgb2gray(i1); % converting the images to gray scale
i2 = rgb2gray(i2);

% elephant frequency transformation

f1 = fftn(i1);        % obtaining the frequency transform of the image
mag1 = abs(f1);       % obtaining the magnitude from the frequency
s = log(1+fftshift(f1));     % obtaining the spectrum of frequency
phase1 = angle(f1);          % obtaining the phase from the frequency


% truck frequency transformation

f2 = fftn(i2);
mag2 = abs(f2);
s2 = log(1+fftshift(f2));
phase2 = angle(f2);
```



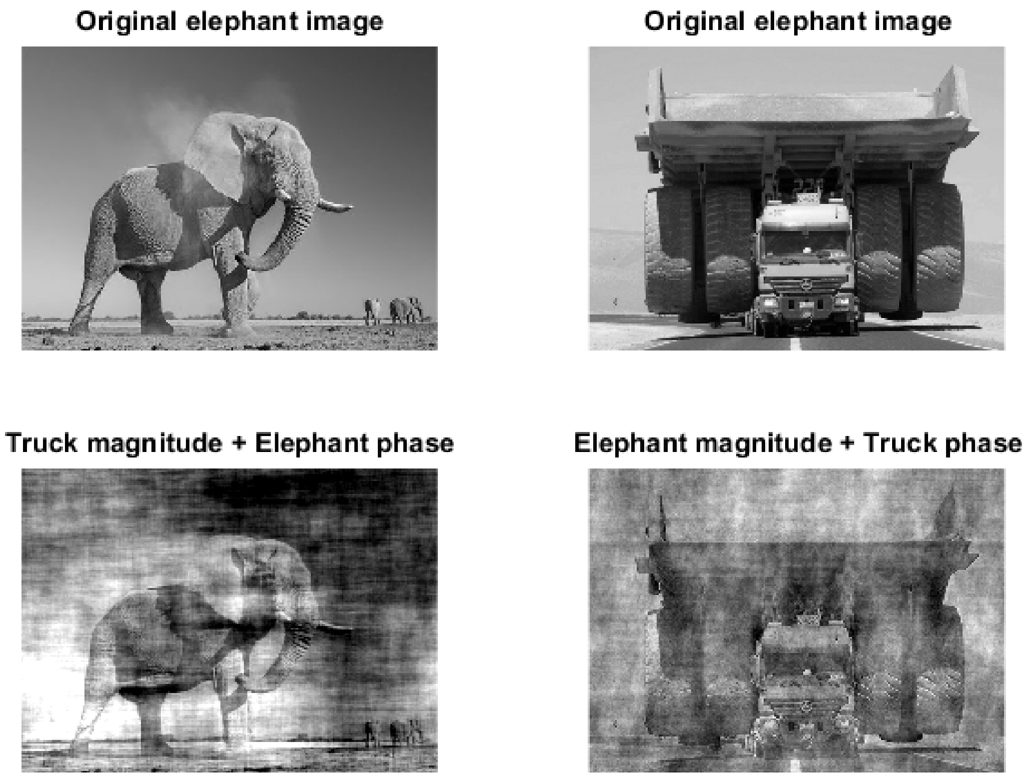
a) magnitude of truck; b) magnitude of elephant ; c) phase of truck; d) phase of truck

Next, we merge the phase of the elephant with the magnitude of the truck and vice versa. We invert the shift and the Fourier in order to obtain the resulting mixed images, taking into consideration that the complex values in the Fourier domain are represented as

$x \in \mathbb{C};\ \ x = r\,e^{j\theta}$, where r is thee magnitude and θ is the phase:

```
f3 = mag1.*exp(1i*phase2);          %merging the elephant magnitude witht the
mag_elephant_phase_truck = ifft2(f3); %inverse crossed transformation

f4 = mag2.*exp(1i*phase1);
mag_truck_phase_elephant = ifft2(f4);
```

Results:



As we can observe in the last image, the dominant parameter in the Fourier transform is the phase compared to the magnitude. In fact we can recognise the elephant in the mix where the elephant phase is present, and similarly for the truck.