

# 236862.2x Final Project - Image Denoising

Matthieu Poulet

March 2018

## Part A: Data Construction and Parameter-Setting

**Original**



**Noisy, PSNR = 22.0892**



- PSNR value of the noisy image: **22.0892**

## Part B: DCT Dictionary

- a. How is the error constraint ( $\|y_i - D\alpha_i\|_2^2 \leq \epsilon^2$ ) satisfied for each patch in batch mode?

As  $D$  is unitary, we have for all  $i$ ,  $\|y_i - D\alpha_i\|_2^2 = \|D^T(y_i - D\alpha_i)\|_2^2 = \|D^T y_i - D^T D\alpha_i\|_2^2 = \|D^T y_i - \alpha_i\|_2^2$ . That means that for each patch we calculate the vector  $q = D^T y_i$ , sort it in ascending order and compute its cumulative sum. From the resulting vector we can extract the indices of the elements that are above the squared noise-level threshold (i.e. the indices of the elements we want to keep). We do this for all patches at once by computing  $D^T Y$ . Then we copy only the elements which indices we want to keep in an empty matrix, zeroing all elements below the threshold in all patches at once.

- Average MSE of the reconstruction: **416.03**
- Average number of non-zeros of the reconstruction: **6.08**

DCT reconstructed image:

**DCT:  $\epsilon = 209.7618$  PSNR = 30.0895**

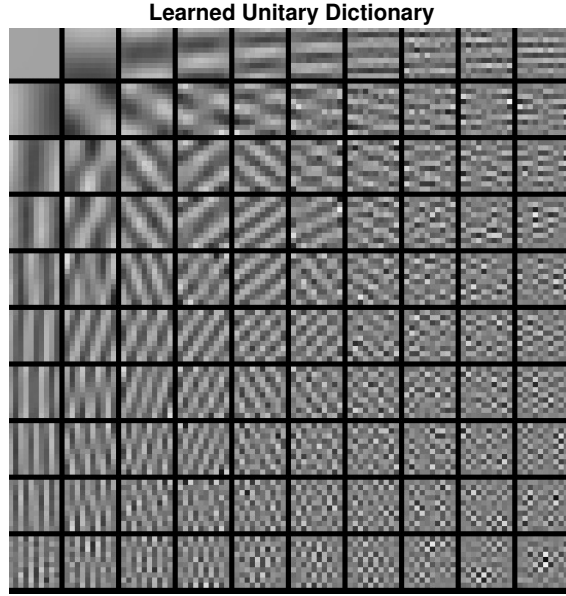


- epsilon value: **209.7618**
- PSNR of reconstruction: **30.0895**

We get an improvement of about 8dB with the DCT dictionary.

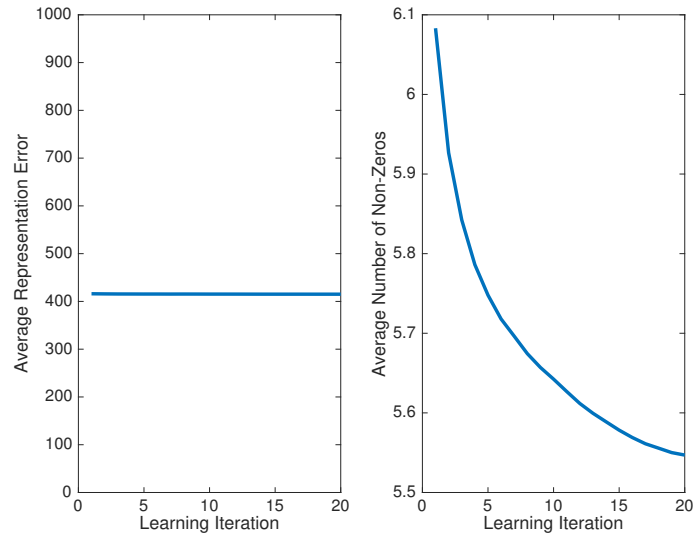
## Part C: Procrustes Dictionary Learning

The obtained learned dictionary:



The obtained dictionary consists of piecewise smooth atoms and textured ones, because of the nature of the cropped Barbara image.

Average MSE and number of nonzeros as a function of the iteration:



The average representation error remains constant but the cardinality of the approximation improves rapidly with each new iteration. After about 20 iterations we see that in average we use 1 atom less with the learned dictionary.

Procrustes reconstructed image:

**Unitary:  $\epsilon = 209.7618$  PSNR = 30.4775**



- epsilon value: **209.7618**
- PSNR of reconstruction: **30.4775**

We get an improvement of about 0.5dB compared to the DCT dictionary.

## Part D: SOS Boosting [1]

SOS-boosted reconstructed image:

**Unitary SOS:  $\epsilon = 230.7379$  PSNR = 30.5938**



- epsilon value: **230.738**
- rho value: **1.00**
- PSNR of reconstruction: **30.594**

We get an improvement of about 0.1dB compared to the learned dictionary.

## References

- [1] Y. Romano and M. Elad, “Boosting of Image Denoising Algorithms,” *SIAM Journal on Imaging Sciences*, vol. 8, no. 2, pp. 1187–1219, 2015.