Advanced image analysis : Pattern removing with fast Fourier method

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Every time in the history of the photography, photographers has an huge problem in the technology, mainly now with the scanning of documents, the appearing of spots, noises, or artefacts due to low resolution, old scanning technology (8 bits to 128 bits), bad computer processing or necessary to send from a satellite. And this is important for all the cases to analyse this documents in the best way possible. The main goal of this project is to remove the pattern of an image (grid, noise, circles, etc..) thanks to Fourier transform algorithm. Here we will use the Fast Fourier Transform algorithm, in Matlab.

A fast Fourier transform (FFT) is an algorithm that computes the discrete Fourier transform (DFT) of a sequence, or its inverse (IDFT). Fourier analysis converts a signal from its original domain (often time or space) to a representation in the frequency domain and vice versa. We will see this technique is very useful to manipulate frequencies but with little sacrifices in the image like detail removing, reducing the resolution, etc.. . First, for the example, we will create a mask, a simple grid on a clear image in gray scale, in the resolution of 256x256, and try to remove it. Then try with a pattern noisy image and compare the results.

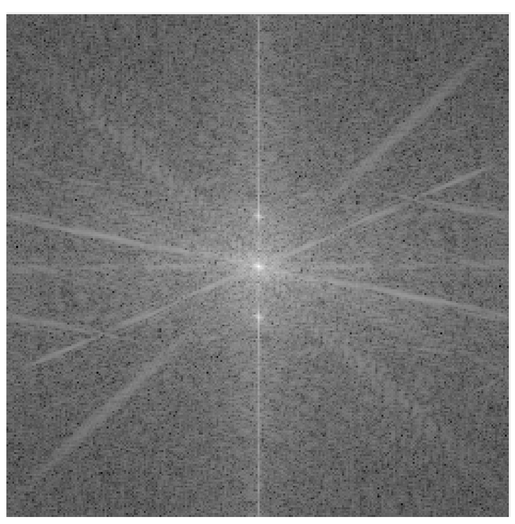
Inserting a grid mask on the image

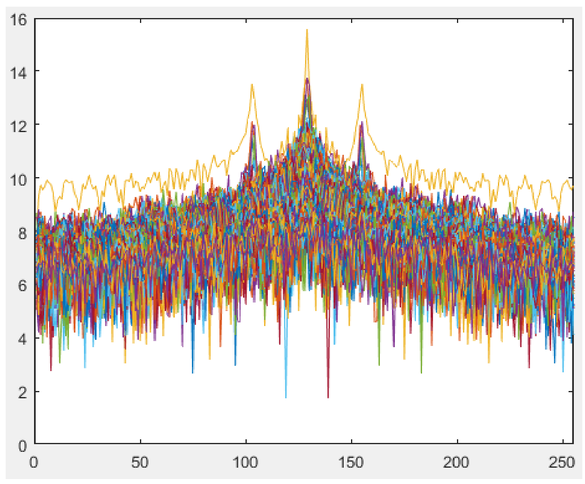
For the experimentation, we forced the image to have a known grid in which we can variate the angle, the thickness, the amplitude (to control the magnitude of the ripples) and the period.

Cameraman image with grid mask Here the image is masked with a grid in an angle of 0 degree, a period of 10 to have 20 rows and an amplitude of 0.5. This parameters will be used for the entire experimentation.

Extracting the Fourier Spectrum

The extracting of the Fourier Spectrum will allow use to find the little spots created by the grid : On the image and on the graph. The fundamental in the center describe the image and the little harmonics describe the ripples. That's what we need to remove, corresponding to the pattern.

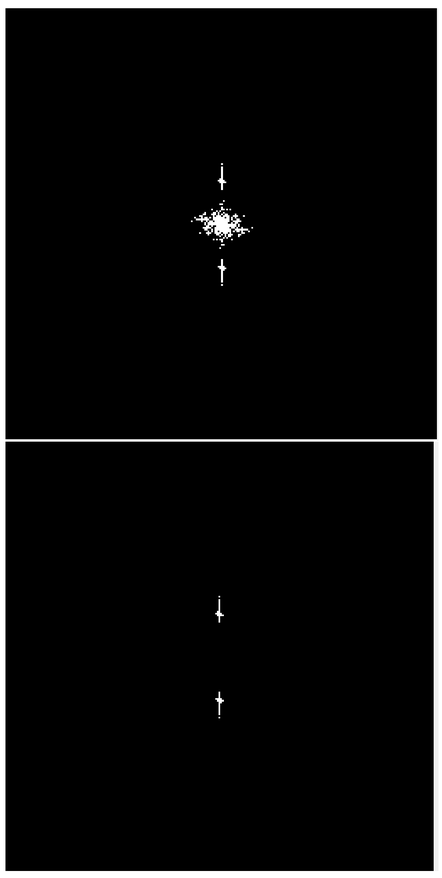




Fourier Spectrum Extraction a) The fundamental describing the image is in the center**b)** The harmonics describes the ripples are the two spots in the top and bottom of the fundamental.

Binarisation of the Spectrum

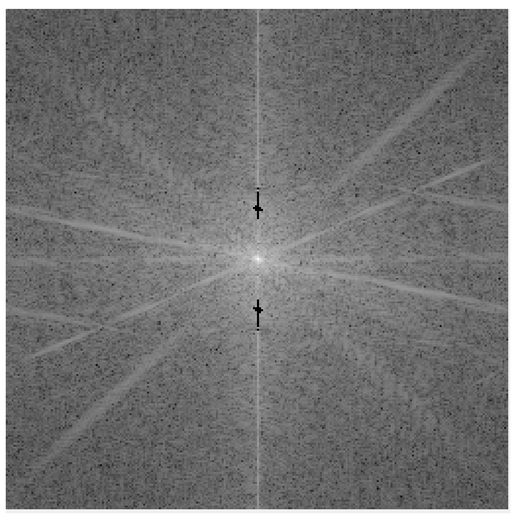
We need to binarize the spectrum to highlight the spots we need to remove, but it count the fundamental we need to exclude. Usually, the fundamental is located in the center of the image, on a scale of 110 to 150 pixels.



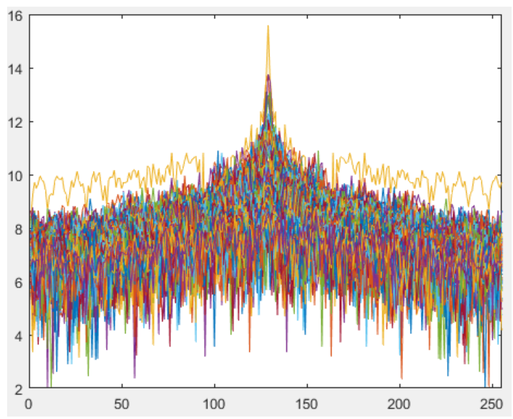
Binarisation of the Spectrum a) We see in detail the harmonics and fundamental in white **b)** The fundamental corresponding to the image is excluded

Applying the filter to the spectrum image

Now we can apply the filter to the spectrum image. Now the white spots corresponding to the harmonics are black and the fundamental is preserved but with a decrease of quality.



Applying the filter to the spectrum image a) The two harmonic spots are removed, textured in black**b)** The fundamental in the center is preserved, now we can compute the inverse Fourier transform.



Applying the filter to the spectrum image : Graph a) The two harmonic peaks are removed but not enough, a Gaussian smoother could resolve this problem with a decreasing the details.**b)** We see the fundamental is a little bit damaged, but not enough to change to much the quality of the image.

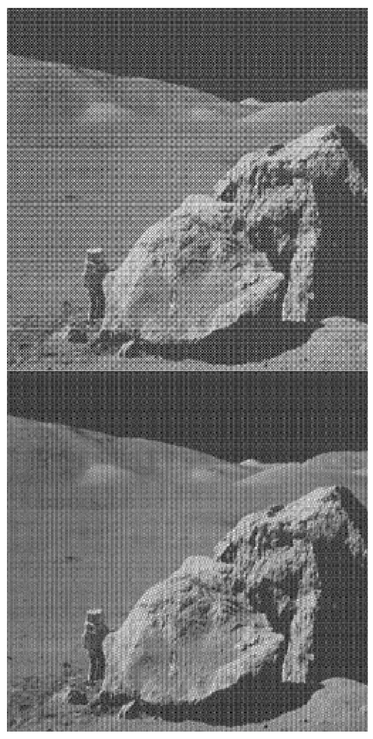
Result

The pattern of the image is removed, but not totally. There's still some artefacts present in the image, due to the harmonics which are not quite deleted but the quality of the image is way better than the noised one. Another technique could be better: Separate the fundamental and the harmonics and apply an high-pass filter to remove it. Then, replace the fundamental and compute the inverse Fourier Transform.

Result filtering Pattern partially removed

Testing with a common image

This program works very well with a common image with less reducing of the quality. We can conclude this algorithm is no very nice for removing line patterns whereas it's way better to remove smaller patterns.



Testing with a common image a) The first image is the noised one **b)** The second one is the filtered one

References

[1] Image denoising by FFT
http://scipy-lectures.org/intro/scipy/auto$_examples/solutions/plot_fft_image_denoise.html$

[2] FFT Raster Removal
http://www.robotplanet.dk/graphics/raster$_removal/$

[3] Chapter 4. Frequency and the Fast Fourier Transform
https://www.oreilly.com/library/view/elegant-scipy/9781491922927/ch04.html