Image denoising
Experimental assignment Course 2

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1. Introduction

In this assignment, we will compare the performance of two algorithms "Multi-Scale DCT Denoising" and "Non-Local Means Denoising". We will complete this goal in an experimental way: use both of them on the same images and compare results. The main factor will be the PSNR value and visibility of the artifacts. The images will be of different complexity: chessboard, flat image, and high-texture image.

2. Algorithms introduction

2.1. Description of the "Multi-Scale DCT Denoising"

In the paper, two algorithms evolved from DCT are presented. In the first, a two-step approach is utilized in the algorithm. At first, it applies at first local DCT to

denoise the image patches and secondly estimates the empirical Wiener filtering factors. In the second, a multi-scale approach is used. The decomposition of the image in a dyadic DCT pyramid is performed. Then the single scale denoising to all scales is applied and finally fusion of the obtained estimates. The paper shows the superiority of the two algorithms compared to classic DCT. The multi-scale DCT has shown the best performance.

2.2. Description of the "Non-Local Means Denoising"

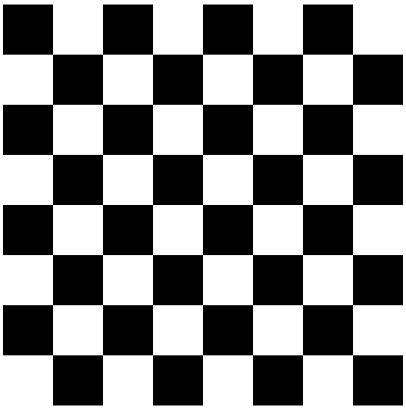
The algorithm is based on replacing the color of each pixel with an average of the colors of similar pixels. In the paper, two possible implementations were presented: per-pixel and per-patch. For the per-pixel implementation, the value of each pixel is calculated as the weighted sum of the values of the most similar pixels belonging to a specific neighborhood of the underlying pixel. In the case of a color image, for each pixel, each channel value is the result of the average of the channel values of the resembling pixels. For the per-patch implementation, we perform the same denoising, but to calculate the value of a certain pixel, we take a patch centered on this pixel and estimate it as a weighted sum of its similar patches. And in the end, the estimated value of the pixel in question is the mean of the pixel values of the obtained patch estimate. The similarity between patches and pixels is computed using Euclidean distance.

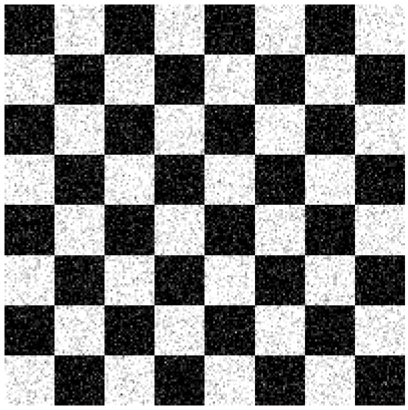
3. Experiments on the images

In this part we will take some classical examples of the images, some of them will be with understandable structure, and some will be more complex.

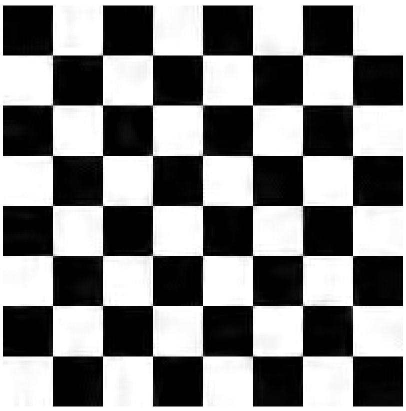
3.1. Chessboard image

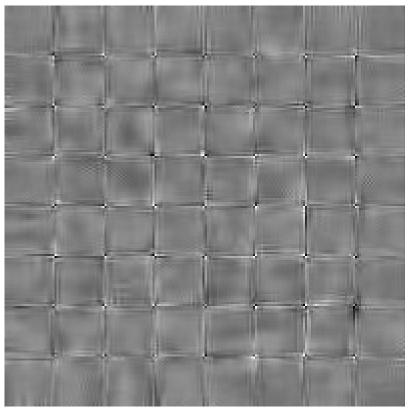
Images:



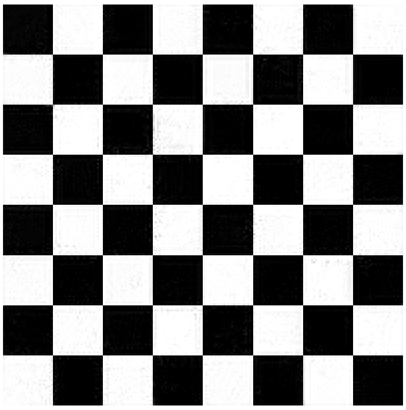


Original image *Noisy image with sigma = 40*

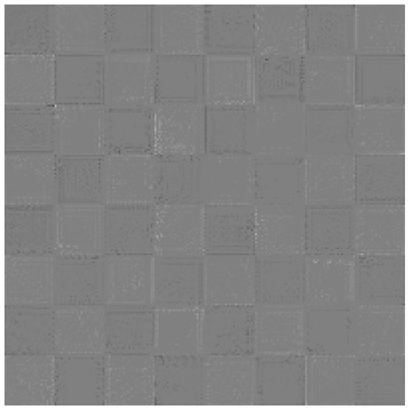




Denoised with MS DCT, PSNR = 33.0496dB *Difference image MS DCT*



Denoised with NL, PSNR = 34.43dB



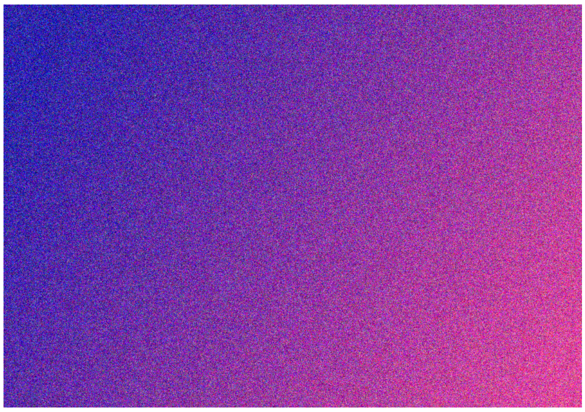
Difference image NL

Each algorithm performed well from a visual perspective. Both denoised images look similar to the original and to be honest it is really hard if not impossible to see the difference between them. However, the PSNR value shows that NL performed better with 34.43dB compared to NL with 33.05dB. From the difference images, we can clearly see the difference between algorithms. NL shows the better result on the smooth areas of the image, MS DCT has problems with that. Though, both of them don't show good performance on discontinuities. Therefore, we conclude that NL is better in smooth areas than MS DCT and by a small margin on discontinuities, but both of them can't handle them very well.

3.2. Flat image

Images:

Original image



Noisy image with sigma = 40

Denoised with MS DCT, PSNR = 46.5871dB

Difference image MS DCT

Denoised with NL, PSNR = 39.64dB

Difference image NL

Again, both methods worked really well. We can see some lines on the MS DCT image, PSNR on the flat image is clearly larger for MS DCT than for NL. However, both of them made a good job, so both of them don't have problems with smooth areas.

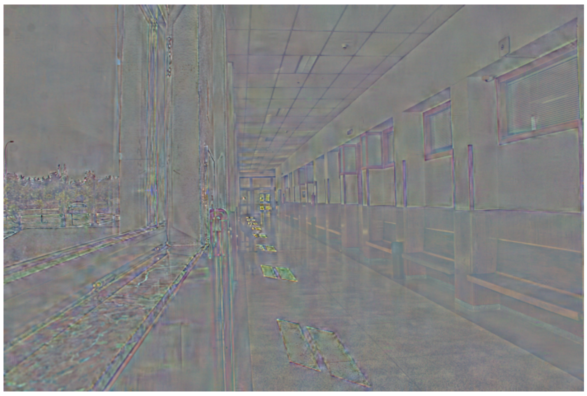
3.3. Real-world image

Images:

Original image

Noisy image with sigma = 30

Denoised with MS DCT, PSNR = 34.9917dB



Difference image MS DCT

Denoised with NL, PSNR = 33.06dB

Difference image NL

Again, both of the algorithms removed the noise pretty well. However, here we can see the big differences between them. NL ignored texture differences on the windowsill and removed them. Contrary, MS DCT tried to preserve it, so we can see some small white spots on the windowsill. This happens due to the fact that averaging happens, and because there are not enough white spots on the original image they are just not included in averaging. Also, NL preserved the edges of the light on the floor, but the MS DCT image has small artifact rings around them. The PSNR value for MS DCT is higher than for NL. Therefore, we can say that NL is worse than MS DST in smooth areas and textures, but better at discontinuities.

4. Conclusion

The MS DCT and the NL show decent results for denoising. However, these algorithms have some crucial differences. The MS DCT preserves some of the small texture areas, but NL tends to remove them due to averaging. However, NL preserves some fine structures of the original image, there are no artifacts around the edges, so NL is better at discontinuities. The loss in details of the textured parts of the image is noticeable and they are estimated rather randomly.