Image Denoising: Experimental Report 2

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In this report, we evaluate the performance of two interesting yet quite different algorithms: Non-Local Means (NLM) and Multi-Scale Discrete Cosine Transform (MS-DCT). Through experiments on natural and patterned images, we aim to compare their efficiency, identify artifacts, and interpret their results based on algorithmic properties. The PSNR is the most common metric to quantify the results and compare between them.

1 Algorithms Overview

1.1 Non-Local Means (NLM)

NLM utilizes the concept of self-similarity within images, averaging similar patches to reduce noise. This method excels in repetitive and uniform structures but may blur intricate details in more complex regions where we have more details, more objects belonging fundamentally different.

1.2 Multi-Scale DCT (MS-DCT)

MS-DCT leverages the sparse representation of images in the frequency domain via the Discrete Cosine Transform. By operating across multiple scales, it effectively denoises while retaining edges. However, frequency-based methods can occasionally introduce artifacts such as residual patterns.

2 Experimental Setup

Experiments were performed on two types of images to emphasize each time the expertise somehow of each denoising approach. The Gaussian noise is artificially added at a constant $\sigma = 35$ which is rather mid to high noise level. We use PSNR to quantify the effectiveness of denoising as well as visual inspection to analyze detail preservation and artifacts.

3 Results and Analysis

3.1 Natural image with simple objects

We chose a forest image in order to display the advantage of NLM compared to MS-DCT in using self-similarity to denoise. Moreover, the chosen image only contains trees and leafs, providing many similar patches, perfect for NLM.
As expected, the results shows that the for NLM $PSNR = 26.58dB$ whereas for MS-DCT we have $PSNR = 26.1dB$. Visually, we can say they are rather close but we can see some weak points for MS-DCt for example the area with some yellow tends more to be green while it's more preserved with NLM. The following figures are the clean chosen forest image and its noisy version.

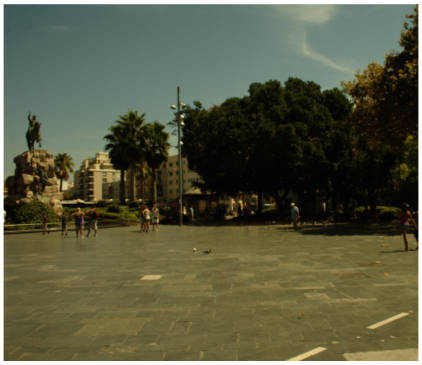
(a) Original forest image (b) Noisy Image ($\sigma = 35$)

Now, we dispaly the denoised versions obtained with the two considered methods:

(a) Denoised image (NLM) (b) Denoised image (MS-DCT)

3.2 Complex image

On images rich in details, MS-DCT shows superior performance in maintaining edges and textures. That's why, we chose the following plaza image consisting of numerous complex regions:

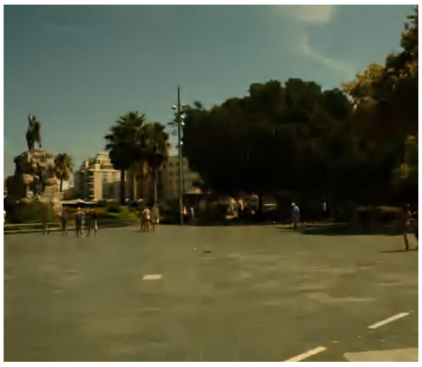


(a) Original plaza image

(b) Noisy Image ($\sigma = 35$)

As expected, NLP performs rather poorly compared to MS-DCT as reflected in lower PSNR values: for NLM $PSNR = 29.48dB$ versus MS-DCT $PSNR = 30.34dB$. Visually, one can say NLM struggles to retain intricate patterns namely in the paving of the plaza which led to oversmoothing and thus we can no longer see the paves lines meaning we lost completely this detail while we still have some traces with MS-DCT as seen in the following two denoised figures:

(a) Denoised image (NLM)



(b) Denoised image (MS-DCT)